Leviathan Field Development – Environmental Impact Assessment Addendum

Leviathan Expansion Project: Leviathan 10, 11, and 23 Drilling and Completion and Infield Subsea Infrastructure Installation

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ES-1 BACKGROUND AND LEVIATHAN EXPANSION PROJECT SUMMARY

The Leviathan Field is located approximately 120 km to the west of Haifa and approximately 35 km to the west of the Tamar Field, in water depths ranging from approximately 1,600 to 1,700 m. Natural gas was discovered in the Leviathan Field in 2010, and gas production from the field commenced at the end of 2019. At present, there are five producing wells in the field (Leviathan 3, 4, 5, 7 and 8). The gas flows from the Leviathan Field to the Leviathan Production Platform (LPP) via two ~118 km long 18-inch gathering lines. A third 20-inch gathering line is scheduled to be installed in 2025; that work is not included in this document and is not further discussed.

The Levithan Expansion Project includes the drilling and completion of three new production wells, and the installation of subsea production trees, infield flowlines and associated subsea infrastructure that will connect the subsea production trees to the existing manifold. The Levithan Expansion Project also includes the installation of the Regional Export Module (REM) onto the LPP. The implementation of the expansion plan will allow the increase of gas production up to 2,100 million standard cubic feet per day.

The Leviathan Expansion Project will involve the drilling and completion of three subsea production wells: Leviathan-10 (Lev-10), Leviathan-11 (Lev-11) and Leviathan-23 (Lev-23). These well locations were selected to provide both high-confidence production and to improve the delineation and understanding of the reservoir for future development.

ES-2 IMPACT ASSESSMENT SOURCES

CSA (2016) previously provided a description of general activities planned and a breakdown of Environmental Impact Assessment (EIA) Sections (see Section 1.1 of the 2016 document). The EIA was prepared for the Ministry of Energy (MoE) and the Ministry of Environmental Protection (MoEP) in accordance with the "Guidelines for Preparing the Environmental Impact Assessment in the Israeli Exclusive Economic Zone (EEZ) – Leviathan Expansion Project" issued 09 January 2025.

Key Findings of 2016 EIA:

- Chevron Mediterranean Limited [(CML, then Noble Energy Mediterranean Limited (NEML)] planned to conduct well drilling and completion activities for gas production.
- The development plan for the Leviathan Field included the drilling and completion of up to 29 wells.
- Eight initial development drill sites were selected and evaluated in detail in the 2016 EIA.
- The 2016 EIA was intended to encompass all future drilling and completion activities in the field.
- The 2016 EIA comprised six chapters:
  - **Chapter 1:** Described the baseline environment, including site-specific data from the background monitoring survey.
  - **Chapter 2:** Provided reasoning for the location of the proposed plan and possible alternatives. Alternatives included well locations, technologies, and infrastructure for future production.
  - **Chapter 3:** Described the drilling program, including schedule, drilling unit and support vessels, drilling mud program, well completion, production testing, underwater noise hazards, air quality, hazardous materials, discharges, wastes and abandonment plans.
  - **Chapter 4:** Evaluated potential impacts on the environment from routines activities and accidental events.
  - **Chapter 5:** Presented the guidelines for preservation and prevention of harm to the environment, including management and mitigation strategies.
  - **Chapter 6:** Literature and supporting information.

This Leviathan Field Development – Environmental Impact Assessment Addendum evaluates the environmental impacts of CML's proposed expansion drilling and completion activities, and installation and operation of new subsea and topsides infrastructure.

ES-3 IMPACT ASSESSMENT APPROACH

The impact assessment includes both routine activities and accidental events. The following definitions are used:

- **Aspect** – an element of an organization's activities or products or services that can interact with the environment (International Organization for Standardization, 2004; ISO 14001);
- **Resource –** a component of the natural or human environment that could be affected by any aspect of an organization's activities; and
- **Impact –** any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects (International Organization for Standardization, 2004).

The following aspects and resources were included in the analysis:

Aspects:

- Seafloor disturbance;
- Drilling discharges;
- Routine discharges;
- Air emissions;
- Safety and protection;
- Noise hazards;
- Light disturbances;
- Waste and marine debris;
- Support vessel traffic;
- Helicopter traffic;
- Accidental fuel loss of containment; and
- Accidental condensate release from a well loss of containment.

Resources:

- Geological, Seismic, and Sedimentological Characteristics
  - Bathymetry and Seafloor Morphology
  - Shallow Stratigraphy
  - Seismicity
  - Sediment Grain Size
  - Geologic Setting
- Geohazards
- Hydrodynamic Regime (Physical Oceanography)
  - Waves
  - Extreme Storms
  - Currents
  - Winds
- Nature and Ecology
  - Benthic Communities
  - Marine Mammals, Sea Turtles, Birds, and Fishes
  - Coastal Habitats and Infrastructure
  - Fishing Areas and Landings
- Seawater and Sediment Quality
  - Water Quality
  - Sediment Quality
- Culture and Heritage Sites
- Meteorology and Air Quality
  - Existing Meteorological Conditions
  - Air Quality
- Noise
- Marine Transportation System and Infrastructure

The first step in the impact analysis was a screening assessment to identify the resources potentially affected by each aspect. The next step was to analyze each potential impact by describing and quantifying each impact to the extent practicable. This step included an assessment of the "consequence" (severity) and likelihood of each impact.

Finally, the overall environmental risk posed by each impact was assessed using a risk matrix that combines aspect likelihood and impact consequence. The likelihood of each aspect (taking into account all of the identified management and mitigation measures) was given a score between 1 and 5 based on the definitions in the matrix. The consequence of each potential environmental impact was also rated on a scale of 1 to 5. Each cell in the matrix (i.e., each intersection of likelihood and consequence) was calculated as the product of likelihood and consequence. These risk values were grouped into three risk categories: Low, Moderate, and High.

ES-4 IMPACT DETERMINATIONS – DRILLING AND COMPLETION AND SUBSEA INFRASTRUCTURE INSTALLATION AND OPERATION

ES-4.1 Routine Activities

Impacts from routine activities are summarized in **Table ES-1**, summarizing potential impacts to marine resources resulting from proposed expansion drilling and completion activities at three drill sites, and installation and operation of new subsea and topsides infrastructure. Impacts from most aspects on most resources were classified to have a Low residual risk. Only impacts from drilling discharges may potentially pose a Moderate residual risk, specifically to water quality, fish, sediment quality, and benthic communities.

Table ES-1. Summary of potential impacts, mitigation measures, likelihood, consequence, and residual risk from routine activities associated with the Leviathan Expansion Project.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Artificial lighting on drillship, installation vessel, and supply vessels	Sea turtles	Possible attraction of hatchlings resulting in exposure to discharges and predation	To the extent practicable without compromising safety or work performance, lighting in open deck areas will be shielded (i.e., oriented downward) to minimize excess light emissions into the environment.	3	1	3 Low
	Seabirds and migratory birds	Possible attraction and/or disorientation including circling behavior and collisions with drillship structure	Same as above	3	1	3 Low
	Pelagic fishes	Attraction to lights resulting in exposure to discharges and noise	Same as above	3	1	3 Low
Noise from drillship, installation vessel, supply vessels, and helicopters	Marine mammals	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
	Sea turtles	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
	Fishes	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
Seafloor disturbance	Sediment quality	Physical disruption and suspension of sediments	None	3	1	3 Low
	Benthic communities	Localized burial and crushing of individual organisms; areal extent 2,500 m^2 or less per drill site and from seafloor infrastructure installation	None	3	1	3 Low
	Water quality	Mobilization of local sediments, potential mobilization of sediment-bound contaminants, deposition of muds and cuttings	None	3	1	3 Low

Table ES-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Drilling discharges	Water quality; fishes	Turbidity within a few tens of meters to a few kilometers from discharge locations	Selection of low-toxicity MOBM No discharge of MOBM or MOBM-wetted cuttings Preferably, all additives to the WBM/Brine will be PLONOR or Gold-rated according to OSPAR guidelines; barite will have a low metals concentration and will comply with the discharge-to-sea permit thresholds for mercury and cadmium; WBM and brine will be tested in accordance with Discharge to Sea Permit requirements Drilling mud samples will be taken for every drilling section in compliance with Discharge to Sea Permit requirements, including the periodic toxicity testing of drilling muds during drilling Surface waters in the vicinity of the drillship shall be visually monitored for oil sheen on a daily basis	5	1	5 Mod
	Sediment quality	Deposition of cuttings particles on the seafloor, causing changes in grain size and mineralogy	No discharge of MOBM or MOBM-wetted cuttings	4	2	8 Mod
	Benthic communities	Localized burial and smothering of benthic organisms. Burial impacts are most likely within 65 m of drill sites. Anoxia and other benthic impacts may occur due to changes in sediment grain size.	Background monitoring survey conducted to verify there are no deepwater coral or other hard bottom communities present	4	2	8 Mod

Table ES-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Drillship, installation vessel, support vessel routine discharges (sanitary and grey water, food waste, cooling water, desalination brine, deck drainage)	Water quality; fishes; marine mammals; sea turtles	Localized, transient impacts on water quality within a few meters to a few hundred meters of drillship, installation vessel, or other vessels	Compliance with MARPOL requirements Drillship discharges and other project vessel (including the installation vessel) discharges will be in compliance with the Discharge to Sea Permit	3	1	3 Low
Flowline pre-commissioning fluid discharges (including preservation fluids)	Water quality; fishes; benthic communities	Localized, transient impacts on water quality within a few meters to a few hundred meters of the discharge; potential exposure to fishes and benthic communities when discharged at depth	Preferably, all pre-commissioning and preservation fluids will be PLONOR or Gold-rated under the Offshore Chemical Notification Scheme	4	2	8 Mod
Other discharges (sanitary and grey water, food waste, cooling water, desalination brine, deck drainage)	Water quality; fishes; marine mammals; sea turtles	Localized, transient impacts on water quality within a few meters to a few hundred meters of drillship or other vessels	Sanitary waste will pass through an International Maritime Organization (IMO) approved sewage treatment plant prior to discharge Food waste will be macerated to pass through a 25 mm mesh in accordance with MARPOL Annex V requirements, commingled with the grey water and discharged overboard more than 12 nmi from shore Drainage from hazardous areas will be collected and sent to shore for proper disposal Bilge water and deck drainage from machinery areas will pass through an oil-water separator prior to discharge (in accordance with MARPOL Annex I	3	1	3 Low

Table ES-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
			requirements) or be retained on board to be disposed of onshore			
Other discharges (ballast water)	Fishes; benthic communities	Potential introduction of AIS in ballast water	All operating project vessels will provide the following documentation for AIS clearance to minimize the risk of introducing AIS: Declaration letter with working areas in the past 5 years, Ballast Water Management Plan and international Ballast Water Management Certificate, International Anti-fouling System certificate and haul cleaning reports	3	1	3 Low
Support vessel traffic	Marine mammals, sea turtles	Short-term behavioral disturbance; potential for a vessel to strike a marine mammal or sea turtle	None recommended	3	1	3 Low
Helicopter traffic	Marine mammals; sea turtles; seabirds and migratory birds	Short-term behavioral disturbance of marine mammals, sea turtles, or birds; potential for a helicopter to strike a bird	Maintain recommended minimum altitudes when flying over sensitive coastal habitats such as parks and preserves	3	1	3 Low
Marine debris	Water quality; sediment quality; benthic communities	Potential accumulation of metal debris on the seafloor, with growth of fouling biota	Drillship and vessel operator's Garbage Management Plan and the additional requirements set by CML will minimize the potential for accidental loss of items overboard Post-drilling and post-installation ROV surveys to ensure the seafloor is clear of equipment and debris	2-3	1	2-3 Low
	Marine mammals; sea turtles; seabirds; migratory birds; fishes	Potential entanglement, ingestion; leaching of residual chemicals due to accidental loss of debris	Drillship and vessel operator's Garbage Management Plan and the additional requirements set by CML will minimize the potential for accidental loss of items overboard	2-3	1	2-3 Low

Table ES-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Seafloor disturbance	Culture and heritage sites	Possible physical damage to wreck sites	305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts (	2	2	4 Low
Drilling discharges	Culture and heritage sites	Possible burial or contamination of wreck sites	305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts (	2	2	4 Low
Air emissions (drillship)	Air quality	Localized, transient elevations in air pollutant concentrations near drillship; greenhouse gas emissions	Routine maintenance and inspection of engines and generators Compliance with MARPOL Annex VI regulations including the use of low sulfur fuel and meeting the NOx emission limits under Regulation 13 of Annex VI	3	1	3 Low
Air emissions (installation vessel, support vessels and helicopters)	Air quality	Localized, transient elevations in air pollutant concentrations along installation and transportation routes; greenhouse gas emissions	Routine maintenance and inspection of engines and generators Compliance with MARPOL Annex VI regulations including the use of low sulfur fuel and meeting the NOx emission limits under Regulation 13 of Annex VI	3	1	3 Low

ES-4.2 Accidents

Two accidental spill scenarios were evaluated in the CSA (2016) document and remain relevant for the Leviathan Expansion Project: a fuel release and a condensate release from a well loss of containment event. The diesel fuel release scenario assumed an instantaneous release of 8,415.6 m^3 from the drillship. The condensate release scenario assumed a well loss of containment resulting in the release of continuing for a period of 30 days.

Within these two different accidents, four time periods representative of various climatic conditions were used in the model:

- Scenario 1 – 9 December 2010 to 8 January 2011, a period that included an extreme winter storm;
- Scenario 2 – 26 January to 25 February 2008, typical winter conditions;
- Scenario 3 – 17 July to 16 August 2008, typical summer conditions with persistent northwesterly winds and swell; and
- Scenario 4 – 25 September to 25 October 2007, autumn conditions typical of the transition seasons and including at least one episode of strong easterly to northeasterly wind.

The models predicts that diesel fuel would evaporate rapidly, with approximately 45.6% of the spill evaporating in the first 42 to 55 hours in each of the assessed scenarios. A release is predicted to reach the shoreline after 12 days under Scenario 4, after 20 or 21 days under Scenario 2 or 3, or essentially not at all under Scenario 1. At the end of 30 days, all four scenarios show 45.6% evaporation, from 0% to approximately 42% oil remaining on the sea surface, and between 2.5% and 11.9% dispersed.

The condensate release scenario assumed a well loss of containment of condensate (API gravity of 30), resulting in the release rate of), continuing for a period of 30 days. The model predicts that nearly 40% of the spill would evaporate in the first 24 hours. A spill is predicted to reach the shoreline after 7 days under Scenario 2, 13 days under Scenario 4, 23 days under Scenario 3, or after 25 days under Scenario 1. At the end of 30 days, all four scenarios show 44% evaporation, from 25.8% to 41.5% oil remaining on the sea surface, and 11.6% to 14.2% dispersed in the water column. The percent of the spill deposited on the coastline ranges from 0.3% (Scenario 1) to 15.8% (Scenario 2), with impacts to the coastlines of Lebanon and Cyprus under Scenario 1, Israel, Lebanon, and southern Syria under Scenario 2, Lebanon and Syria under Scenario 3, and Egypt, Israel, and Lebanon under Scenario 4. The locations and magnitude of shoreline deposition are highly seasonally dependent. Total length of affected shoreline ranges from 54.2 to 388.5 km. Impact hotspots are Madfoun, Lebanon (up to 26.9 m^3/km); Sidon, Lebanon (up to 39.7 m^3/km); Latakiya, Syria (up to 68.3 m^3/km); and Haifa Bay (up to 149.6 m^3/km).

ES-5 DECOMMISSIONING

At the end of the production life of the Leviathan Expansion Project wells, CML will initiate decommissioning of wells and subsea infrastructure. Prior to decommissioning, in accordance with the MoE guidelines, CML will conduct an environmental impact assessment to determine the most environmental method of decommissioning and will obtain approval from appropriate Ministry authorities; development of a comparative assessment and net environmental benefit analysis may be conducted. Existing regulatory requirements at the time of decommissioning will provide the primary framework for decommissioning options to be considered. Sources of potential impact resulting from future decommissioning are similar to those identified for drilling and subsea infrastructure emplacement, including vessel or infrastructure discharges, physical presence, exclusion zones, vessel movement, air emissions, vessel sound emissions, light emissions, solid waste, helicopter traffic/sound emissions, and seafloor disturbance. These sources of impact potentially affect a suite of environmental resources, including physical/chemical, biological, and environmental/social attributes. Decommissioning operations are expected to be temporary and short term in nature, producing limited, localized impacts. The decommissioning assessment, to be conducted prior to decommissioning, will fully outline decommissioning options and expected impacts from each.

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List of Acronyms and Abbreviations

3D	three-dimensional
ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
AIS	Alien Invasive Species
AoI	Areas of Interest
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AUV	autonomous underwater vehicle
bbl	barrel(s)
BHA	Bottom Hole Assembly
BML	below mud line
BOEM	U.S. Bureau of Ocean Energy Management
BOP	blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
CCC	criterion continuous concentrations
CH4	methane
CIRES	Cooperative Institute for Research in Environmental Studies
CL	confidence limit
CML	Chevron Mediterranean Ltd.
CO	carbon monoxide
CO2	carbon dioxide
CSA	CSA Ocean Sciences Inc
CTD	conductivity-temperature-depth (Instrument)
CVS	Coastal Valve Station
CYCOFOS	Cyprus Coastal Ocean Forecasting and Observing System
DO	dissolved oxygen
DP	dynamic positioning
DSM	Domestic Supply Module
DST	Dead Sea Transform
DVS	Dor Valve Station
EBS	environmental baseline survey
EDS	emergency disconnect system
EEZ	Exclusive Economic Zone
EHS	Environment, Health, and Safety
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
EMS	Environmental Management System
ERL	effects range low
ERM	effects range median
ESI	Environmental Sensitivity Index
EUCEQS	European Commission Environmental Quality Standard
FAD	Fish Aggregating Devices
FFPI	Fossil Fuel Pollution Index
GEMS	Geoscience Earth & Marine Services
GHG	greenhouse gas
H2S	Hydrogen Sulfide
IBA	Important Bird Areas
IMO	International Maritime Organization
IOLR	Israel Oceanographic & Limnological Research
IPIECA	International Petroleum Industry Environmental Conservation Association
ITC	internal tree cap
IUCN	International Union for Conservation of Nature

List of Acronyms and Abbreviations (Continued)

LBB	Levantine Basin Baseline
Lev-10	Leviathan-10
Lev-11	Leviathan-11
Lev-23	Leviathan-23
LIW	Levantine Intermediate Water
LPP	Leviathan Production Platform
LWD	Logging While Drilling
MAC	Maximum Allowable Concentration
MARPOL	International Convention for the Prevention of Pollution from Ships
MASP	maximum anticipated surface pressure
MAW	Modified Atlantic Water
MDW	Mediterranean Deep Water
MEG	monoethlyene glycol
MEPC	Marine Environment Protection Committee
MEWQS	Mediterranean Environmental Water Quality Standards
MM	Middle Miocene
MMSCFD	Million Standard Cubic Feet per Day
MOBM	Mineral Oil-Based Mud
MoE	Ministry of Energy
MoEP	Ministry of Environmental Protection
MPA	Marnie Protected Area
MPD	Managed Pressure Drilling
MWD	Measurement While Drilling
NCEP	National Center for Environmental Predictions
NMFS	U.S. National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen Oxides
NTU	Nephelometric Turbidity Units
OGP	International Association of Oil & Gas Producers
OMS	Operations Management System
OSCP	Oil Spill Contingency Plan
OSPAR	Convention for the Protection of Marine Environment in the Northeast Atlantic
OWS	oil/water separator
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PLET	Pipeline End Termination
PM	particulate matter
PNEC	Predicted No Effect Concentration
ppb	parts per billion
ppg	pounds per gallon
ppm	parts per million
PSU	practical salinity units
PTS	permanent threshold shift
RDIF	Reservoir Drill-in-Fluid
REM	Regional Export Module
ROV	remotely operated vehicle
SCSSV	Surface-Controlled Subsurface Safety Valve
SD	standard deviation
SDA	subsea distribution assembly
SDS	safety data sheet
SOLAS	International Convention for Safety of Life at Sea

List of Acronyms and Abbreviations (Continued)

SOPEP	Shipboard Oil Pollution Emergency Plan
SOx	sulfur oxides
SPL	sound pressure level
SSCV	semi-submersible crane vessel
SSTT	Subsea Test Tree
TA	temporarily abandoned
TCC	thermomechanical cuttings cleaner
TN	total nitrogen
TOC	total organic carbon
TOG	total oil and grease
TP	total phosphorus
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TTS	temporary threshold shift
USEPA	United States Environmental Protection Agency
UTA	umbilical termination assembly
VOC	volatile organic compounds
WBM	water-based mud

Introduction – Leviathan Expansion Project General Overview

The Leviathan Field is located approximately 120 km to the west of Haifa and approximately 35 km to the west of the Tamar Field, at a water depth range from approximately 1,600 to 1,700 m. Natural gas was discovered in the Leviathan Field in 2010, and gas production from the field commenced at the end of 2019. At present, there are five producing wells in the field (Leviathan 3, 4, 5, 7 and 8). The gas flows from the Leviathan Field to the Leviathan Production Platform (LPP) via two ~118 km long 18-inch gathering lines (a third 20-inch gathering line is scheduled to be installed in 2025).

The LPP is located approximately 10 km west of Dor beach, in the western part of the northern maritime polygon of National Outline Plan (TAMA) 37H. Treatment of natural gas and the production by-products is carried out entirely on the LPP. From the LPP, treated gas is delivered via an offshore and onshore pipeline to the Israel Natural Gas Lines Ltd. (INGL) Dor Valve Station (DVS). Condensate is treated and stabilized onboard the LPP, subsequently transmitted via offshore and onshore pipeline to the Coastal Valve Station (CVS), and from there via a pipeline system to refineries.

The design of the LPP was based on two main processing modules: the Domestic Supply Module (DSM) and the Regional Export Module (REM). The DSM is operating and capable of treating up to 1,200 million standard cubic feet per day (MMSCFD) of natural gas. With the planned addition of the third gathering line in 2025, the DSM will be able to receive and process up to 1,400 MMSCFD of natural gas.

The Leviathan Expansion Project will include the drilling and completion of three additional production wells, installation of infield flowlines and associated subsea infrastructure that will connect the wells' subsea trees to the existing manifold, and the installation of the REM onboard the LPP. The implementation of the expansion plan will allow the increase of gas production up to 2,100 MMSCFD.

The Leviathan Expansion Project will begin with the drilling and completion of three subsea production wells: Leviathan-10 (Lev-10), Leviathan-11 (Lev-11) and Leviathan-23 (Lev-23) (**Figure I-1**). These wells were selected to provide both high-confidence production and delineation of the reservoir for future development.

Infield production flowlines will link the new three subsea wellheads to the existing Infield Gathering Manifold or will be tied into the subsea production system by daisy chaining new flowlines into the existing infrastructure, through spare tie-in points on the infield flowline Pipeline End Terminations (PLETs). The infield flowline from Lev-11 will connect into a new PLET at Lev-10, and a combined infield flowline from Lev-10 and Lev-11 will connect to the existing subsea manifold. The infield flowline from Lev-23 will connect to an existing well Leviathan-4 PLET, already connected to existing manifold. The new infield flowlines will be of 14-inch diameter and of rigid pipe construction. The total new flowline length for the new three wells will be 6.4 km, with the longest individual flowline measuring 3.1 km.

Each infield flowline will feature a PLET at each end. PLETs will facilitate the installation of tie-in jumpers to connect the flowline to the subsea tree at one end, and the existing Infield Gathering Manifold or existing PLET at the other, and will enable connection of pre-commissioning equipment, tools and aids. Infield tie-in jumpers will connect the subsea production structures (subsea trees, existing Infield Gathering Manifold, existing PLETs) to respective new PLETs on the infield flowlines. All jumpers will be of rigid steel pipe construction. To connect the new infield flowline from Lev-10 and Lev-11 to the existing manifold, an intermediate jumper structure (IJS) will be installed about 20 m from the manifold. One new jumper will connect the infield flowline PLET to the IJS, with a second jumper connecting the IJS to the manifold.



Figure I-1. Conceptual diagram of the Leviathan Expansion Project, showing the three new production wells in the Leviathan Field, proposed subsea infrastructure, and the regional export module (REM) on the Leviathan Production Platform (LPP).

To control the trees and deliver Monoethylene glycol (MEG) and chemicals to the new trees, two new infield umbilicals will be installed, pre-commissioned and commissioned for the Leviathan Expansion Project. The new infield umbilicals include one umbilical from Lev-11 to Lev-10 and one umbilical from Lev-23 to the existing Lev-07 well area where it will tie into the existing Lev-6 infield umbilical. Hydraulic and electrical flying leads will connect the existing infield umbilical UTAs, to the new infield umbilical UTAs, and from the new infield umbilical UTAs to the new trees. .

The assessment of the REM has not been included in this analysis as it will lie within territorial waters; details regarding the REM have been provided below for full description of the expansion project. The REM that will be installed on the LPP (**Figure I-1**) will consist of inlet heaters, inlet separators, hydrocarbon dew point control system trains, flowline liquid handling, and process liquids handling. Additional heat is required into the gas production flow due to the increased production on the REM. It will come from the new heat medium module that is part of the Leviathan Expansion Project. The REM will rely on the existing facilities on the LPP for MEG reclamation, condensate stabilization, and for treating produced water. These systems will be integrated via interconnecting piping. The existing produced water treatment facility on the LPP was originally designed for the max gas production rate.

The environmental impact assessment of the REM installation will be thoroughly presented in an Environmental Management and Monitoring Plan (EMMP), which will be submitted as part of the Building Permit Application for the REM. Additionally, the LPP environmental permits (e.g., Toxin Permit, Discharge to Sea Permit, and Air Emission Permit) will be updated to cover both the installation activities, start-up and routine operations on the LPP following the REM installation. REM installation is currently scheduled for late 2028 – beginning of 2029.

Chapter 1: Description of the Current Maritime Environment

1.1 GENERAL

CSA (2016) previously provided a description of general activities planned and a breakdown of EIA Sections (see Section 1.1 of the 2016 document). New information for the Leviathan Expansion Project is mentioned under the proposed project.

The EIA was prepared for the Ministry of Energy (MoE) and the Ministry of Environmental Protection (MoEP) in accordance with the "Guidelines for Preparing the Environmental Impact Assessment in the Israeli Exclusive Economic Zone (EEZ) – Leviathan Expansion Project" issued 09 January 2025 (Natural Resources Administration, Ministry of Energy, 2025; **Appendix A**). Preparers and their qualifications are listed in **Appendix B**.

Key Findings:

- CML (formerly NEML) planned to conduct well drilling and completion activities for gas production.
- The development plan for the Leviathan Field included the drilling and completion of up to 29 wells.
- Eight initial development drill sites were selected and evaluated in detail in the 2016 Environmental Impact Assessment (EIA).
- The 2016 EIA was intended to encompass all future drilling and completion activities in the field.
- The EIA consisted of five key chapters:
    - **Chapter 1:** Described the baseline environment, including site-specific data from the background monitoring survey (**Appendix C**).
    - **Chapter 2:** Provided reasoning for the location of the proposed plan and possible alternatives. Alternatives included well locations, technologies, and infrastructure for future production.
    - **Chapter 3:** Described the drilling program, including schedule, drilling unit and support vessels, drilling mud program, well completion, production testing, underwater noise hazards, air quality, hazardous materials, discharges, wastes and abandonment plans.
    - **Chapter 4:** Evaluated potential impacts on the environment from routines activities and accidental events.
    - **Chapter 5:** Presented the guidelines for preservation and prevention of harm to the environment, including management and mitigation strategies.
    - **Chapter 6:** Literature and supporting information.

Proposed Project:

- CML is proposing to drill and complete three wells (Lev-10, Lev-11, and Lev-23) and install subsea production trees. All three wells fall within the field survey area. Additional information is provided in **Section 1.3**.
- CML is proposing to expand the Leviathan Field subsea production system to gather production from the three new wells to the existing Leviathan gathering manifold (**Figure 1-1**). The production will be transported to the Leviathan Production Platform (LPP) via existing gathering flowlines.

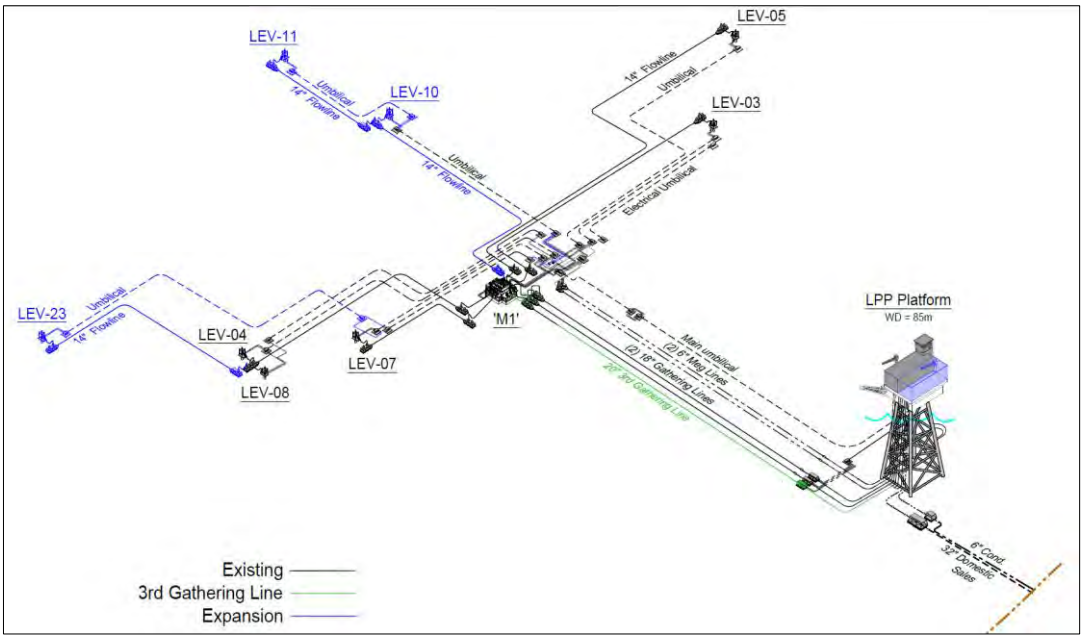


Figure 1-1. Illustration of the proposed Leviathan Expansion Project subsea scope of work. Proposed new infrastructure under the Leviathan Expansion Project is shown in blue. The REM is not in the scope of this document.

1.2 BOUNDARIES OF APPLICATION AND AREA OF INFLUENCE

CSA (2016) previously provided a discussion of Boundaries and the Area of Influence (AoI[1]) from prior drilling activities in the Leviathan Field (see Section 1.2 of the 2016 document). Genesis (2016) provided a discussion of the original Leviathan Field development plan and associated AoI regarding infrastructure installation.

Key Findings:

- The Leviathan Field is located in the I/15 Leviathan North and I/14 Leviathan South leases approximately 120 km off the coast of northern Israel in the Mediterranean Sea at a water depth of 1,540 to 1,800 m (**Figures 1-2** and **1-3**).
- The AoI includes the entire marine and coastal affected by subsea installation activities, routine operations or accidental events **Figure 1-2**.
- The area potentially affected by routine operations include vessel routes between the Leviathan Field and CML's shore base at Haifa. Limassol, Cyprus may be used as an alternate shore base with vessel routes to the Leviathan Field.
- The area potentially affected by accidental events (e.g., spill) includes the Eastern Mediterranean Sea, within a box defined by coordinates: 31°30' N to 35°45' N latitude, 32° E to 35°30' E longitude (Geodatum Ref: WGS84).
- The actual area affected by a particular spill would be much smaller. As discussed in **Section 4.2**, the potential shoreline impacts (depending on the season) range from Ashkelon, Israel to Chekka, Lebanon (north of Beirut) as well as the southern coast of Cyprus.

[1] The Area of Influence (AoI) represents the area potentially affected by a proposed action or activity; the AoI acronym is used throughout this document. AoI corresponds to the Application Area (or application zone) referenced in the 2025 Guidelines (i.e., Section 1.2 – Application Boundaries and Range of Impact).

Proposed Project:

- CML intends to drill and complete three new wells (**Figure 1-3**), and to expand the existing subsea system to gather production from the three new wells to the existing Leviathan gathering manifold and then to the LPP.
- The AoI from routine operations is limited to at least 2 km radius around each proposed drill site and 0.3 km off proposed linear infrastructure routes, and along transit corridors (e.g., supply or support vessels; helicopters) to shore.
- The vessels supporting drilling and completion will be based in Haifa, although support operations from Limassol may also occur. The vessels supporting subsea infrastructure installation are expected to originate from Limassol.
- The AoI for an accidental spill extends from the southern coast of Lebanon to the southern coast of Israel but would still be smaller than model simulations indicate; the actual range of a spill would be highly dependent upon volume released and seasonal meteorological and oceanographic conditions.

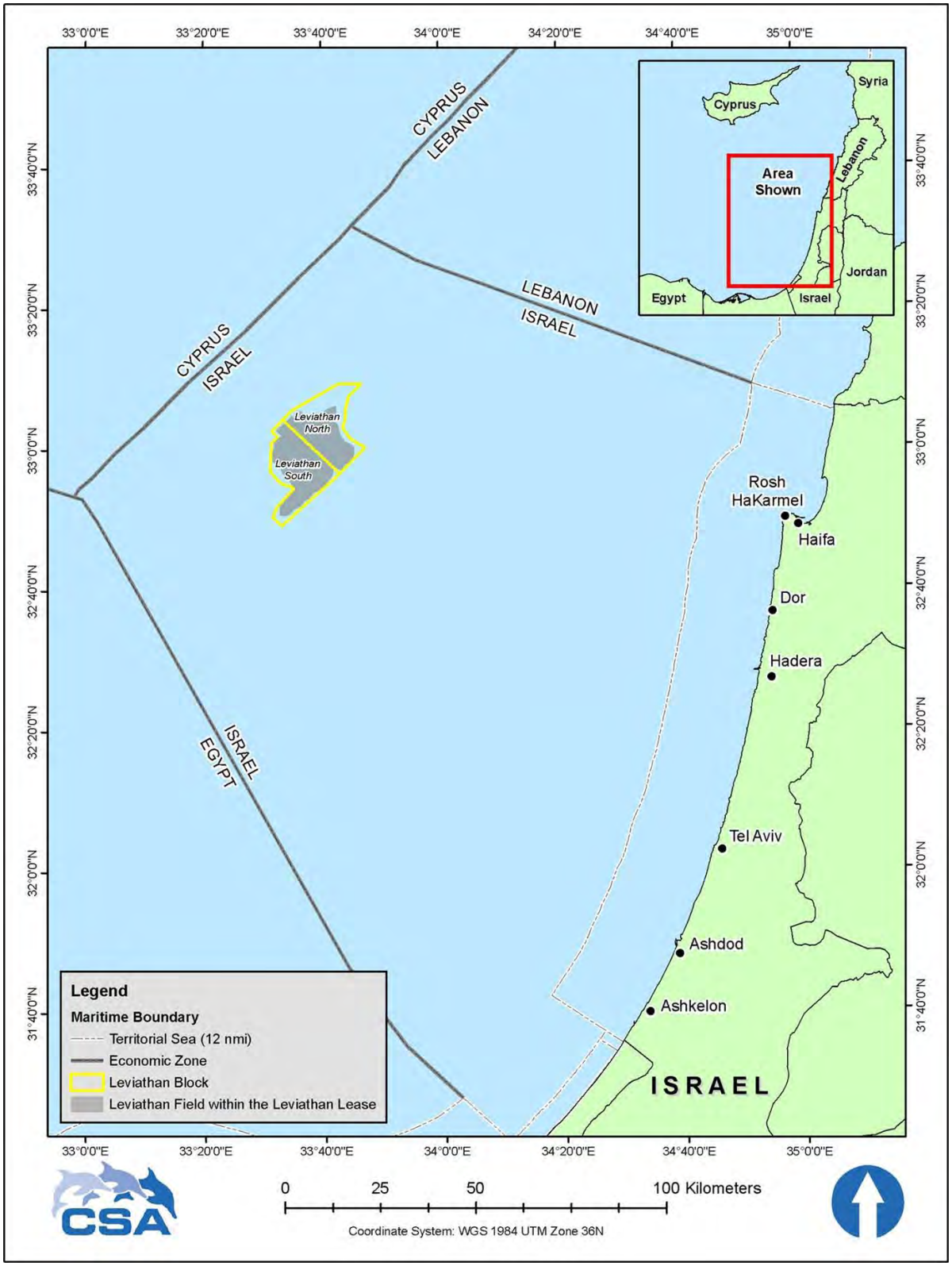


Figure 1-2. Location of the Leviathan Field, offshore Israel.

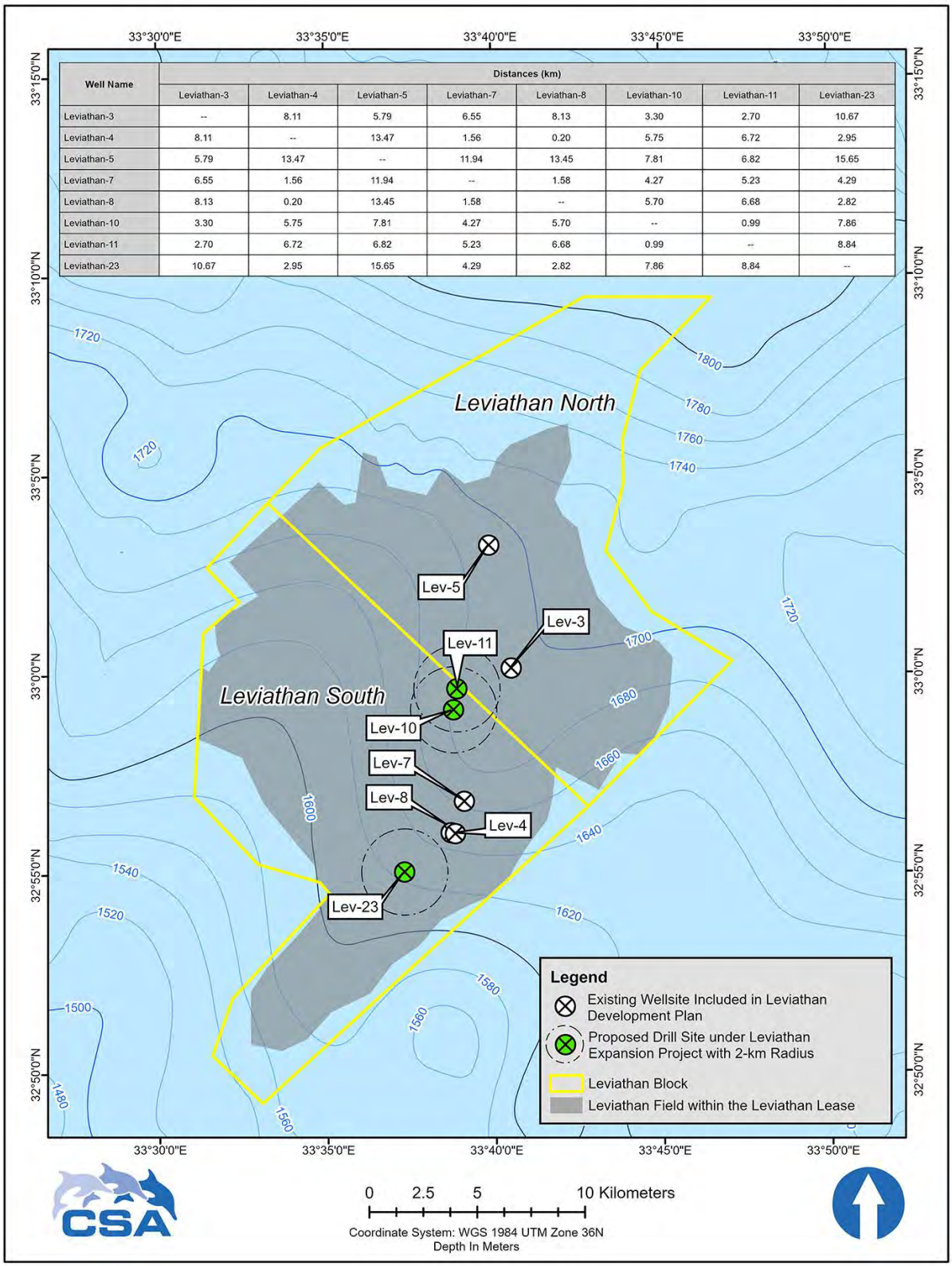


Figure 1-3. Locations of existing wellsites, proposed drill sites, and distances between wells in the Leviathan Field.

1.3 MAPS

Bathymetric and seafloor morphology maps for the proposed Leviathan-10, Leviathan-11, and Leviathan-23 drill sites are presented in **Figures 1-4** to **1-9**.

Key Findings:

- Bathymetric map showing the Leviathan Field, proposed drill sites, existing and proposed maritime boundaries, and shipping routes (**Figure 1-10**; 1:500,000 scale).
- Existing maritime infrastructure within the Application Area includes seven previously drilled wells (**Figure 1-11**; 1:250,000 scale).
- **Figures 1-12** and **1-13** are regional maps of the Leviathan Field.
- The Leviathan Field is located in the 1/15 North and 1/14 South lease areas. Coordinates for drill sites are listed in **Table 1-1** as well as distances from each drill sites to shore.

Figure 1-4. Bathymetry of the proposed Leviathan-10 well location.



Figure 1-5. Seafloor morphology of the proposed Leviathan-10 well location.

Figure 1-6. Bathymetry of the proposed Leviathan-11 well location.

Figure 1-7. Seafloor morphology of the proposed Leviathan-11 well location.

Figure 1-8. Bathymetry of the proposed Leviathan-23 well location.

Figure 1-9. Seafloor morphology of the proposed Leviathan-23 well location.

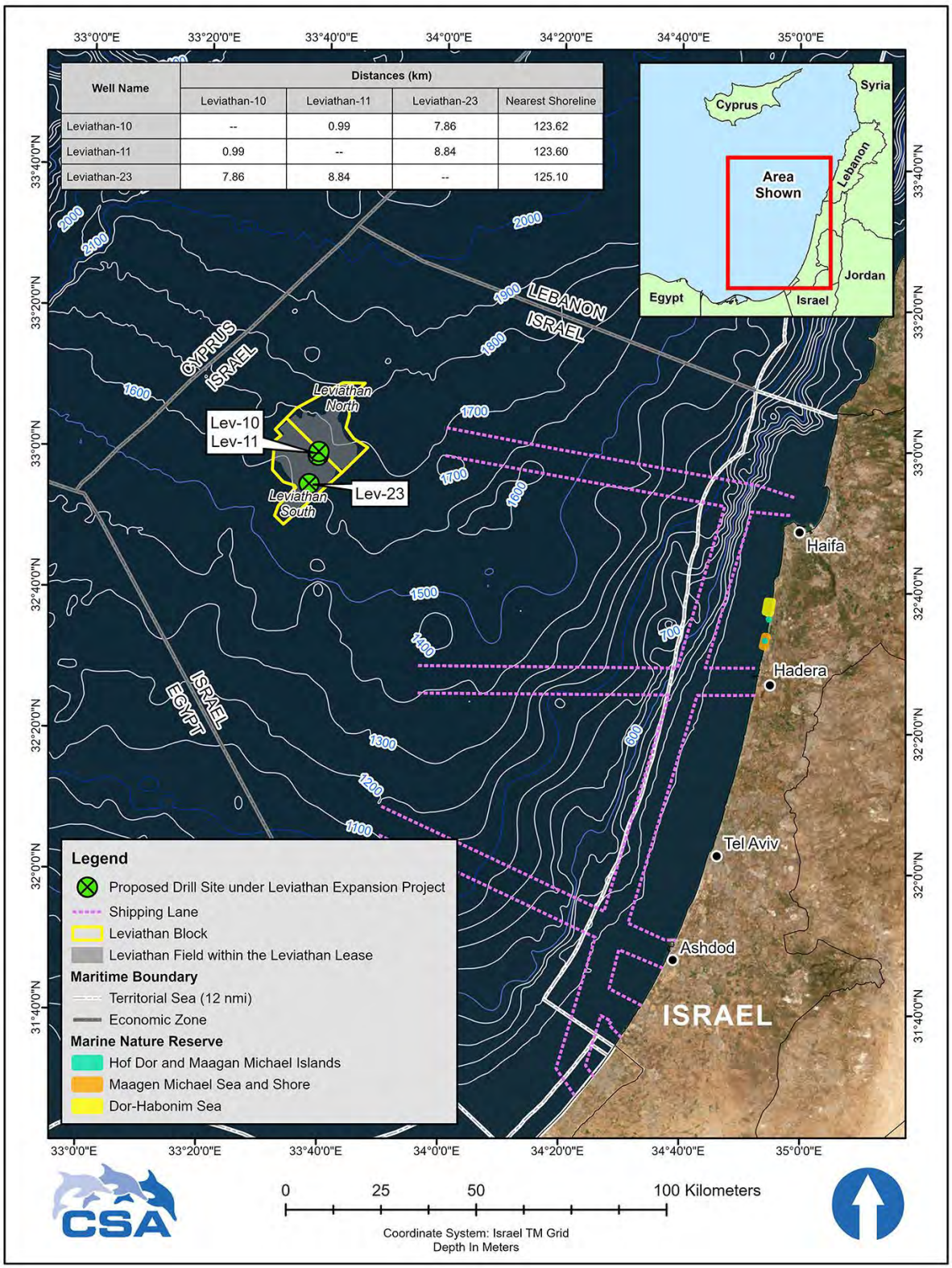


Figure 1-10. Bathymetric map showing the Leviathan Field and proposed drill site locations relative to regional maritime boundaries and shipping routes. Scale: 1:500,000.

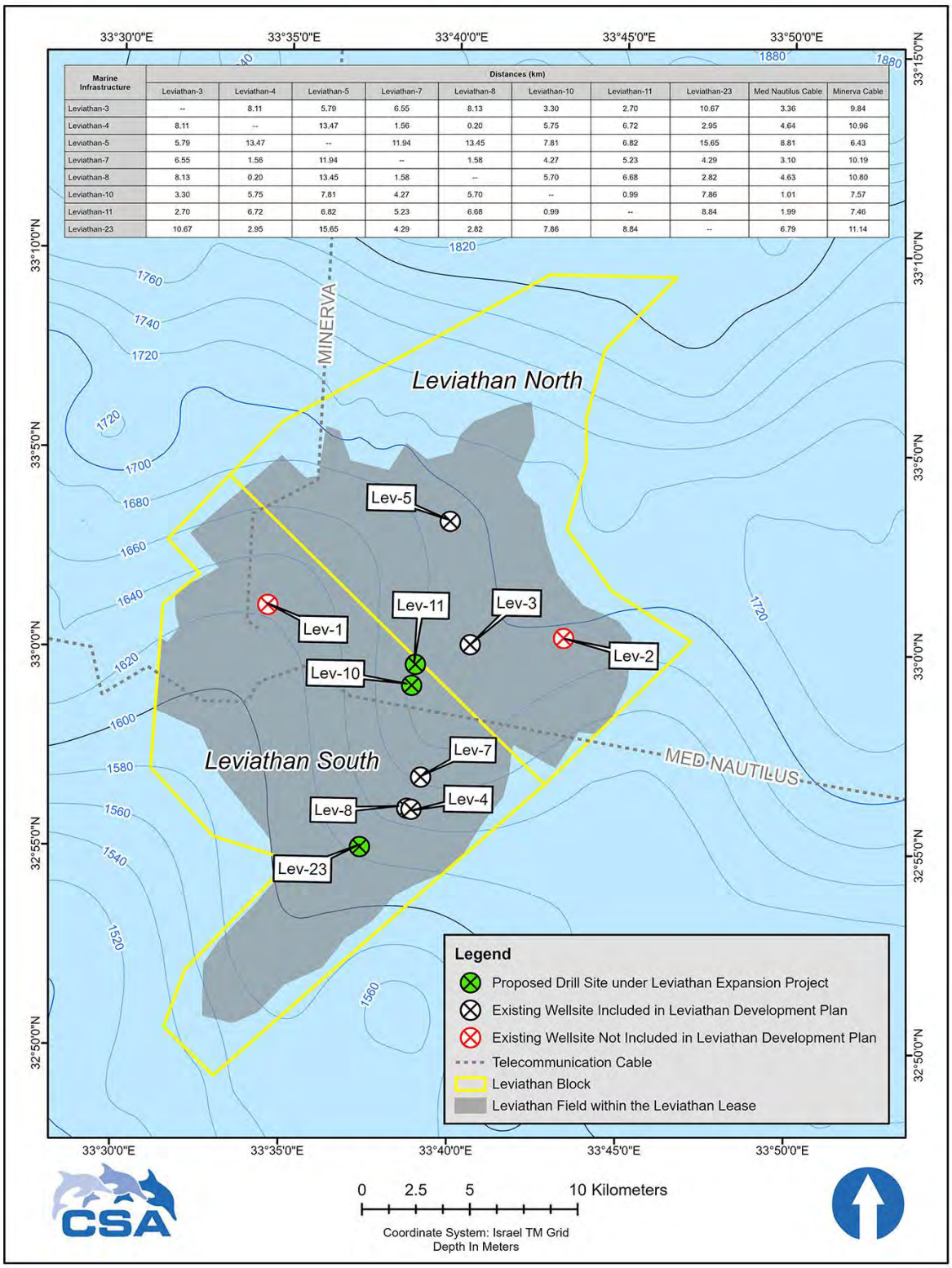


Figure 1-11. Locations of existing marine infrastructure (telecommunications cable and existing wellsites) and distances in relation to the three proposed drill sites in the Leviathan Expansion Project.

Figure 1-12. Bathymetric chart of the Leviathan Field including wells in the Leviathan Development Plan, as of 2016 (including originally proposed Leviathan-5 through Leviathan-10 drill sites, several of which were not drilled). Proposed wells under the Leviathan Expansion Project are not shown (Adapted from: Gardline Surveys Inc., 2015).

Figure 1-13. Seafloor morphology chart of the Leviathan Field (Adapted from: Gardline Surveys Inc., 2015).

Table 1-1. Water depth and coordinates of existing wellsites, and proposed drill sites under the Leviathan Expansion Project in the Leviathan Field and distances from each wellsite and drill site to the nearest shoreline, Rosh Carmel, Hadera, and submarine cables.

Well Name	Water Depth (m)	Coordinates (UTM)[a]	Distances (km)												
			Nearest Shoreline	Rosh Carmel	Hadera	Leviathan-3	Leviathan-4	Leviathan-5	Leviathan-7	Leviathan-8	Leviathan-10	Leviathan-11	Leviathan-23	Med Nautilus Cable	Minerva Cable
Leviathan-3	1,670		121.26	121.93	131.49	0	8.11	5.79	6.55	8.13	3.30	2.70	10.67	3.36	9.84
Leviathan-4	1,619		122.93	123.63	130.54	8.11	0	13.47	1.56	0.20	5.75	6.72	2.95	4.64	10.96
Leviathan-5	1,709		123.27	123.91	135.09	5.79	13.47	0	11.94	13.45	7.81	6.82	15.65	8.81	6.43
Leviathan-7	1,627		122.47	123.25	130.67	6.55	1.56	11.94	0	1.58	4.27	5.23	4.29	3.10	10.19
Leviathan-8	1,619		122.60	123.57	130.47	8.13	0.20	13.45	1.58	0	5.70	6.68	2.82	4.63	10.80
Leviathan-10	1,653		123.62	124.32	133.02	3.30	5.75	7.81	4.27	5.70	0	0.99	7.86	1.01	7.57
Leviathan-11	1,653		123.60	124.29	133.31	2.70	6.72	6.82	5.23	6.68	0.99	0	8.84	1.99	7.46
Leviathan-23	1,607		125.10	125.85	132.01	10.67	2.95	15.65	4.29	2.82	7.86	8.84	0	6.79	11.14

[a] Coordinates based on WGS84 Universal Transverse Mercator (UTM) Zone 36N.
[b] Distances were calculated using UTM coordinates.

Proposed Project:

- The three proposed drill sites lie within the 1/14 South lease (**Figure 1-11**; Leviathan South), the southern portion of the Leviathan Field.
- Several existing wells are found in the vicinity of the proposed wells: Lev-3, Lev-4, Lev-5, Lev-7, and Lev-8, all of which are production wells.

1.4 GEOLOGICAL, SEISMIC, AND SEDIMENTOLOGICAL CHARACTERISTICS

1.4.1 Bathymetry and Seafloor Morphology

1.4.2 Shallow Stratigraphy

1.4.3 Seismicity

1.4.4 Sediment Grain Size

CSA (2016) previously provided a description for Sediment Grain Size (see Section 1.4.6 of the 2016 document).

Key Findings:

- Seafloor sediment consists primarily of clay and silt, localized sand in active channels. Background Monitoring Survey video shows the presence of a smooth, flat seafloor around proposed drill sites, mainly consisting of clays and silts. No sand waves have been observed, indicating low current speeds at depth; no consolidated substrates were noted in the survey area.
- Sediment sampling has been conducted within 117 grid cells in the Leviathan Field. This includes 79 stations sampled during the Background Monitoring Survey, as well as stations sampled near the Leviathan-1, Leviathan 2, Leviathan 3, and Leviathan 4 wellsites (**Figure 1-16**). Lev-2 and Lev-4 samples, including post-drilling surveys, were analyzed for grain size, with other "sediment quality" parameters discussed in Section 1.8.2 of CSA (2016).
- Sediments collected within the Leviathan Field during both the 2014 and 2020 surveys (CSA Ocean Sciences Inc., 2019a,b) were composed predominately of very fine silt and clay. Sediments were classified (per the classification scheme of Shepard, 1954) mainly as silty-clay and a small fraction of sand/clay/silt. However, during the 2020 survey, several stations had slightly higher percentages of silt which classified them within the upper boundary of the clayey-silt designation (**Figure 1-17**).

Proposed Project:

- At Lev-3, sediment grain size structure was similar among sampling stations and classified as silty-clay or clayey-silt. Grain size data were similar compared to 2014 Leviathan Field Environmental Baseline Survey (EBS) data, including the Levantine Basin Baseline (LBB) average at the time of the 2014 Leviathan Field EBS. Thus, overall grain size structure in the vicinity of the Lev-3 wellsite has not changed substantially as a result of drilling activities (CSA Ocean Sciences Inc., 2019a).
- At Lev-7, the Post-Drill Survey results indicated the prevalence of silt (47.2% ± 11.9 [SD]) and clay (43.1% ± 9.6 [SD]), with a small fraction of sand (9.7% ± 4.6 [SD]). The grain size distribution among stations and the average grain size distribution among strata were generally similar throughout the Lev-7 Post-Drill Survey area. Exceptions to this were stations in the 25-m stratum which had much higher silt fractions in comparison to all other strata and thus were also classified mostly as silt (CSA Ocean Sciences Inc., 2019b).
- At Lev-8, grain size distribution varied between sampling depths and sampling distances. At the 25-, 50-, and 150-m sampling distances, the samples collected from the 0 to 4 cm depth sections had a higher content of silt than clay or sand and therefore received a Shepard classification of clayey-silt or sandy silt. These samples differed from the 2014 Leviathan Field EBS and LBB data which had higher content of clay and received a Shepard classification of silty-clay. The samples taken from deeper sections of the seabed (i.e., 4-8, 8-12, 12-16 cm) throughout the 25-, 50-, and 150-m sampling distances displayed closer resemblance to the 2014 Leviathan Field EBS and LBB data, as their clay content was higher than that found in the upper layer of sediment. These findings indicate that the differences in grain size distribution in upper sediments (e.g., surficial or near surficial sediment layers) were likely affected by the drilling activities and were most discernable in the superficial section of the seabed (i.e., were not present in the deeper sediment sections) (CSA Ocean Sciences Inc., 2023).

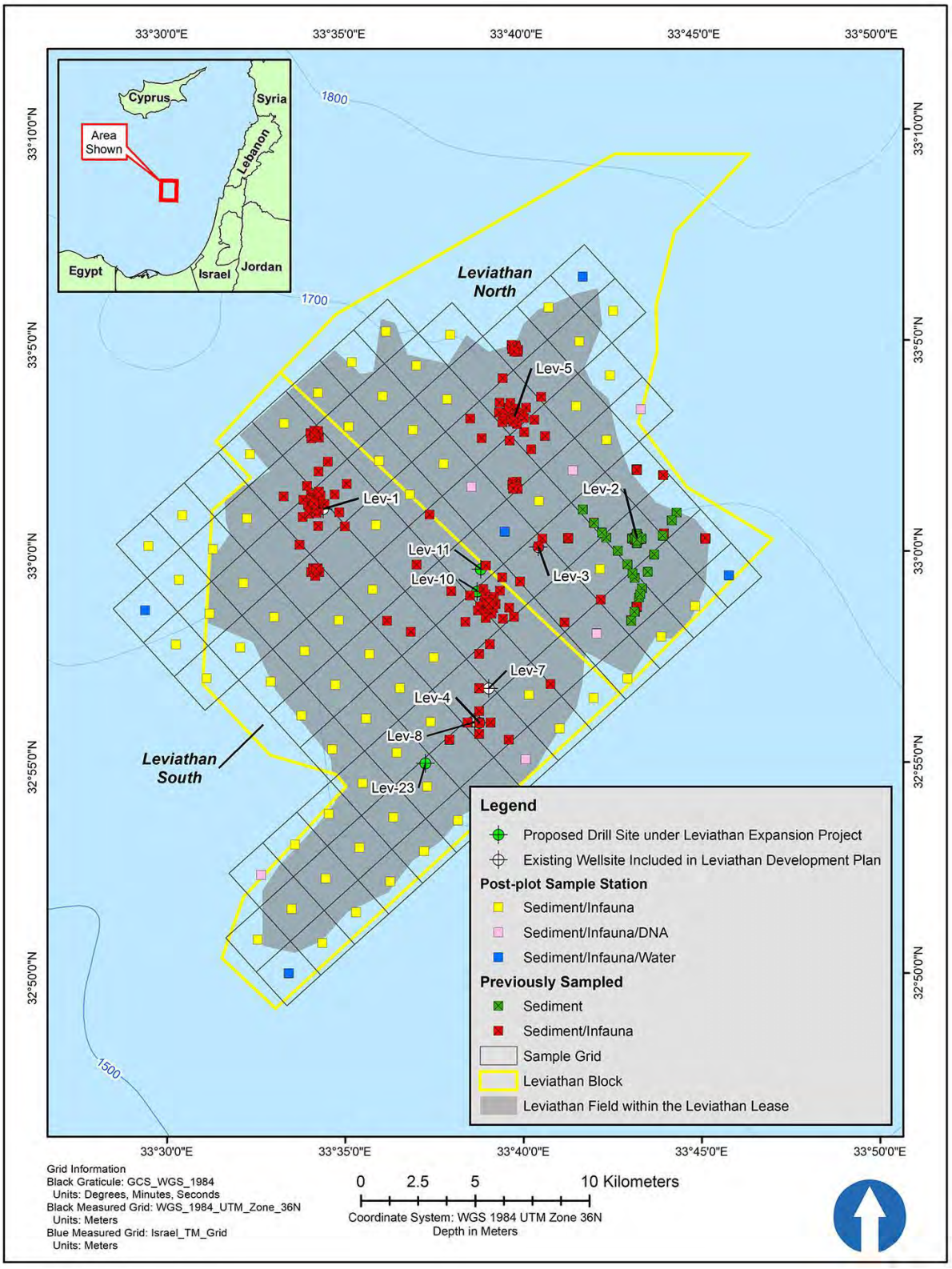


Figure 1-16. Sampling stations within the Leviathan Field, including stations sampled during the Background Monitoring Survey, including previously drilled wellsites and proposed drill sites.

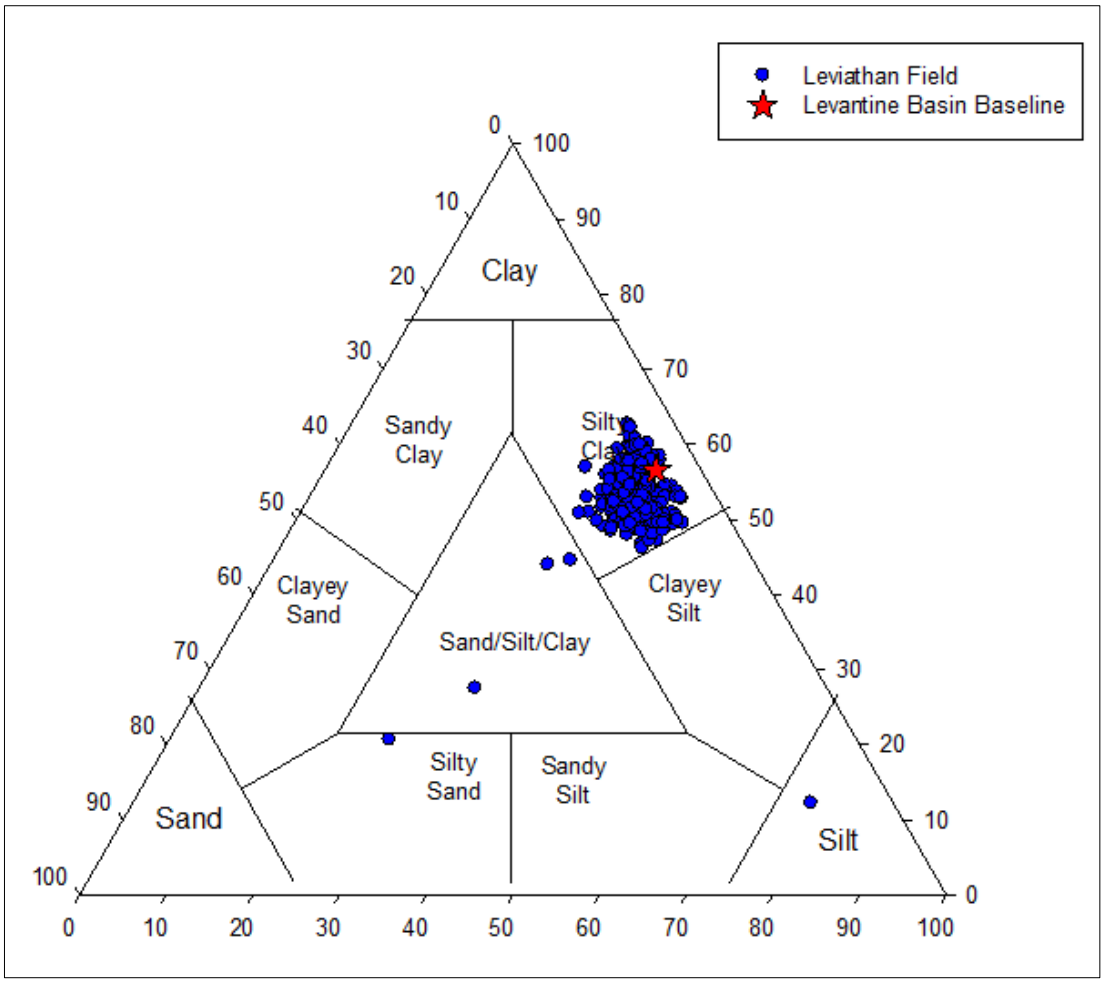


Figure 1-17. Particle size classifications (based on Shepard, 1954) for representative sediment samples collected within the Leviathan Field relative to the Levantine Basin Baseline (mean of pre-drilling samples from the region).

1.4.5 Geologic Setting

CSA (2016) and Genesis (2016) previously provided a description of the Geologic Setting for the Leviathan Field (see Section 1.4.1 of the CSA [2016] document and Section 1.4.3.1 of the Genesis [2016] document).

Key Findings:

- The Eastern Mediterranean region's geological history, shaped by interactions among the African, Arabian, and Eurasian plates, is characterized by the dominant collision of the Arabian and African plates with the Anatolian plate (Dilek and Sandvol, 2009; Özbakir et al., 2010).
- **Levant Margin**: Particularly its southern flank, has focused on the mechanisms for the formation of the Levantine Basin with north-trending normal faults as the primary mechanism, differing from other reports' suggestion of oceanic crust (Makris et al., 1983).
- **Levantine Basin**: Consists of faulted blocks, forming a basin with horst and graben topography covered by 10 to 15 km of sediments. The current model proposes that basin formation occurred through intercontinental rifting without seafloor spreading, resulting in sediment composition variations, including shallow-water clastics and carbonates, turbidites, pelagic carbonates with shales, and basin floor sediments mainly composed of shales and distal turbidites (Abdel Aal et al., 2001; Garfunkel, 2004).

- **Nile Cone:** A major sediment source for the Levantine Basin, exhibits increased thicknesses up to 10 km, including 1.5 km of Messinian evaporites; Post-Messinian sediments undergo significant thin-skin deformation due to downslope movement along slip surfaces in the underlying evaporites (Mascle et al., 2006).
- **Messinian Salinity Crisis:** A unique event in the last 20 million years, caused partial desiccation of the Mediterranean Sea around 5.3 to 6 million years ago, resulting in widespread evaporation sequences; this periodic restriction of seawater inflow from the Atlantic Ocean led to hypersalinity, gypsum deposition in shallow areas, and halite in deep basins, influencing hydrocarbon accumulations through the creation of a potential top seal. The event caused a sea level drop of up to 1,500 m, triggering significant erosion, including canyon formation, and the deposition of coarse sediments that form excellent reservoir rocks (Hsü et al., 1973).
- **Continental Slope:** The lower continental slope near the study area features the Dor disturbances, identified as disturbed areas with mass slumping in a zone of diapirs and associated with Messinian drainage systems, including offshore canyons that serve as conduits for material transport from the shelf into the basin; these canyons were incised during the Oligocene and Miocene through the Messinian, partly reflected in contemporary submarine features (Gardosh et al., 2008).

Proposed Project:
- Existing information presented in CSA (2016) and Genesis (2016) is sufficient for assessment purposes.

1.5 GEOHAZARDS

CSA (2016) and Genesis (2016) previously provided a discussion for Geohazards (see Section 1.4.4 of the CSA [2016] document and Section 1.4.3.4 of the Genesis [2016] document). The Geologic Survey of Israel (2023) did not identify any geohazards in the vicinity of the Leviathan Field that would be a geological risk to drilling or emplacement of subsea infrastructure.

Key Findings:
- Seafloor drainage channels, strike-slip faults, fault-induced ridges, and the fault complex in the west are areas considered unsuitable for future well locations or seafloor infrastructure (Gardline Surveys Inc., 2010).
- Sandy interbeds and fault intersections in Unit A may cause problems with jetting of seafloor casing and wellbore instability.
- Sandy interbeds and fault intersections in Unit B may create minor risk of drilling fluid circulation and wellbore stability problems.
- Thin clastic interbeds and fault intersections in Unit C may cause minor drilling fluid circulation and wellbore stability problems. These sandy interbeds within Unit C are comprised of mud with minor amounts of sand. However, other wells have contacted similar interbeds with no reported problems.
- Consideration of sub-seafloor faults should be given to all proposed well locations. Wells should be designed to avoid setting casing seats at the level of fault intersections to avoid problems with well integrity.

Proposed Project:
- For the Lev-10 drill site, key findings from the well clearance report included:
    - The nearest sonar contact (T0938) occurred 138 m to the east of the proposed well location, interpreted as a geotechnical location and not expected to impact drilling operations;
    - Sonar contact (T0903) occurred 1,744 m to the southwest of the proposed well location and was identified as an amphora with a visual inspection; this contact should be avoided;
    - Numerous umbilicals, flowlines, and a subsea manifold are present within the study area that supports the field and are integral to field operations; CML is aware of the condition and placement of all infrastructure in the field;

- The MedNautilus-1 cable that makes landfall in Haifa is present 1,010 m SSE of the proposed well location trending WNW/ESE; if any anchors are to be used during the Leviathan Expansion Project, CML should consider avoidance of the possible over consolidated seabed regions, especially associated with the crest of the ridge to the east of location, where anchor embedment maybe limited; and
- A high resolution AUV survey identified 21 sonar targets within a 2,000 m radius of the proposed well location.

- For the Lev-11 drill site, key findings from the well clearance report included:
  - The nearest sonar contact (T0938) occurred 954 m to the south of the proposed well location, interpreted as a geotechnical location and not expected to impact drilling operations;
  - There are numerous umbilicals, flowlines, and a subsea manifold within the study area that supports the field and is integral to field operations; CML is aware of the condition and placement of all infrastructure in the field;
  - Anchor placement, if required, should consider avoidance of the possible over consolidated seabed regions, especially associated with the crest of the ridge to the northeast of the well location, where anchor embedment maybe limited; and
  - A high resolution AUV survey identified 17 sonar targets within a 2,000 m radius of the proposed well location.
- For the Lev-23 drill site, key findings from the well clearance report included:
  - The nearest sonar contact (T1023) occurred 921 m to the ENE of the proposed well location and was interpreted as possible debris;
  - There is no existing infrastructure within 2,000 m;
  - Anchor placement, if required, should consider avoidance of the possible over consolidated seabed regions, especially associated with the crest of the ridge to the southeast of the well location, where anchor embedment maybe limited; and
  - Two previous high resolution AUV surveys identified 8 sonar targets within a 2,000 m radius of the proposed well location.
- No seabed channels are found along the IFL-10 or IFL-11 infield flowline corridors; two seabed low-relief channels were identified along the IFL-23 infield flowline.
- No seabed faults are present along the IFL-11 infield flowline route. A 2 m surface expression of a transverse fault crosses the IFL-10 and IFL-23 infield flowline routes.
- The Dead Sea Transform (DST) fault system is the primary geological fault between the Arabian and African tectonic plates.
- Slope characteristics are discussed in CSA (2016), Geologic Setting (see Sections 1.4.1 and 4.3.4, including Table 4-7).

1.6 HYDRODYNAMIC REGIME (PHYSICAL OCEANOGRAPHY)

1.6.1 Waves

CSA (2016) previously provided a description for Waves (station location: 33°02’ N, 33°51’ E); see Section 1.5.1 of the 2016 document.

Key Findings:

- Wave data acquired between July 2011 to April 2014 is divided into eight time periods, as presented in CSA (2016), **Table 1-2**, and summarized below (Mudge and Lawrence, 2014):
  - July to November 2011: Significant wave heights between 0.4 and 1.2 m and periods between 4 and 9 s. The largest waves occurred in October (2.9 m). Maximum wave height was almost (6 m), and the peak period ranged from 10 to 12 s.
  - November 2011 to February 2012: Significant wave heights between 0.5 and 2.0 m and periods between 3 and 9 s. The largest waves occurred in January (6.0 m). Maximum wave height (11.6 m), and the peak period ranged from 10 to 12.4 s.

- February to May 2012: Significant wave heights between 0.5 and 1.5 m and periods between 4 and 7 s. The largest waves occurred in February (6.1 m). The largest maximum wave height (12.0 m) and the peak period ranged from 10 to 12.4 s.
- May to August 2012: Significant wave heights between 0.4 and 1.2 m and periods between 3 and 8 s. The largest waves reached just less than 1.5 m with a peak period of 9 s.
- August 2012 to January 2013: 27% of the waves observed had significant wave heights exceeding 1.0 m and more than 80% had periods between 3 and 8 s. Four wave events had significant wave heights exceeding 4.0 m and the largest event had a significant wave height of 6.2 m and a peak period of 10.5 s.
- January to May 2013: 48% of the waves observed had significant wave heights exceeding 1.0 m and 49% had periods between 4 and 7 s. Six wave events had significant wave heights exceeding 3.0 m and the largest event had a significant wave height of 4.1 m and a period of 9.5 s.
- May to October 2013: 41% of the waves observed had significant wave heights exceeding 1.0 m and less than 1% had periods exceeding 9 s. Three wave events had significant wave heights exceeding 2.0 m and the two largest events had significant wave heights of 2.4 m and 2.3 m with peak periods of 7.7 s and 8.7 s, respectively.
- October 2013 to April 2014: 37% of the waves observed had significant wave heights exceeding 1.0 m. Three wave events had significant wave heights exceeding 4.0 m (5.0 m, 4.6 m, and 4.1 m) with peak periods of 9.5 s, 9.5 s, and 10.0 s, respectively.

- While wave height and direction vary daily across the Levantine Basin, these yearly statistics can be regarded as representative values spatially and temporally for the entire basin (**Figure 1-18**).
- **Table 1-3** presents significant wave height distribution for a point near the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) MedGoos 3 buoy (33°42’ N, 32°08’ E) between July 2005 and February 2008.

Proposed Project:

- Throughout the water column, water temperature, salinity, and dissolved oxygen values were nearly identical in 2020 as compared to those recorded during the 2014 Survey (Marine Ventures International Inc., 2021b).
- Turbidity was consistently very low throughout the water column, similar to values observed during the 2014 Survey, ranging from 0.08 nephelometric turbidity units (NTU) in surface waters to approximately 0.06 NTU near the bottom. By comparison, 2014 values ranged from 0.03 to 0.19 NTU.

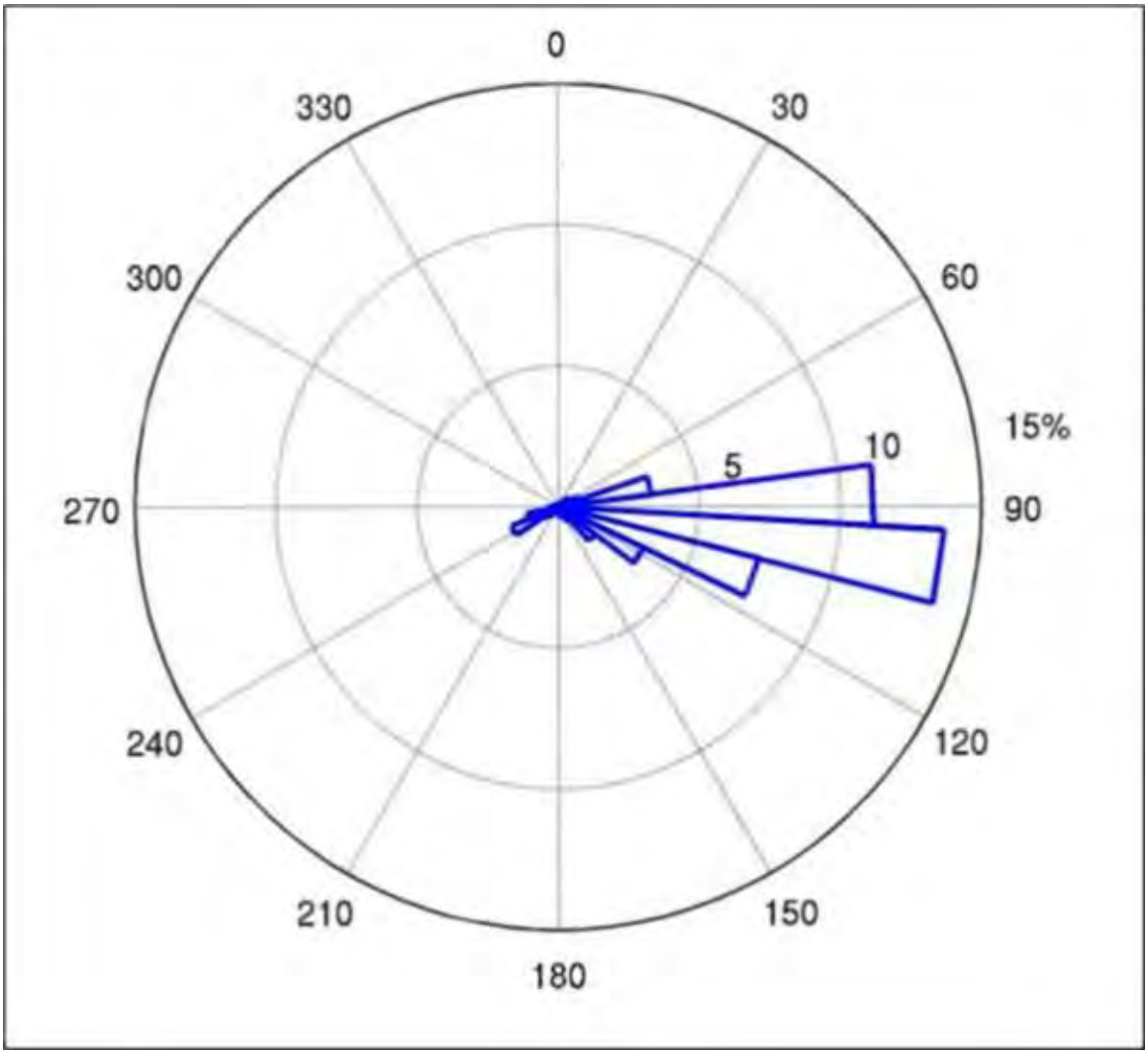


Figure 1-18. Rose diagram for annual frequency of wave direction per 10° sector across the Levantine Basin based on data from the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) MedGoos 3 buoy (33°42’ N, 32°08’ E). The 5, 10, and 15% concentric circles refer to the percentage of waves within each 10° sector.

Table 1-2. Exceedance of significant wave heights for Site LV1-1[a] in the Leviathan Field for eight periods from 26 July 2011 to 17 April 2014.

Significant Wave Height (m)	Exceedance		Exceedance		Exceedance		Exceedance		Exceedance		Exceedance		Exceedance		Exceedance	
	July-Nov 2011		Nov 2011-Feb 2012		Feb-May 2012		May-Aug 2012		Aug 2012-Jan 2013		Jan-Jun 2013		Jun-Oct 2013		Oct 2013-Apr 2014	
	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves	No. of Waves	Percent of Waves
0	2,420	100	1,913	100	2,539	100	2,197	100	3,288	100	3,287	100	2,920	100	4,294	100
0.25	2,418	99.9	1,913	100	2,466	97.12	2,197	100	3,262	99.21	3,220	97.96	2,920	100	4,225	98.39
0.5	2,125	87.8	1,856	97.02	1,949	76.76	1,896	86.3	2,671	81.23	2,752	83.72	2,755	94.35	3,395	79.06
0.75	1,206	49.8	1,526	79.77	1,406	55.38	999	45.47	1,597	48.57	2,164	65.84	2,122	72.67	2,323	54.1
1	491	20.3	1,182	61.79	992	39.07	314	14.29	908	27.62	1,568	47.7	1,189	40.72	1,593	37.1
1.25	195	8.1	1,035	54.1	740	29.15	33	1.5	612	18.61	1,159	35.26	559	19.14	1,014	23.61
1.5	112	4.6	888	46.42	584	23	0	0	504	15.33	839	25.52	238	8.15	680	15.84
1.75	64	2.6	689	36.02	501	19.73	0	0	410	12.47	544	16.55	100	3.42	482	11.22
2	32	1.3	538	28.12	426	16.78	0	0	325	9.88	356	10.83	31	1.06	304	7.08
2.25	16	0.7	438	22.9	365	14.38	--	--	289	8.79	215	6.54	7	0.24	177	4.12
2.5	11	0.5	362	18.92	314	12.37	--	--	251	7.63	143	4.35	0	0	110	2.56
2.75	5	0.2	294	15.37	244	9.61	--	--	223	6.78	87	2.65	0	0	85	1.98
3	0	0	231	12.08	182	7.17	--	--	182	5.54	50	1.52	0	0	64	1.49
3.25	--	--	174	9.1	128	5.04	--	--	160	4.87	29	0.88	--	--	50	1.16
3.5	--	--	110	5.75	99	3.9	--	--	131	3.98	17	0.52	--	--	42	0.98
3.75	--	--	66	3.45	86	3.39	--	--	94	2.86	11	0.33	--	--	35	0.82
4	--	--	36	1.88	67	2.64	--	--	77	2.34	2	0.06	--	--	25	0.58
4.25	--	--	22	1.15	57	2.24	--	--	50	1.52	0	0	--	--	11	0.26
4.5	--	--	18	0.94	48	1.89	--	--	37	1.13	0	0	--	--	8	0.19
4.75	--	--	10	0.52	38	1.5	--	--	26	0.79	0	0	--	--	3	0.07
5	--	--	9	0.47	33	1.3	--	--	17	0.52	0	0	--	--	0	0
5.25	--	--	9	0.47	24	0.95	--	--	11	0.33	--	--	--	--	--	--
5.5	--	--	6	0.31	19	0.75	--	--	8	0.24	--	--	--	--	--	--
5.75	--	--	3	0.16	12	0.47	--	--	7	0.21	--	--	--	--	--	--
6	--	--	1	0.05	6	0.24	--	--	5	0.15	--	--	--	--	--	--
6.25	--	--	0	0	1	0.04	--	--	2	0.06	--	--	--	--	--	--
6.5	--	--	--	--	0	0	--	--	0	0	--	--	--	--	--	--
6.75	--	--	--	--	0	0	--	--	--	--	--	--	--	--	--	--
7	--	--	--	--	0	0	--	--	--	--	--	--	--	--	--	--

[a] Coordinates of the LV1-1 mooring: 33°01.838’ N, 33°51.447’ E.
-- indicates no waves exceeded the given significant wave height.

Table 1-3. Significant wave heights and their frequency of occurrence in the Levantine Basin during the period from July 2005 to February 2008 based on data from the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) MedGoos-3 buoy (33°42' N, 32°08' E).

Wave Height Range[1] (m)	Frequency (Occurrences over Period of Record)	Percent
0 to 0.25	91	1.52
0.5	1,132	18.95
0.75	2,183	36.54
1	1,388	23.23
1.25	565	9.46
1.5	261	4.37
1.75	140	2.34
2	69	1.15
2.25	52	0.87
2.5	21	0.35
2.75	14	0.23
3	10	0.17
3.25	11	0.18
3.5	4	0.07
3.75	7	0.12
4	11	0.18
4.25	9	0.15
4.5	6	0.1
4.75	1	0.02
Total	5,975	100

[1] Upper limit of bin.

1.6.2 Extreme Storms

CSA (2016) previously provided a discussion for Extreme Storms (see Section 1.5.2 of the 2016 document).

Key Findings:

- The Eastern Mediterranean region lies between the subtropics and mid-latitudes, and cyclones that develop in this area obtain significant energy from both baroclinicity and surface fluxes (Flocas et al., 2010, 2011) (**Figure 1-19**).
- Storm tracks are most numerous from December to April, then decrease during the warm period, with a tendency to increase again in October.
- January held the highest cyclonic tracks (11.2% of annual total), with the minimum number evident in July (5.3%).
- Winter is dominated by interconnected succession of Red Sea Trough, Winter Lows, Polar Cyclones and Siberian and Mediterranean subtropical anticyclones. Withdrawal of the Red Sea Trough for 5 to 7 months of the year affects large scale succession of temporary cyclone systems (Mandel et al., 2006).
- Summer is dominated by the Persian Trough bringing with it subtropical anticyclones dominating at upper levels (Alpert and Ziv, 1989).

Proposed Project:

- Existing information presented in CSA (2016) is deemed sufficient for assessment purposes.

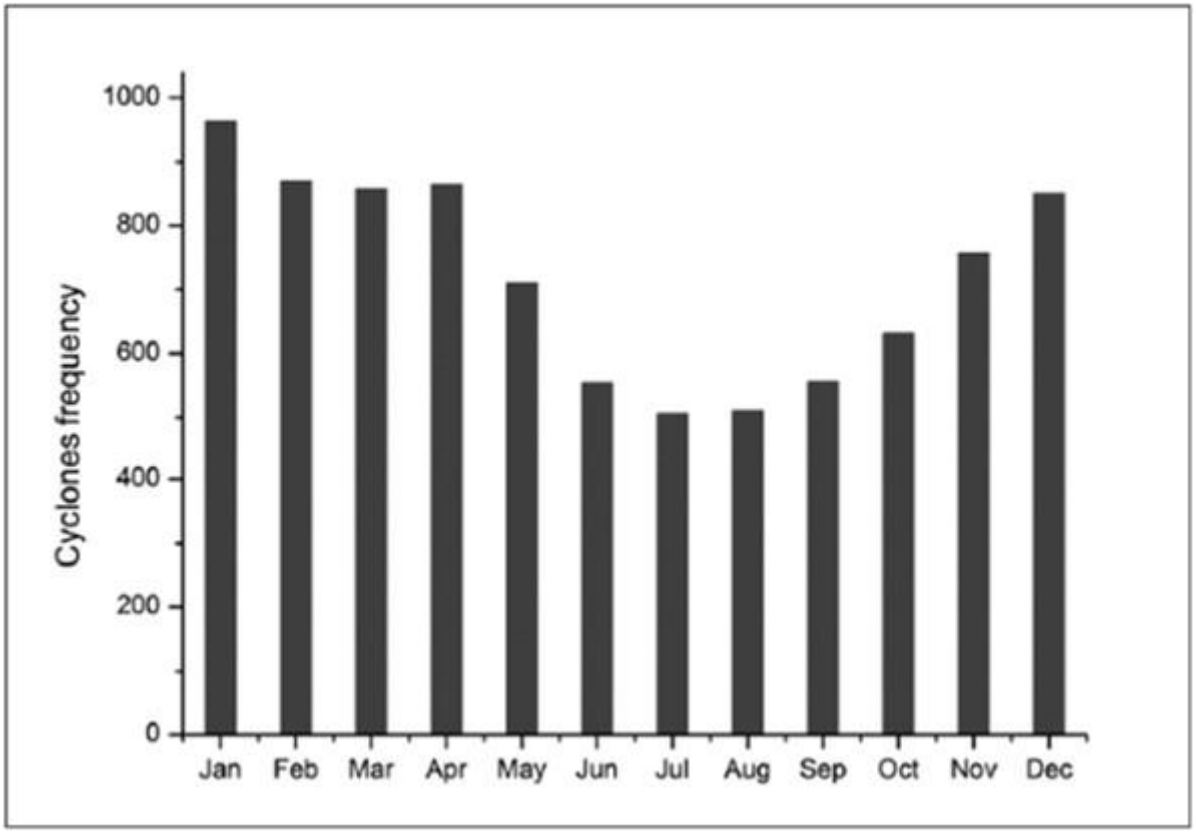


Figure 1-19. Mean annual cycle of the number of storm tracks that passed through the eastern Mediterranean, 1962 to 2001 (From: Flocas et al., 2011).

1.6.3 Currents

CSA (2016) previously provided a discussion of Currents (see Section 1.5.3 of the 2016 document).

Key Findings:

- The Mediterranean Sea comprises three main water masses, per Zavattarelli et al. (1995):
  - The upper layer, called Modified Atlantic Water (MAW), moves east to west, exhibits a thickness of 50 to 200 m, and salinity values that change from 36.2 practical salinity units (PSU) near Gibraltar to 38.6 PSU in the Levantine Basin.
  - The intermediate layer, called Levantine Intermediate Water (LIW), is formed in the Levantine Basin and moves east to west. LIW occurs at water depths between 200 and 800 m, and exhibits temperatures of 13°C to 15.5°C and salinity of 38.4 to 39.1 PSU.
  - The deep water layer, called Mediterranean Deep Water (MDW), moves from west to east. The Eastern Mediterranean Deep Water (EMDW) is characterized by a temperature of 13.6°C and salinity of 38.7 PSU.
- MAW is seasonally warmed or cooled, but overall its salt content increases and it becomes denser. This water mass remains at the surface in autumn, while in in winter it experiences an increased density due to the passage of cold and dry air masses which induce evaporation, causing it to sink. Sinking generally occurs in the northern parts of the region.
- Surface currents vary seasonally with wind-stress curl, transitioning from cyclonic in winter to anticyclonic in summer. Baroclinicity reduces strong seasonality, and Levantine Basin currents are influenced by thermohaline fluxes (Malanotte-Rizzoli and Bergamasco, 1991).
- **Table 1-4** summarizes the minimum and maximum current speeds at the ALS Environmental Sciences Inc. station for the period between January 2013 and April 2014.
- **Figures 1-20** through **1-22** present compass rose plots of the directional distribution of currents at different depths from January to June 2013.

- January to June 2013: Currents were strongest in the upper 44 m of the water column with a maximum observed current speed of 60.7 cm/s at 11 m depth. The mean current at 11 m depth was 21.8 cm/s, and the mean decreased with depth to less than 10 cm/s at 200 m and below (Rohling et al., 2009).
- June to October 2013: Currents were strongest in the upper 38 m of the water column with a maximum observed current speed of 50.9 cm/s at 10 m depth. Maximum current decreased with depth in the water column until the near-bottom, which had a maximum slightly higher than the 1,450 m depth of 10.0 cm/s (Rohling et al., 2009).
- October 2013 to April 2014: Currents were strongest in the upper 42 m of the water column with a maximum observed current speed of 41.8 cm/s at 10 m depth. The maximum current decreased with depth in the water column until the near-bottom, which had a maximum slightly higher than the 1,450-m depth of 11.8 cm/s (Rohling et al., 2009).

Proposed Project:

- Existing information presented in CSA (2016) is deemed sufficient for assessment purposes.

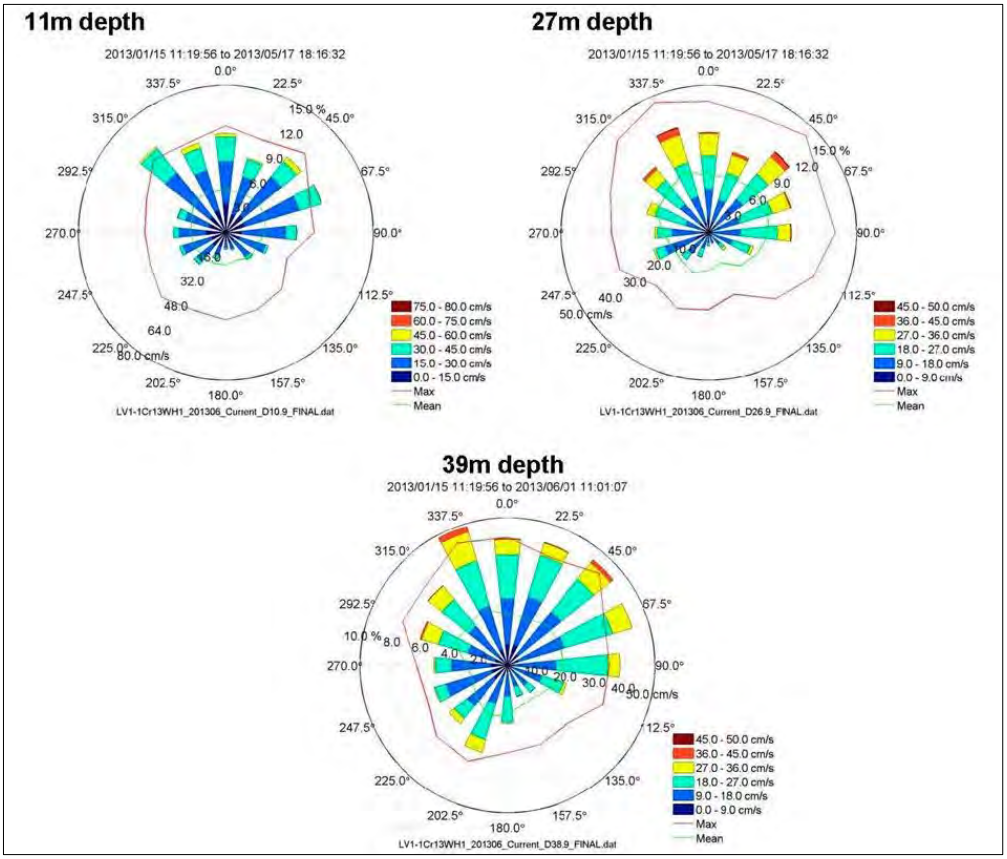


Figure 1-20. Compass rose plots of the directional distribution of currents at depths of 11 m, 27 m, and 39 m at Site LV1-1 (January to June 2013).

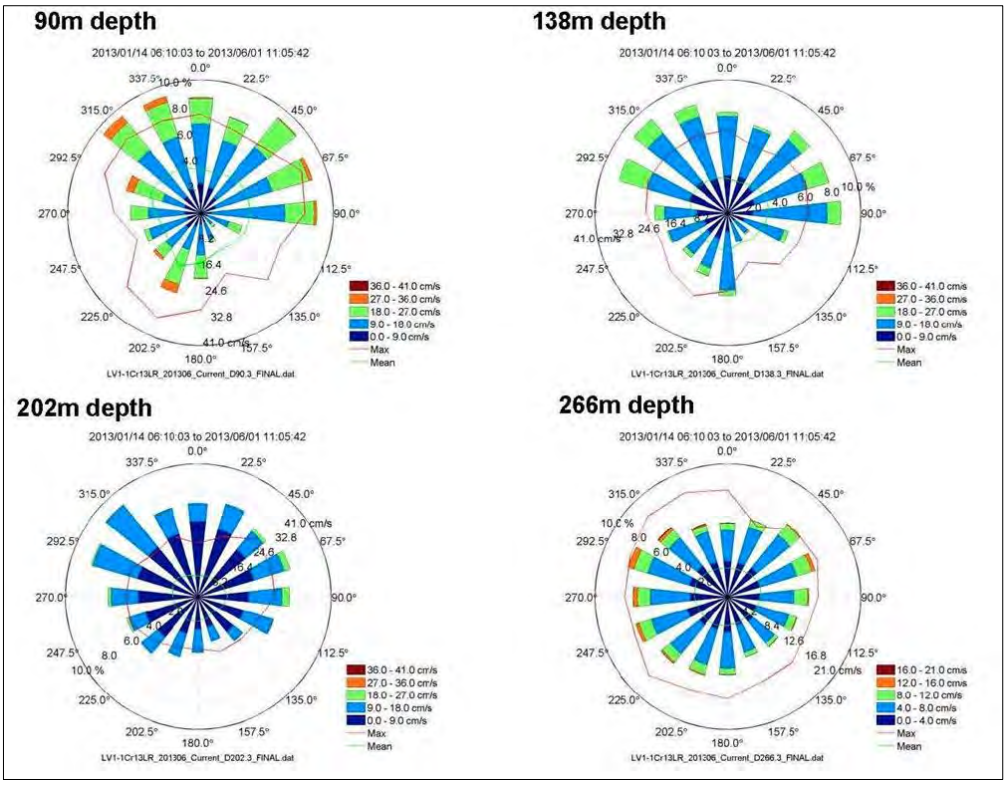


Figure 1-21. Compass rose plots of the directional distribution of currents at depths of 90 m, 138 m, 202 m, and 266 m at Site LV1-1 (January to June 2013).

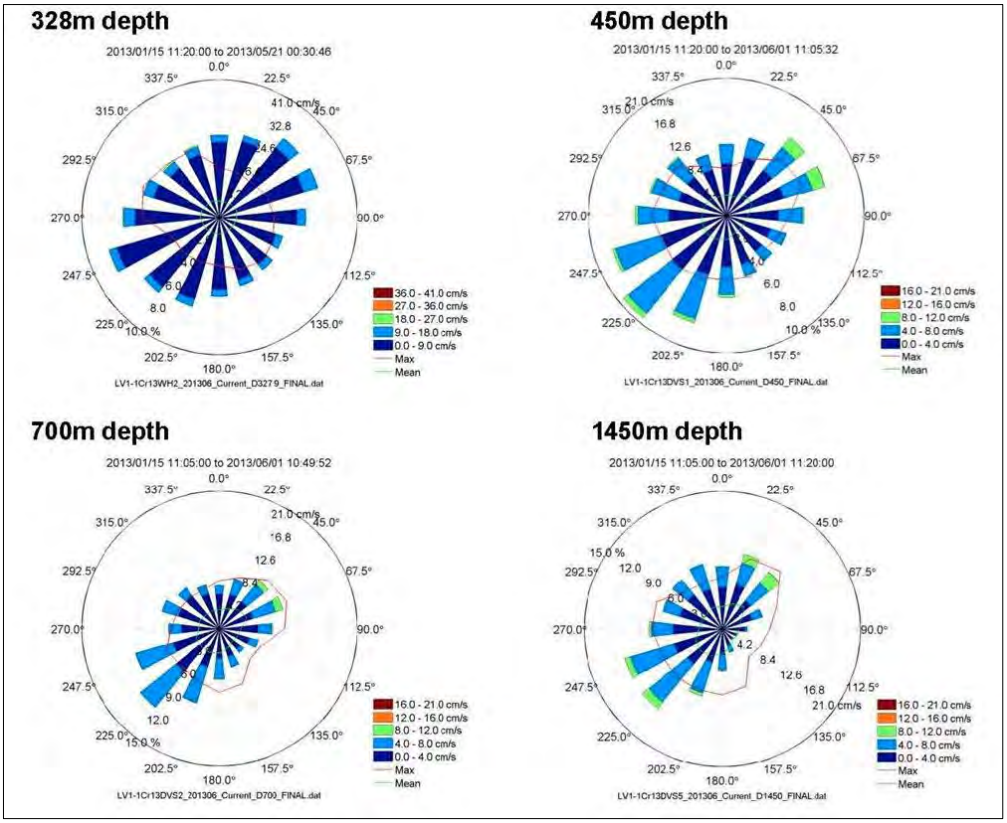


Figure 1-22. Compass rose plots of the directional distribution of currents at depths of 328 m, 450 m, 700 m, and 1,450 m at Site LV1-1 (January to June 2013).

Table 1-4. Summary of mean and maximum current speeds (cm s^{-1}) at the LV1-1[a] station in the Leviathan Field from January 2013 to April 2014.

Depth (m)	January to June 2013		June to October 2013		October 2013 to April 2014	
	Mean Current Speed	Maximum Current Speed	Mean Current Speed	Maximum Current Speed	Mean Current Speed	Maximum Current Speed
11	21.8	60.7	13.2	50.9	11.7	41.8
27	19	47.8	11.3	45.1	11.3	40.1
39	17.7	44.7	10.2	42.6	10.2	33.6
90	14.9	35	7.3	22.1	8.5	28.4
138	11.6	27.6	5.5	17.8	6.8	22.1
202	7.7	25.2	4.6	16.4	5.9	19
266	5	17.9	3.1	11.2	4.4	14.3
328	5.2	24.4	2.7	9.8	3.6	12.8
450	3.6	12.5	2.6	8.6	2.6	10
700	3.5	11.1	2	5.9	2	8.5
1,450	3.8	12.5	2	6.9	2.4	9.3

[a] Coordinates of the LV1-1 mooring located at 33°01.838’ N, 33°51.447’ E.

1.6.4 Winds

CSA (2016) previously provided a discussion for Winds (see Section 1.5.4 of the 2016 document).

Key Findings:

- The general wind direction is westerly during winter with a stronger northerly component during late summer (Pinardi and Masetti, 2000).
- There is no known wind dataset specific to the Leviathan Field area.
- In the absence of localized data, The National Center for Environmental Predictions (NCEP) Environmental Modeling Center Regional Spectral Model provided by the U.S. National Oceanic and Atmospheric Administration – Cooperative Institute for Research in Environmental Studies (NOAA – CIRES) was assessed.
- **Figure 1-23** (taken from Figure 1-24 of CSA, 2016) shows wind speed and direction data from the NCEP model grid location closest to the Leviathan Field, as obtained from the Climate Diagnostics Center data server for the 10-year period from January 1999 to January 2009 as representative.

Proposed Project:

- Existing information presented in CSA (2016) is deemed sufficient for assessment purposes.

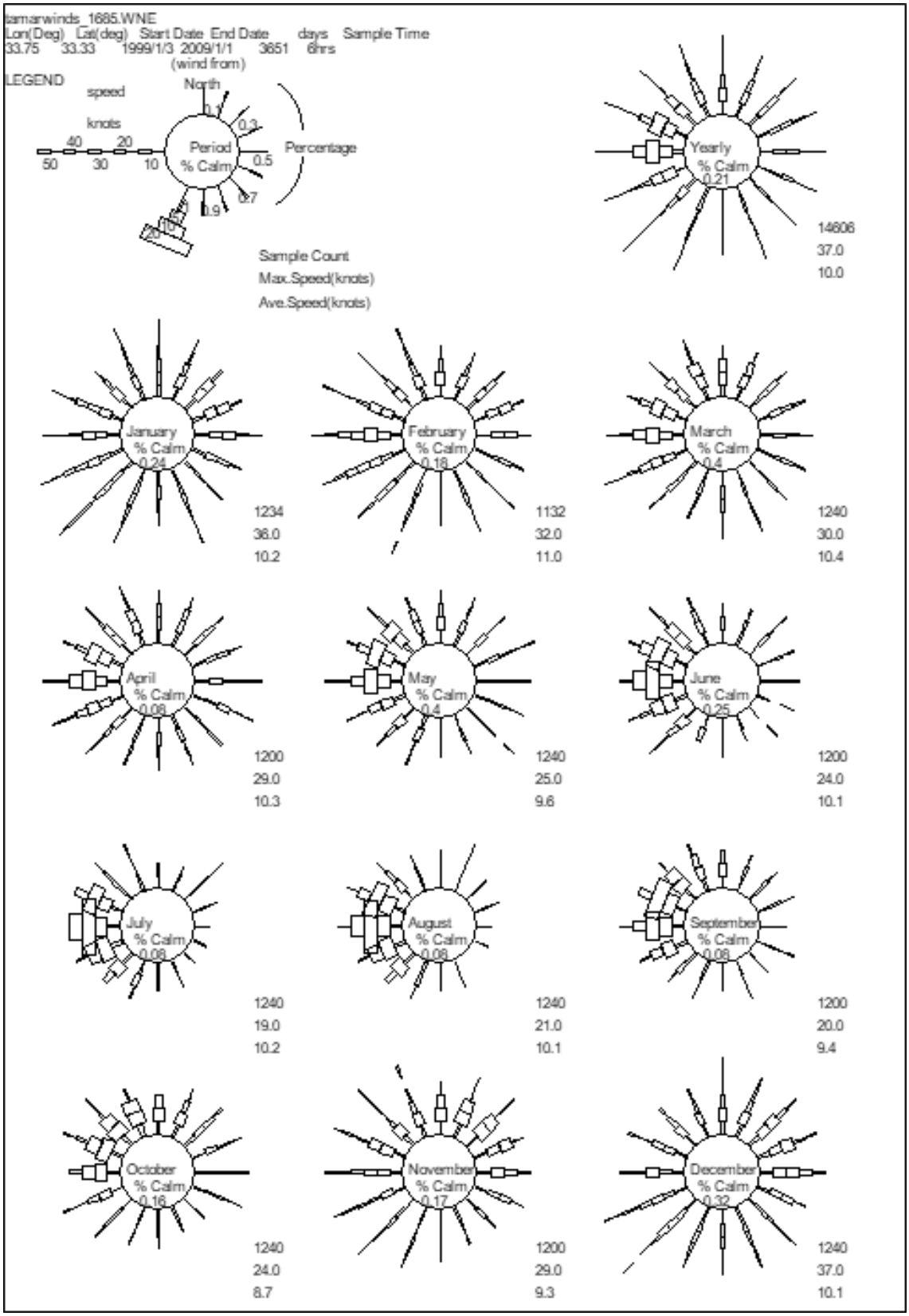


Figure 1-23. Monthly and yearly wind roses of National Center for Environmental Predictions Wind Station 1685, January 1999 through January 2009.

1.6.5 Wind Regime

The statistical distribution of the wind regime in the eastern Mediterranean is reflected in **Figure 1-23** showing wind speed and direction data from the NCEP model grid location closest to the Leviathan Field, as obtained from the Climate Diagnostics Center data server for the 10-year period from January 1999 to January 2009 as representative. The frequency of wind direction, wind intensity (including gusts), seasonal influences, and extreme wind conditions are provided.

1.7 NATURE AND ECOLOGY

1.7.1 Benthic Communities

CSA (2016) and Genesis (2016) previously provided a discussion for Benthic Communities (see Section 1.6.1 of the CSA [2016] document and Section 1.6 of the Genesis [2016] document). Tom and Kanari (2023) also present an online mapper of offshore Israel, including previous benthic sampling events in the Leviathan Field. Data presented in the mapper did not indicate any sensitive benthic communities in the Leviathan Field. According to the Strategic Environmental Survey prepared by IOLR (2015), the deep sea zone of the economic waters of Israel has a very low combined ecological sensitivity. More recently, the Israel Ministry of National Infrastructure, Energy and Water Resources (now MoE) implemented a Strategic Environmental Assessment (SEA) of the offshore Mediterranean region specifically designed to characterize available environmental data, map offshore habitats, and characterize environmental vulnerability (Geo-prospect Ltd. and IOLR, 2016), supplemented with a series of updated maps (State of Israel, 2021a) for both benthic and pelagic habitats and an accompanying map set depicting vulnerability to offshore oil and gas activities (State of Israel, 2021b).

The Leviathan Expansion Project encompasses a deepwater environment as determined by Geo-prospect Ltd. and IOLR (2016). The State of Israel (2021a,b) revisited the 2016 assessment to generate a series of habitat maps for the Israeli offshore region. Updates were derived from data from different and additional survey types including multibeam sonar, chirp, autonomous underwater vehicles equipped with high-resolution side-scan sonar, ROVs, synthetic aperture sonar, box cores, and varying fishing methods. Results of the 2021 mapping exercise indicate that the Leviathan Expansion Project is located within an area of low vulnerability.

Key Findings:

- Soft bottom assemblages are composed of biota living within the sediments (infauna) and on the sediment surface (epifauna).
- **Figure 1-24** represents the density of infauna within a grid cell and this correlates to the number of standard deviations above the Levantine Basin Baseline for infaunal density.
- Infauna and epifauna generally are in low abundance compared to nearshore environments (Kress et al., 1993; Galil and Goren, 1994; Kröncke et al., 2003; Galil, 2004).
- Data presented in this section are results of the taxonomic analysis of infauna from the Leviathan Background Monitoring Survey and from previous surveys conducted by CSA in the Leviathan blocks (CSA International, Inc., 2011, 2012; CSA Ocean Sciences Inc., 2013a,b, 2014a,b).
- The dominant phyla during the 2014 Survey were Annelida (63.59%) and Arthropoda (25.87%). The phyla Mollusca and Platyhelminthes also contributed 5.30% and 2.79% to benthic abundance, respectively. During the 2020 Survey, Nematoda (54.0%) and Arthropoda (37.7%) were the dominant phyla (**Table 1-5**).
- The most abundant subgroup during the 2014 Survey was the arthropod *Typhlotanais* sp. (16.09% of total infauna). Other dominant subgroups within the Annelida included: *Notomastus* sp., Polycirrinae, *Scolelepis* sp., and *Prionospio* sp. During the 2020 Survey, the most abundant subgroup (other than Nematoda) was *Prionospio* sp., comprising 4.8% of total infauna (**Table 1-6**).

- Infaunal density was mostly within 99% confidence limits (2014 survey), except near Lev-2 and a western grid location.), the color scale indicates infaunal density in standard deviations above the baseline, with yellow representing over 462 individuals per m^2 (3.5+ standard deviations) (**Figure 1-24**).
- Increased infauna density during the 2014 survey around Leviathan-2 wellsite was primarily due to the abundance of members of the phylum Annelida (*Prionospio* sp. and Spionidae).
- Densities of Annelida as a whole, *Prionospio* sp., and Spionidae around the Lev-2 wellsite were 511, 169, and 184 individuals per m^2, respectively (2014 survey).
- An uncontrolled discharge event of formation sands between 2011 and 2012 was the likely cause of increased infauna density. The sand layer depth ranged from more than 3 m thick within 50 m of the discharge, and 2 cm thick within 200 m of the wellsite.
- The formation sand exhibited low concentrations of most metals and hydrocarbon concentrations. The loose, large grained formation sand likely provided an excellent substrate for infauna colonization that was otherwise devoid of sharp pteropod shell hash prevalent throughout the region.
- Mollusk densities were low and uniform (2014 survey), staying below the 99% confidence limits throughout the Leviathan Field. Mean mollusk density: 5.5 individuals per m^2. Stylochidae (flatworm) showed patches of higher density in northern and southern Leviathan areas, with a mean density of 3.19 individuals per m^2 (range: 0 to 40.8 individuals per m^2). Higher Sipuncula (peanut worm) densities occurred in the western Leviathan Field, with a mean density of 1.75 individuals per m^2 (range: 0 to 32.7 individuals per m^2).
- The number of taxonomic subgroups throughout the region was low and below the 99% confidence limit (CL) of the Leviathan Field mean, averaging 7 ± 3 taxa per grid cell (2014 survey; **Figure 1-25**).
- Taxonomic diversity, as calculated by the Shannon-Wiener Diversity Index, was low to moderate throughout the region (2014 survey). There were no locations within the Leviathan Field where taxonomic diversity was greater than the 99% confidence limit. The evenness index was high indicating that the taxa within the region have comparable numerical equality.
- Diversity indices for the Leviathan Field from the 2014 and 2020 surveys are summarized in **Table 1-7**.
- There was no apparent pattern to organism density, composition, or diversity with the exception of *Prionospio* sp.
- Chemosynthetic communities have not been encountered in Leviathan Field.
- Visual surveys were conducted for pre-drill studies. No hard bottom outcroppings were observed during the visual survey of sites located within the Leviathan Field. (CSA International, Inc., 2011, 2012; CSA Ocean Sciences Inc., 2013a,b).

Proposed Project:

- No pockmark clusters or biological communities were identified near the proposed drill sites or along the IFL-10, IFL-11, or IFL-23 infield flowline corridors.
- The mean infaunal density for the Leviathan Field during the 2020 survey was 119.5 individuals m^{-2} at the infauna station (Marine Ventures International, Inc., 2021b). This density is similar to the 2014 Survey average of 107.3 individuals m^{-2}. The most dominant phylum was Nematoda which composed 54.0% of the abundances observed at the central field infauna station. The second most dominant phylum was Arthropoda, which composed 37.7% of infauna (Marine Ventures International, Inc., 2021b).
- The most abundant taxonomic subgroups were *Prionospio* sp., Cirratulidae, and *Notomastus* sp. at the infauna station. In the 2014 Survey (CSA Ocean Sciences Inc., 2015a), *Typhlotanais* sp., *Notomastus* sp., Polycirrinae, and *Scolelepis* sp. were the most abundant taxonomic subgroups; the only subgroup dominant between both surveys was *Notomastus* sp., however the fifth-most abundant taxonomic subgroup was *Prionospio* sp. in the Leviathan Field in 2014.
- In the 2020 Survey, the most abundant taxa (other than Nematoda) were *Prionospio* sp. (4.8% of all individuals) and annelids from the Family Cirratulidae (2.7% of all individuals) (Marine Ventures International, Inc., 2021b).

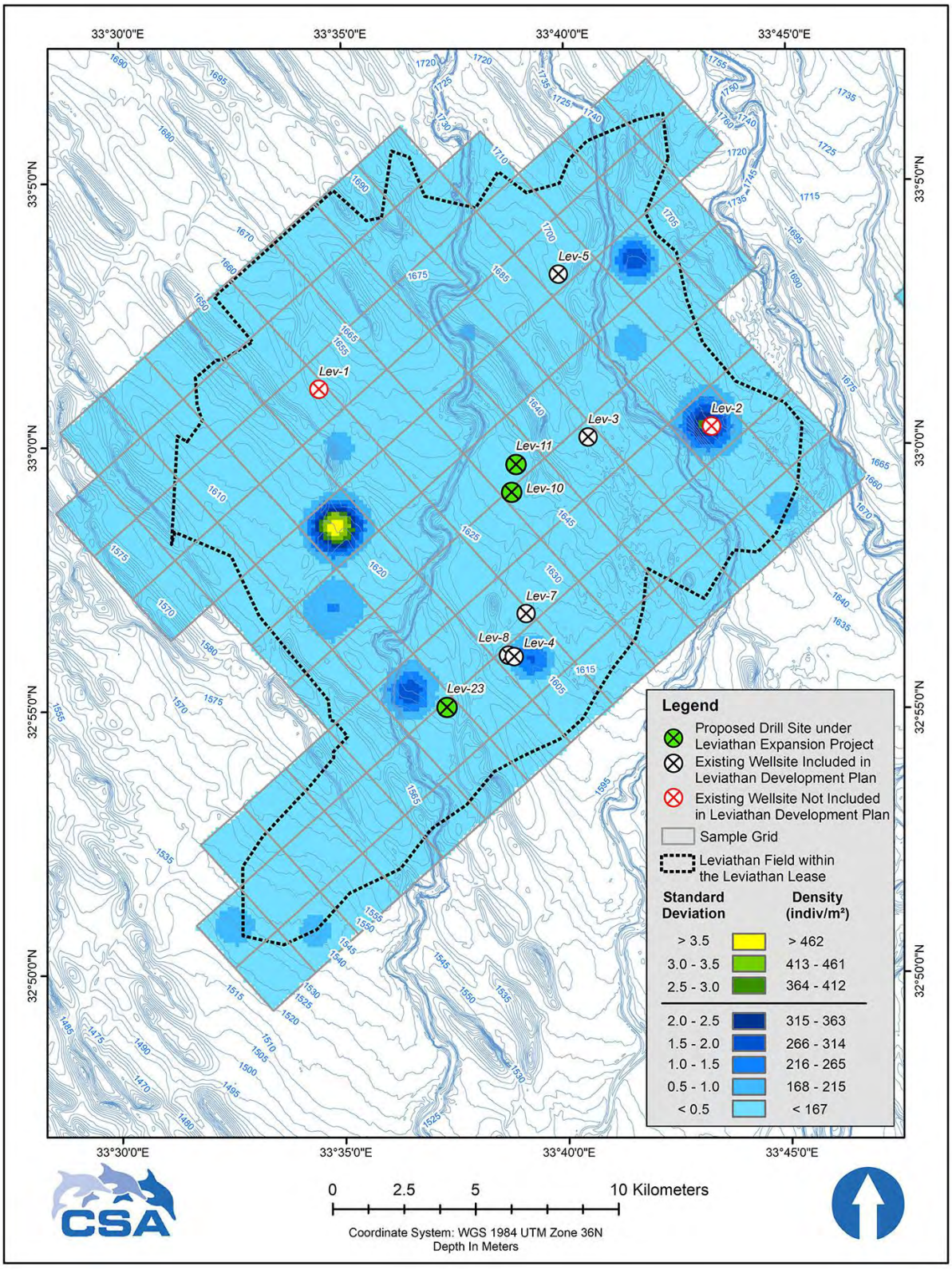


Figure 1-24. Kriged densities (individuals per m^2) of benthic infauna within the Leviathan Field.

Table 1-5. Density and percent composition of major infauna phyla during the 2014 Leviathan Field Survey and from the singular station sampled during the 2020 Leviathan Field Survey.

Phyla	2014 Leviathan Field Survey		2020 Leviathan Field Survey	
	Density (individuals m^{-2})	Percentage of Total Infauna	Density (individuals m^{-2})	Percentage of Total Infauna
Annelida	68.23	63.55%	45.0	37.7%
Arthropoda	27.73	25.84%	7.0	5.9%
Cnidaria	0.07	0.07%	--	--
Echinodermata	0.08	0.07%	--	--
Echiura	0.03	0.03%	--	--
Mollusca	5.67	5.29%	0.5	0.4%
Nematoda	--	--	64.5	54.0%
Nemertea	0.67	0.63%	1.5	1.3%
Platyhelminthes	2.99	2.79%	--	--
Sipuncula	1.85	1.73%	1	0.8%
Total of Major Phyla	**107.3**	**100%**	**119.5**	**100%**

Table 1-6. Standardized density and percent composition of the five most abundant infauna subgroups calculated from all stations sampled during the 2014 Leviathan Field Survey and from the singular station sampled during the 2020 Leviathan Field Survey.

Phylum	Taxonomic Identification	2014 Leviathan Field Survey		2020 Leviathan Field Survey	
		Density (individuals m^{-2})	Percentage of Total Infauna	Density (individuals m^{-2})	Percentage of Total Infauna
Annelida	*Chaetozone* sp.	--	--	5.5	2.3%
Annelida	Cirratulidae	--	--	6.5	2.72%
Nematoda	Nematoda	--	--	64.5	54.0%
Annelida	*Notomastus* sp.	14.87 ± 15.98	13.85%	4.5	1.88%
Annelid	Polycirrinae	11.81 ± 15.99	11.00%	--	--
Annelida	*Prionospio* sp.	4.12 ± 26.72	3.84%	10	4.80%
Annelid	*Scolelepis* sp.	4.96 ± 7.46	4.62%	--	--
Arthropod	*Typhlotanais* sp.	17.27 ± 70.61	16.09	--	--

Table 1-7. Diversity metrics calculated from all stations sampled during the 2014 Leviathan Field Survey and from the singular station sampled during the 2020 Leviathan Field Survey.

Survey	Number of Uniquely Identified Taxa	Shannon-Wiener Diversity (H′)	Pielou's Evenness (J′)
2014	149	1.66	0.92
2020	27	1.89	0.57

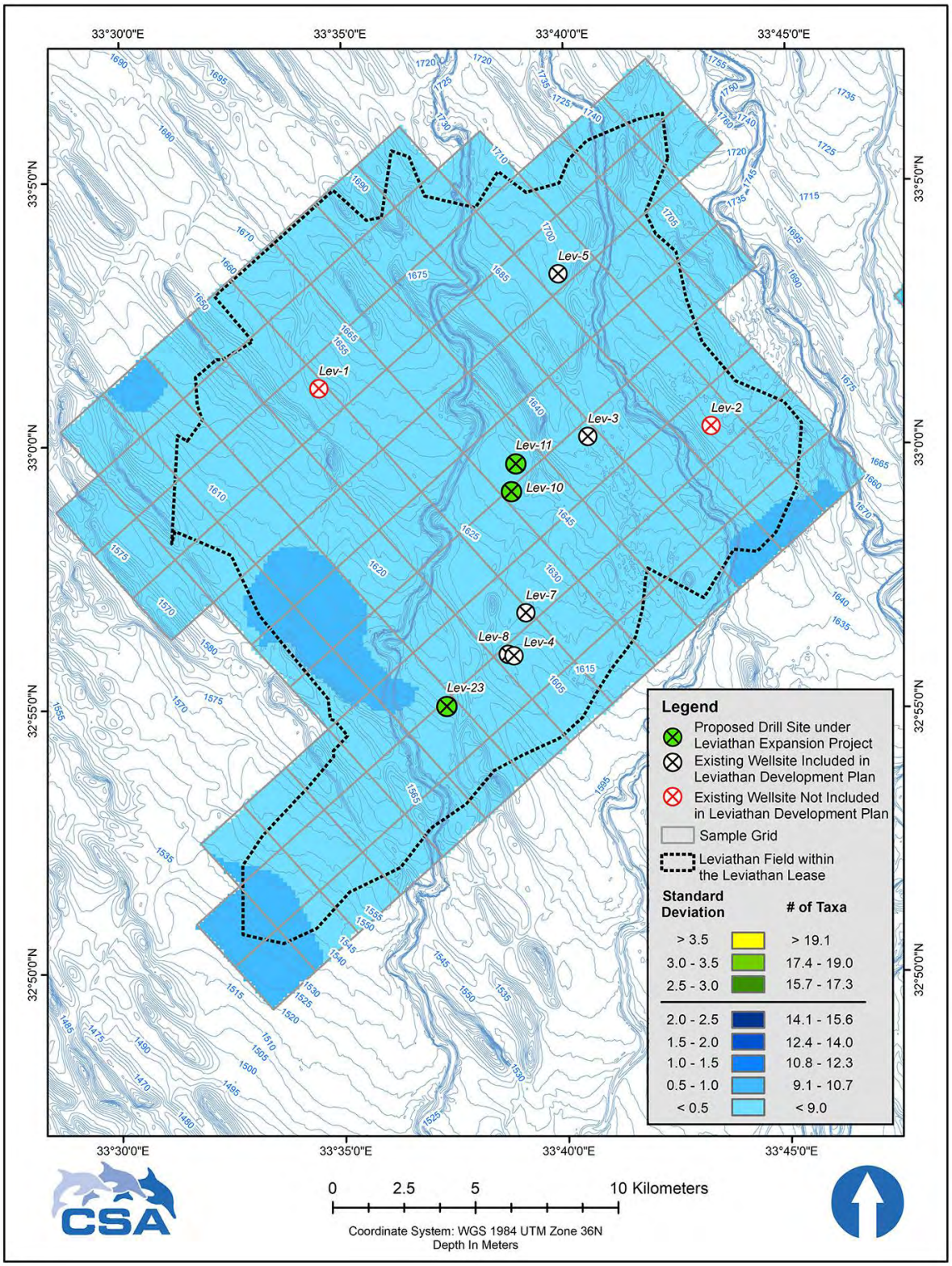


Figure 1-25. Taxonomic richness (i.e., number of taxa) within the Leviathan Field.

1.7.2 Marine Mammals, Sea Turtles, Birds, and Fishes

CSA (2016) and Genesis (2016) previously provided a discussion for Marine Mammals, Sea Turtles, Birds and Fishes (see Section 1.6.2 of the CSA [2016] document and Section 1.6.3 of the Genesis [2016] document).

1.7.2.1 Marine Mammals

Key Findings:

- No site-specific marine mammal data are available for the Leviathan Field area.
- Several small cetacean taxa are considered regular visitors – e.g., Bottlenose Dolphin (*Tursiops truncatus*), Risso's Dolphin (*Grampus griseus*), and False Killer Whale (*Pseudorca crassidens*). (Kerem et al., 2012).
- Based on these studies, **Table 1-8** lists marine mammal species that may be present in the Application Area.
- Several large cetacean taxa are considered regular visitors to the area – e.g., Fin Whale (*Balaenoptera physalus*), sperm whale (*Physeter macrocephalus*), and minke whale (*Balaenoptera acutorostrata*). The humpback whale (*Megaptera novaeangliae*) and killer whale (Orcinus orca) are considered vagrants in the Levantine Basin (Kerem et al., 2012).
- Six of the marine mammal species which may be present are listed as either Near Threatened, or Vulnerable, per the current IUCN Red List (International Union for Conservation of Nature [IUCN], 2024); of these, the most frequented species is the Bottlenose Dolphin (Kerem et al., 2012).
- Mediterranean Monk Seal (*Monachus monachus*) is the only Vulnerable pinniped on the IUCN Red List; this species is extremely rare off Israel, with only two sightings of this species noted within the past 50 years. A single seal was observed offshore Herzliya in 2010. More recently, in May 2023, a female monk seal came ashore along the central Israel coast.
- Based on strandings and sightings data, Bottlenose Dolphin appears to be the most abundant marine mammal taxa present in Israeli waters. Bottlenose Dolphins account for 85% of all marine mammal sightings and 60% of the strandings in Israel. Sightings have occurred up to 30 km offshore in up to 1,300 m water depths (Kerem et al., 2012).
- A Mediterranean subpopulation of Rough-toothed Dolphin (*Steno bredanensis*) is present in the eastern Mediterranean, near Cyprus; this species is IUCN-listed as Least Concern.
- CSA conducted a marine protected species survey as part of a two dimensional (2D) bathymetric survey offshore Israel from 29 September to 24 October 2014. There were five marine mammal sightings during the survey period, and all were bottlenose dolphins. No sea turtle or whale species were observed during the survey (CSA Ocean Sciences Inc., 2014c).

Proposed Project:

- Several marine mammal species which may be present are considered Near Threatened, or Vulnerable, per the IUCN Red List (IUCN, 2025).

Table 1-8. Marine mammal species potentially occurring in the Application Area based on Kerem et al. (2012), ACCOBAMS (2012), and Notarbartolo di Sciara and Birkun (2010).

Common Name	Scientific Name	IUCN Status[1]	Presence Confirmed in Israeli Waters
Regular Species (Levantine Basin)			
Short-beaked common dolphin	*Delphinus delphis*	LC	Yes
Risso's dolphin	*Grampus griseus*	LC	Yes
Striped dolphin	*Stenella coeruleoalba*	LC	Yes
Rough-toothed dolphin	*Steno bredanensis*	LC	Yes
Common bottlenose dolphin	*Tursiops truncatus*	LC/VU[2]	Yes
Visitor Species (Levantine Basin)			
Fin whale	*Balaenoptera physalus*	VU	Yes
Minke whale	*Balaenoptera acutorostrata*	LC	Yes
Sperm whale	*Physeter macrocephalus*	VU	Yes
False killer whale	*Pseudorca crassidens*	NT	Yes
Cuvier's beaked whale	*Ziphius cavirostris*	LC	Yes
Vagrant Species (Levantine Basin)			
Indo-Pacific humpback dolphin	*Sousa chinensis*	VU	Yes
Humpback whale	*Megaptera novaeangliae*	LC	No
Killer whale	*Orcinus orca*	DD	Possibly
Other Vagrant Species (Mediterranean Sea)			
Sei whale	*Balaenoptera borealis*	EN	No
North Atlantic right whale	*Eubalaena glacialis*	EN	No
Long-finned pilot whale	*Globicephala melas*	LC	No
Dwarf sperm whale	*Kogia sima*	LC	No
Sowerby's beaked whale	*Mesoplodon bidens*	LC	No
Blainville's beaked whale	*Mesoplodon densirostris*	LC	No
Gervais' beaked whale	*Mesoplodon europaeus*	LC	No
Harbor porpoise	*Phocoena phocoena*	LC	No
Mediterranean monk seal	*Monachus monachus*	VU	No

[1] International Union for Conservation of Nature (IUCN, 2025) status: CR = critically endangered; DD = data deficient.
[2] The VU designation for bottlenose dolphins applies to the Mediterranean subpopulation.
EN = endangered; LC = least concern; VU = vulnerable; NT =Not Threatened.

1.7.2.2 Sea Turtles

Key Findings:

- No site-specific data are available regarding sea turtles.
- Tracking studies suggest sea turtles could occur within the Application Area – e.g., Green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*) (**Table 1-9**).
- Loggerhead and green turtles are listed on the IUCN Red List (IUCN, 2025).
- Loggerhead and green turtles are known to nest along the Israel coast.
- Greece, Cyprus, and Turkey provide the primary nesting grounds for turtles in the Mediterranean (Levy, 2011).

Proposed Project:

- Existing information presented in CSA (2016) and Genesis (2016) is deemed sufficient for assessment purposes.
- Green Turtles (*Chelonia mydas*) are now the only sea turtle listed as Endangered, with Loggerheads being put on the Vulnerable category (IUCN, 2025).

Table 1-9. Updated: Sea turtle species potentially occurring in the Application Area (From: IUCN, 2025).

Common Name	Scientific Name	IUCN Status[1]	Nesting in Israel
Loggerhead turtle	*Caretta caretta*	VU	Yes
Green turtle	*Chelonia mydas*	EN	Yes
Leatherback turtle	*Dermochelys coriacea*	VU	No

[1] IUCN status: EN = endangered; VU = vulnerable.

1.7.2.3 Seabirds and Migratory Birds

Key Findings:

- No site-specific bird data are available regarding seabirds and migratory birds.
- At least 38 seabird species are native to Israeli waters (**Table 1-10**). This includes 36 seabird species listed (BirdLife International, 2025a).
- Due to the distance offshore (100 km+), pelagic seabirds are likely to be the most prevalent species present in the Leviathan Field area.
- Birds native to Israeli waters include Cory's Shearwater (*Calonectris diomedea*), Leach's Storm-Petrel (*Oceanodroma leucorhoa*), Sooty Shearwater (*Puffinus griseus*), and Yelkouan Shearwater (*Puffinus yelkouan*).
- Two seabirds which may occur offshore Israel are listed as Vulnerable (i.e., Yelkouan Shearwater and Dalmatian Pelican) on the IUCN Red List, however no observed breeding in Israel has been reported (**Table 1-10**).
- Several pelagic species are listed in Annex II as Vulnerable or Near Threatened (IUCN, 2025), however, of the species listed only two are listed for waters in Israel (Great White Pelican, Little Tern); both of these species are listed on the IUCN Red List as being of Least Concern.
- Annex II includes shorebirds reported from Israel of which the Slender-billed Curlew is Critically Endangered (**Table 1-10**), however it is considered a vagrant species and does not breed there (**Table 1-11**).
- Israel is known as a major migratory pathway with up to 500 million birds using the airspace (Leshem and Atrash, 1998).
- The highest numbers of migratory birds are observed during autumn and spring. A total of 315 migratory bird species occur in Israel, with many species listed as Endangered, Critically Endangered, or Vulnerable per the IUCN Red List (BirdLife International, 2025b).
- Fifteen important bird areas (IBAs) have been designated in Israel, two of which are important coastal habitats: the Zvulun Valley includes small wetlands, ponds, coastal marshes and the Carmel Coast includes large complex fish ponds (BirdLife International, 2025c).

Proposed Project:

- Status designation of Dalmatian Pelican per the IUCN Red List has changed from Vulnerable to Near Threatened; Leach's Storm-Petrel has been changed from Least Concern to Vulnerable; White-eyed Gull has been changed from Near Threatened to Least Concern.
- There has been a taxonomic change for Pygmy Cormorant from *Phalacrocorax pygmeus* to *Microcarbo pygmaeus*.
- No site-specific data are available, however based on previous reports and data, pelagic seabirds are prevalent. Several species are listed as Vulnerable (IUCN, 2025).
- Some species do not breed within or near the project area, reducing the potential for impact.
- For migratory birds, up to 500 million individuals representing 315 species utilize Israel airspace on an annual basis, with many seeking refuge along Israel's coastal habitats.

Table 1-10. Updated seabird species occurring in Israeli waters (Adapted from: BirdLife International, 2025a).

Common Name	Scientific Name	IUCN Status[1]	Listed in Annex II[2]	Breeding in Israel[3]
Cory's Shearwater	*Calonectris diomedea*	LC	Yes	--
Black Tern	*Chlidonias niger*	LC	--	--
Caspian Gull	*Larus cachinnans*	LC	--	--
Mew Gull	*Larus canus*	LC	--	--
Lesser Black-backed Gull	*Larus fuscus*	LC		--
Slender-billed Gull	*Larus genei*	LC	Yes	--
Pallas's Gull	*Larus ichthyaetus*	LC	--	--
White-eyed Gull	*Larus leucophthalmus*	LC	--	--
Mediterranean Gull	*Larus melanocephalus*	LC	Yes	--
Yellow-legged Gull	*Larus michahellis*	LC	--	--
Little Gull	*Larus minutus*	LC	--	--
Black-headed Gull	*Larus ridibundus*	LC	--	--
Red-breasted Merganser	*Mergus serrator*	LC	--	--
Northern Gannet	*Morus bassanus*	LC	--	--
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	VU	--	--
Dalmatian Pelican[4]	*Pelecanus crispus*	NT	Yes	--
Great White Pelican	*Pelecanus onocrotalus*	LC	Yes	Yes
Great Cormorant	*Phalacrocorax carbo*	LC	--	--
Pygmy Cormorant[4]	*Microcarbo pygmaeus*	LC	Yes	--
Red Phalarope	*Phalaropus fulicarius*	LC	--	--
Red-necked Phalarope	*Phalaropus lobatus*	LC	--	--
Great crested Grebe	*Podiceps cristatus*	LC	--	--
Black-necked Grebe	*Podiceps nigricollis*	LC	--	--
Sooty Shearwater	*Puffinus griseus*	NT	--	--
Yelkouan Shearwater	*Puffinus yelkouan*	VU	Yes	--
Long-tailed Jaeger	*Stercorarius longicaudus*	LC	--	--
Parasitic Jaeger	*Stercorarius parasiticus*	LC	--	--
Pomarine Jaeger	*Stercorarius pomarinus*	LC	--	--
Little Tern	*Sterna albifrons*	LC	Yes	Yes
Bridled Tern	*Sterna anaethetus*	LC	--	--
Lesser Crested Tern	*Sterna bengalensis*	LC	Yes	--
Great Crested Tern	*Sterna bergii*	LC	--	--
Caspian Tern	*Sterna caspia*	LC	Yes	--
Common Tern	*Sterna hirundo*	LC	--	Yes
Gull-billed Tern	*Sterna nilotica*	LC	Yes	--
White-cheeked Tern	*Sterna repressa*	LC	--	--
Sandwich Tern	*Sterna sandvicensis*	LC	Yes	--
Brown Booby	*Sula leucogaster*	LC	--	--

[1] International Union for Conservation of Nature (IUCN, 2025) status: LC = least concern; NT = near threatened; VU = vulnerable.
[2] Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity of the Mediterranean (United Nations Environment Programme, 2013).
[3] Breeding in Israel based on BirdLife International (2025a) map viewer showing range and breeding locations.
[4] Dalmatian Pelican and Pygmy Cormorant are not listed as native to Israel by BirdLife International (2025a) but have been added based on IUCN (2025) and their individual species descriptions on the BirdLife International website.
-- = not listed in Annex II, or not breeding in Israel.

Table 1-11. Updated shorebird species occurring in Israel that are on the Annex II list (From: IUCN, 2025).

Common Name	Scientific Name	IUCN Status[1]	Israel Occurrence[2]	Breeding in Israel[3]
Kentish Plover	*Charadrius alexandrinus*	LC	Native	No
Greater Sand Plover	*Charadrius leschenaultii*	LC	Native	No
Pied Kingfisher	*Ceryle rudis*	LC	Native	Yes
White-throated Kingfisher	*Halcyon smyrnensis*	LC	Native	Yes
Slender-billed Curlew	*Numenius tenuirostris*	CR	Vagrant	No
Osprey	*Pandion haliaetus*	LC	Native	No
Eleonora's Falcon	*Falco eleonorae*	LC	Native	No

[1] International Union for Conservation of Nature (IUCN, 2025) status: CR = critically endangered; LC = least concern.
[2] Occurrence in Israel based on IUCN (2014).
[3] Breeding in Israel based on BirdLife International (2025a) map viewer showing range and breeding locations.

1.7.2.4 Fish

Key Findings:

- There are 636 marine fish species reported from Israeli waters, including 582 natives and 54 introduced species (Froese and Pauly, 2024).
- The waters of the Levantine Basin are considered oligotrophic (nutrient-starved) and do not support particularly rich fisheries.
- Ichthyofauna is generally composed of species with Atlantic (75%) or cosmopolitan (20%) affinities (Golani, 2005).
- The presence of Indo-Pacific species introduced through the Suez Canal is significant for local ecosystems as well as fisheries because several invaders have become numerically dominant in some habitats.
- Marine fishes may be broadly classified as either demersal (hard or soft bottom dwelling) or pelagic (water column dwelling).
- A total of 12 cruises were conducted between 1988 and 1991 to study the bathyal environment off the coast of Israel. A total of 566 specimens from 31 fish species was collected with spiderfish (*Bathypterois mediterraneus*) and roughtip grenadier (*Nezumia sclerorhynchus*) being the most common, representing 38% and 27% of the specimens collected, respectively (Galil, 2004).
- Cusk eels (*Cataetyx laticeps*), Sloane's viperfish (*Chauliodus sloani*), and spiderfish (*Bathypterios*) were photographed at a depth of 2,900 m. Other fish included anglerfish (*Lophius piscatorius)*, forkbeards (*Phycis phycis and Phycis blennioides*), ghost shark (*Chimaera monstrosa*), a dragonfish (*Stomias boa*), and several unidentified hatchetfishes (Sternoptychidae), scorpionfishes (Scorpaenidae), gurnards (Triglidae), and flatfishes (Bothidae and Scophthalmidae) (Galil, 2004).
- Several deep dwelling shark species such as bluntnose sixgill shark (*Hexanchus griseus),* blackmouth catshark (*Galeus melanostomus*), several gulper shark species (*Centrophorus* spp.), Portuguese dogfish (*Centroscymnus coelolepis*) and velvet belly (*Etmopterus spinax*) were recorded (Galil, 2004).
- A recent deep water study cruise in 2010 was performed at depths of 650 to 1,600 m. Wreckfish (*Polyprion americanus)* and tripodfish (*Bathypterois mediterraneus*) emerged as the most dominant fish taxa observed (Bell and Fuller, 2011).
- The pelagic offshore environment includes both small and large fish species. Atlantic Bluefin Tuna (*Thunnus thynnus*) warrants a special mention due to its high commercial value. Specimens caught in Israeli waters are often observed with ripe gonads. Other large species within the Levantine Basin include Albacore Tuna (*Thunnus alalunga*), Dolphinfish (*Coryphaena hippurus*), Swordfish (Xiphiidae), Sailfish (Istiophoridae) and Pelagic Sharks (e.g., Hammerhead Shark Sphyrnidae spp. blue shark *Prionace glauca*).
- Hake (Merluccliidae) has all but disappeared in the deep water, once abundant and caught by the ton has largely disappeared possibly down to higher sea temperatures or overfishing (Shapiro, 2007).

Proposed Project:

- Existing information presented in CSA (2016) is deemed sufficient for assessment purposes.

1.7.3 Sensitive Habitats

There are no known sensitive habitats within 10 km downstream of the Leviathan Field or the proposed drill sites. Tom and Kanari (2023) present an online mapper of offshore Israel, including previous benthic sampling events in the Leviathan Field. Data presented in the mapper does not indicate any sensitive habitats in the vicinity of the Leviathan Field. Furthermore, benthic habitat maps prepared by the State of Israel (2021a) show that the deepwater offshore area in the vicinity of the Leviathan Field does not have any sensitive habitats present.

1.8 SEAWATER AND SEDIMENT QUALITY

CSA (2016) and Genesis (2016) previously provided a discussion for both Seawater Quality and Sediment Quality (see Section 1.7.1 of the CSA [2016] document and Section 1.7 of the Genesis [2016] document).

1.8.1 Seawater Quality and Sediment Quality Properties

1.8.1.1 Seawater Quality

Key Findings: Seawater Quality

- Total organic carbon (TOC) in the form of carbohydrates, oils, proteins, and amino acids is a natural component of the water column in the marine environment typically resulting from the mineralization of organic matter and biological activity. During the 2014 Background Monitoring Survey, mean TOC concentrations near the surface averaged 0.86 ± 0.13 mg L^{-1}, decreasing at mid-depth to 0.58 ± 0.13 mg L^{-1} and stabilizing near the bottom at 0.53 ± 0.08 mg L^{-1}. During the 2020 Leviathan Field survey, mean TOC concentrations near the surface averaged 0.85 ± 0.20 mg L^{-1}, decreasing at mid-depth to 0.51 ± 0.16 mg L^{-1} and stabilizing near the bottom at 0.49 ± 0.14 mg L^{-1}. Results were found to be within or below the Levantine Basin values and the mean permissible level according to the proposed Mediterranean Environmental Water Quality Standards (MEWQS) (**Table 1-12**).
- Nutrients in the form of total phosphorus (TP) and total nitrogen (TN) were found to be lowest in the near-surface, increasing at mid-depth, and slightly decreasing at near the bottom during the 2014 and 2020 surveys (**Table 1-12**). This is typical of the conservative biolimiting constituents, phosphate and nitrate, affected by biological and chemical processes in which they are added to or removed from solution. TP and TN concentrations are similar to the established Levantine Basin Baseline mean. Approximately 40% of TP was bound within phosphate in the near-surface water, and 55% of TP was bound within phosphate in the near-bottom.
- Total Suspended Solids (TSS) values averaged 4.7 ± 0.49 mg L^{-1} in near-surface water, 5.56 ± 1.24 mg L^{-1} at mid-depth, and 5.3 ± 2.51 mg L^{-1} in the near-bottom (**Table 1-13**). Discrete turbidity measured on board the vessel (<0.37 NTU) was found to be consistent with these TSS results and the turbidity readings taken during the CTD cast. Both TSS and discrete turbidity values were well below the proposed MEWQS maximum permissible levels.
- The pH and Chlorophyll *a* of most surface seawater in equilibrium with the atmosphere is 8.2 ± 0.1, and the gross trends in pH are those expected from the surface pCO2 (higher carbon dioxide [CO2] would yield lower pH) (Millero, 2005).
- Very low nutrient concentrations are the key factor in limiting biological activity and primary production in the area. Chlorophyll *a* concentrations ranged from 0.23 to 0.56 µg L^{-1} in 2014 (CSA, 2016) and were consistently 0.68 µg L^{-1} in the near-surface waters of all stations sampled during the 2020 survey (Marine Ventures International, 2021b).

- Cation and Anion composition from water stations at the Leviathan Field were compared with the major ion composition of average seawater under standard conditions (salinity = 35; pH = 8.1; and temperature = 25°C) and typical eastern Mediterranean values (**Table 1-14**). According to ASTM Standard D 596-83, a clean water sample with an anion sum between 10 and 800 milliequivalents per liter (typical of seawater) should not exceed ±5%. The cation/anion balance for several water samples was slightly greater than the recommended ±5% analytical difference for seawater samples; however, all ion concentrations were similar to average seawater d typical of the eastern Mediterranean Sea (**Table 1-14**).
- Dissolved Metals determinations from previous regional sampling indicate that metal concentrations in seawater are below detection limits and/or below the relevant criteria and standards. The results from the 2020 Leviathan Field Monitoring survey and the 2014 Background Monitoring Survey (**Table 1-15**) are consistent with previous findings.
- Radionuclides determinations from seawater analysis during 2014 Background Monitoring Survey indicated that radium (Ra 226 and Ra 228) are present (**Table 1-16**). Due to the high natural concentration of sulfate in the ocean, radium has a low solubility in seawater (Neff, 2005) and is unlikely to contribute to seawater radioactivity. Radionuclides in seawater were not analyzed during the 2020 survey.
- Seawater in the Levantine Basin has very low nutrient concentrations.
- Concentrations of metals, total petroleum hydrocarbons, and polycyclic aromatic hydrocarbons are below detection limits.

Proposed Project:

- All seawater parameters (i.e., water temperature, dissolved metals, nutrients, hydrocarbons, ions, total suspended solids, and radionuclides) at all water stations sampled during the Monitoring Survey were similar to LBB mean values and the 2014 Leviathan Field Survey mean values and were below internationally and locally accepted environmental standards (Marine Ventures International, Inc., 2021b).

Table 1-12. Mean concentrations of total organic carbon, total phosphorus, phosphate, total nitrogen, nitrate, nitrite, and ammonium in seawater samples collected at the Leviathan Field during the 2020 survey. All values are in mg L^{-1} (From: Marine Ventures International, 2021b).

Depth Stratum	Station	Total Organic Carbon	Total Phosphorus	Total Nitrogen	Nitrate	Nitrite	Ammonium
Near-Surface	J06	0.63	0.0050	0.07	0.0094	0.0007	0.020
	H08	0.71	0.0101	0.13	0.0090	0.0007	0.009
	G02	1.11	0.0069	0.09	0.0155	0.0007	0.009
	D06	1.00	0.0075	0.08	0.0075	0.0007	0.009
	C03	0.79	0.0058	0.08	0.0301	0.0007	0.009
2020 Mean ± Standard Deviation		0.85 ± 0.20	0.007 ± 0.002	0.09 ± 0.02	0.014 ± 0.009	0.0007 ± 0	0.011 ± 0.005
2014 Mean ± Standard Deviation		0.86 ± 0.13	0.005 ± 0.001	0.09 ± 0.02	0.006 ± 0.005	0.0007 ± 0	0.003 ± 0.001
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		1.17 ± 0.14; 1.54	0.008 ± 0.004; 0.018	0.44 ± 0.49; 1.70	--[3]	--[3]	--[3]
Mid-Depth	J06	0.57	0.0136	0.11	0.0568	0.0007	0.009
	H08	0.45	0.0078	0.10	0.0337	0.0007	0.009
	G02	0.36	0.0063	0.07	0.0537	0.0007	0.009
	D06	0.40	0.0111	0.09	0.0465	0.0007	0.009
	C03	0.76	0.0132	0.14	0.0830	0.0007	0.009
2020 Mean ± Standard Deviation		0.51 ± 0.16	0.0104 ± 0.003	0.102 ± 0.03	0.055 ± 0.02	0.0007 ± 0	0.009 ± 0
2014 Mean ± Standard Deviation		0.58 ± 0.13	0.0116 ± 0.002	0.150 ± 0.01	0.091 ± 0.005	0.0007 ± 0	0.003 ± 0.001
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		0.89 ± 0.22; 1.45	0.014 ± 0.002; 0.019	0.48 ± 0.47; 1.69	--[3]	--[3]	--[3]
Near-Bottom	J06	0.60	0.0089	0.08	0.0382	0.0007	0.009
	H08	0.40	0.0131	0.17	0.0343	0.0007	0.009
	G02	0.39	0.0066	0.07	0.0403	0.0007	0.009
	D06	0.37	0.0082	0.09	0.0355	0.0007	0.009
	C03	0.68	0.0123	0.14	0.0739	0.0007	0.009
2020 Mean ± Standard Deviation		0.49 ± 0.14	0.0098 ± 0.003	0.11 ± 0.04	0.044 ± 0.02	0.0007 ± 0	0.009 ± 0
2014 Mean ± Standard Deviation		0.53 ± 0.09	0.0115 ± 0.001	0.15 ± 0.02	0.076 ± 0.01	0.0007 ± 0	0.004 ± 0.002
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		0.84 ± 0.14; 1.21	0.011 ± 0.002; 0.016	0.48 ± 0.48; 1.71	--[3]	--[3]	--[3]
Proposed MEWQS in Israel[2]		N/A	0.1; --	1; --	N/A	N/A	0.5; 2.4

[1] Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to December 2013; updated 20 August 2014.
[2] Values denote Mean; Maximum permissible levels.
[3] Pre-drill and environmental baseline data from previous surveys do not exist for these parameters as they have only recently been requested by the Ministry of Environmental Protection and Ministry of Energy; therefore, the Levantine Basin baseline mean cannot be calculated.
CL = confidence limit; MEWQS = Mediterranean Environmental Water Quality Standards; N/A = not applicable.

Table 1-13. Mean concentrations of total suspended solids in seawater samples collected in the Leviathan Field during the 2020 survey (From: Marine Ventures International, 2021b).

Depth Stratum	Station	Total Suspended Solids (mg L^{-1})
Near-Surface	C03	4.1
	D06	5.1
	G02	5.2
	H08	5.4
	J06	6.5
2020 Mean ± Standard Deviation		5.3 ± 0.86
2014 Mean ± Standard Deviation		4.7 ± 0.49
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		9.79 ± 7.73; 29.7
Mid-Depth	C03	7.5
	D06	8.3
	G02	6
	H08	6.5
	J06	3.1
2020 Mean ± Standard Deviation		6.28 ± 1.99
2014 Mean ± Standard Deviation		5.56 ± 1.24
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		9.92 ± 7.13; 28.3
Near-Bottom	C03	2.5
	D06	5.7
	G02	6.6
	H08	6.1
	J06	6.6
2020 Mean ± Standard Deviation		5.5 ± 1.72
2014 Mean ± Standard Deviation		5.3 ± 2.51
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		9.63 ± 8.21; 30.8
Proposed MEWQS in Israel[2]		N/A; seasonal mean +10% or 10 mg L^{-1}

[1] Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to December 2013; updated 20 August 2014.
[2] Values denote Mean; Maximum permissible levels.
[3] Pre-drill and environmental baseline data from previous surveys do not exist for these parameters as they have only recently been requested by the Ministry of Environmental Protection and Ministry of Energy; therefore, the Levantine Basin Baseline mean cannot be calculated.
CL = confidence limit; MEWQS = Mediterranean Environmental Water Quality Standards; N/A = not applicable.

Table 1-14. Ion composition in the Leviathan Field from the 2014 survey compared with average standard seawater and eastern Mediterranean seawater (From: CSA Ocean Sciences, 2015a).

Depth Stratum	Station	Cations (mg L^{-1})					Anions (mg L^{-1})		Balance		
		Calcium (Ca^{2+})	Potassium (K^{+})	Magnesium (Mg^{2+})	Sodium (Na^{+})	Strontium (Sr^{2+})	Chloride (Cl^{-})	Sulfate (SO_4^{2+})	Cations (meq L^{-1})	Anions (meq L^{-1})	% Difference
Near-Surface	C01/89	473	442	1,410	11,500	8.7	22,500	3,110	651	702	3.7
	B10/91	475	424	1,350	11,200	8.6	22,600	3,080	633	704	5.3
	F05/91	472	419	1,340	10,900	8.5	22,900	3,160	619	714	7.2
	J01/95	482	428	1,360	11,100	8.7	22,500	3,100	630	702	5.4
	J14/90	495	448	1,420	11,300	8.7	22,300	3,020	645	695	3.7
Mean ± Standard Deviation		479 ± 9.56	432 ± 12.3	1,376 ± 36.5	11,200 ± 224	8.64 ± 0.104	22,560 ± 219	3,094 ± 50.8	635.61 ± 12.76	703.38 ± 7.13	5.06 ± 1.45
Mid-Depth	C01/866	468	424	1,360	11,000	8.4	22,300	3,050	625	695	5.3
	B10/832	484	430	1,370	11,300	8.6	22,500	3,080	640	701	4.6
	F05/839	473	417	1,320	10,800	8.5	22,100	3,030	613	689	5.8
	J01/821	465	415	1,320	10,700	8.4	21,900	3,040	608	684	5.9
	J14/775	471	424	1,350	10,800	8.4	22,200	3,060	615	693	5.9
Mean ± Standard Deviation		472 ± 7.26	422 ± 6.04	1,344 ± 23.0	10,920 ± 239	8.46 ± 0.092	22,200 ± 223	3,052 ± 19.2	620.17 ± 12.47	692.36 ± 6.63	5.50 ± 0.56
Near-Bottom	C01/1554	460	409	1,300	10,700	8.4	22,400	3,080	606	699	7.1
	B10/1495	483	431	1,370	11,200	8.6	22,500	3,100	635	702	5
	F05/1505	468	424	1,340	10,900	8.5	22,400	3,140	619	700	6.1
	J01/1470	470	430	1,360	10,900	8.4	22,300	3,060	621	695	5.7
	J14/1390	477	415	1,330	10,800	8.5	22,200	3,080	614	693	6.1
Mean ± Standard Deviation		472 ± 8.79	422 ± 9.58	1,340 ± 27.4	10,900 ± 187	8.48 ± 0.08	22,360 ± 114	3,092 ± 30.3	619 ± 10.7	698 ± 3.7	6.00 ± 0.76
Average Seawater[1]		412	399	1,283	10,783	7.9	19,352	2,712	--	--	--
Eastern Mediterranean Seawater[2]		423	463	1,403	11,800	5–7.5[3]	21,200	2,950	--	--	--

[1] Millero, 2005.
[2] Al-Mutaz, 2000.
[3] Ladewig and Asquith, 2012.

Table 1-15. Metal concentrations (µg L^{-1}) in seawater samples from Leviathan Field during the 2020 survey compared with averages from the Background Monitoring Survey (May 2014). Toxicity reference values (Criterion Continuous Concentrations [CCCs]) (Buchman, 2008), Levantine Basin Baseline survey data, the proposed Mediterranean Environmental Water Quality Standards (MEWQS) in Israel (Ministry of Environmental Protection, 2002), and European Commission Environmental Quality Standard (EUCEQS) for priority substances in the field of water policy (Directive 2008/105/EC and proposed amendment COM(2011)876) are provided for comparison (Adapted from: CSA Ocean Sciences, 2015a and Marine Ventures International, 2021b).

Depth Stratum	Station	Silver (Ag)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Antimony (Sb)	Selenium (Se)	Thallium (Tl)	Vanadium (V)	Zinc (Zn)
Near-Surface	J06	<0.02	1.46	13.4	<0.03	0.004	0.17	0.15	0.07	0.29	0.291	<1.0	<1.0	0.013	2.7	1.69
	H08	<0.02	1.49	9.7	<0.03	0.004	0.18	0.14	0.1	0.31	0.117	<1.0	<1.0	0.013	2.5	1.67
	G02	<0.02	1.28	8.1	<0.03	0.003	0.18	0.13	0.09	0.29	0.143	<1.0	<1.0	0.013	2.5	1.74
	D06	<0.02	1.45	7.8	<0.03	0.004	0.18	0.14	0.11	0.27	0.084	0.6	<1.0	0.014	2.5	0.6
	C03	<0.02	1.47	8.2	<0.03	0.004	0.17	0.14	< 0.02	0.29	0.125	<1.0	<1.0	0.014	2.5	0.5
2020 Mean ± Standard Deviation		<0.02	1.43 ± 0.09	9.44 ± 2.33	<0.03	0.0038 ± 0.0004	0.176 ± 0.005	0.14 ± 0.007	0.09 ± 0.02	0.29 ± 0.014	0.152 ± 0.08	<1.0	-<1.0	0.0134 ± 0.0005	2.54 ± 0.09	1.24 ± 0.63
2014 Mean ± Standard Deviation		<0.02	1.42 ± 0.04	9.18 ± 0.43	<0.03	<0.03	0.25 ± 0.07	0.6 ± 0.78	<0.0005–0.0010[5]	0.32 ± 0.04	0.03 ± 0.01	<1.0	<1.0	<0.03 – 0.04[5]	4.24 ± 0.25	0.66 ± 0.25
Levantine Basin Baseline Data[1] (Mean ± SD; Upper 99% CL)		0.02 ± 0.01; --	1.27 ± 0.08; 1.48	8.98 ± 0.43; 14.65	<0.02; --	<0.02; --	0.25 ± 0.08; --	0.42 ± 0.15; 0.81	0.0006 ± 0.0002; --	0.65 ± 0.35; 1.55	0.08 ± 0.05; 0.21	<0.5; --	<0.5; --	<0.02; --	2.95 ± 1.48; --	5.1 ± 5.5; 19.29
Mid-Depth	J06	<0.02	1.51	13.4	<0.03	0.004	0.19	0.11	0.09	0.32	0.071	<1.0	<1.0	0.013	2	0.68
	H08	<0.02	1.49	12.3	<0.03	0.005	0.19	0.1	0.09	0.32	0.087	<1.0	<1.0	0.013	2.4	0.91
	G02	<0.02	1.49	11.2	<0.03	0.004	0.19	0.11	0.1	0.3	0.096	<1.0	<1.0	0.013	2.1	0.7
	D06	<0.02	1.49	11.4	<0.03	0.005	0.19	0.09	0.14	0.31	0.091	0.4	<1.0	0.013	1.8	0.72
	C03	<0.02	1.53	11.9	<0.03	0.005	0.19	0.11	0.18	0.32	0.072	0.9	<1.0	0.015	2.5	0.81
2020 Mean ± Standard Deviation		<0.02	1.5 ± 0.02	12.04 ± 0.87	<0.03	0.0046 ± 0.0005	0.19 ± 0	0.104 ± 0.009	0.15 ± 0.04	0.314 ± 0.009	0.08 ± 0.01	<1.0	<1.0	0.01 ± 0.0009<0.03	2.16 ± 0.29	0.76 ± 0. 10
2014 Mean ± Standard Deviation		<0.02	1.5 ± 0	12.36 ± 0.18	<0.03	<0.03	0.3 ± 0	0.24 ± 0.14	<0.0005	0.36 ± 0.05	0.03 ± 0.01	<1.0	<1.0	<0.03	3.86 ± 1.1	<0.6 – 0.70[5]
Levantine Basin Baseline Data[1] (Mean ± SD; Upper 99% CL)		<0.02; --	1.33 ± 0.27; 2.02	11.8 ± 0.28; 12.52	<0.02; --	<0.02; --	0.28 ± 0.13; --	0.3 ± 0.09; 0.53	<0.0005; --	0.88 ± 0.66; 2.58	0.05 ± 0.02; 0.10	<0.5; --	<0.5; --	<0.02; --	3.2 ± 1.32; --	3.18 ± 3.99; 13.47

Table 1-15. (Continued).

Depth Stratum	Station	Silver (Ag)	Arsenic (As)	Barium (Ba)	Beryllium (Be)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Antimony (Sb)	Selenium (Se)	Thallium (Tl)	Vanadium (V)	Zinc (Zn)
Near-Bottom	J06	<0.02	1.48	11.9	<0.03	0.004	0.19	0.12	0.09	0.3	0.121	<1.0	<1.0	0.013	1.9	0.76
	H08	<0.02	1.49	11.5	<0.03	0.005	0.18	0.11	0.11	0.32	0.078	<1.0	<1.0	0.013	2.1	1.5
	G02	<0.02	1.46	11.5	<0.03	0.003	0.19	0.15	0.11	0.31	0.213	<1.0	<1.0	0.013	2.3	0.83
	D06	<0.02	1.52	11.7	0.022	0.004	0.19	0.15	0.12	0.34	0.062	0.5	<1.0	0.013	2.3	0.55
	C03	<0.02	1.44	11.4	<0.03	0.005	0.19	0.12	0.1	0.32	0.048	1	<1.0	0.015	2.2	0.66
2020 Mean ± Standard Deviation		<0.02	1.5 ± 0.03	11.6 ± 0.2	<0.03	0.004 ± 0.0008	0188 ± 0.004	0.13 ± 0.02	0.11 ± 0.01	0.3 ± 0.01	0.104 ± 0.07	<1.0	<1.0	0.01 ± 0.0009	2.2 ± 0.17	0.86 ± 0.4
2014 Mean ± Standard Deviation		<0.02	1.5 ± 0	12.54 ± 0.34	<0.02	<0.02	0.3 ± 0	0.22 ± 0.03	<0.0005	0.3 ± 0	0.03 ± 0.01	<1.0	<1.0	<0.02	3.4 ± 0.06	0.66 ± 0.2
Levantine Basin Baseline Data[1] (Mean ± SD; Upper 99% CL)		<0.02; --	1.35 ± 0.1; 1.60	12.28 ± 0.92; 14.65	<0.02; --	<0.02; --	0.25 ± 0.08; --	0.23 ± 0.05; 0.35	<0.0005; --	0.78 ± 0.7; 2.58	0.05 ± 0.03; 0.12	<0.5; --	<0.5; --	<0.02; --	2.9 ± 1.41; --	1.22 ± 0.4; 2.25
Proposed MEWQS in Israel[2]		3; 7	36; 69	--	--	0.5; 2	10; 20	5; 10	0.16; 0.4	10; 50	5; 20	--	60; 150	--	50; 100	40; 100
EUCEQS (Directive 2008/105/EC and Proposed Amendment COM (2011)876)[3]		--	--	--	--	0.2; 1.5	--	--	--; 0.07	8.6; 34	1.3; 14	--	--	--	--	--
CCC Value[4]		0.95 (1/2)	36	200 BC	100 BC	8.8	50	3.1	0.94	8.2	8.1	500[p]	71	17 NZ	50 BC	81

[1] Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to December 2013; updated 20 August 2014.
[2] Values denote Average; Maximum permissible levels.
[3] Values denote AAC; MAC.
[4] Sources of CCC toxicity reference values: primary entry is the U.S. Ambient Water Quality Criteria; BC = British Columbia Water Quality Guidelines; NZ = Australian and New Zealand Environmental Concern Levels and Trigger Values.
[5] A range is reported because the mean could not be calculated as the majority of the data were below the laboratory's method reporting limit.
-- = concentration not determined.
[p] = proposed.
(1/2) = CCC has been halved to be comparable to 1985 guidelines for minimum data requirements and derivation procedures.
AAC = annual average concentration; CCC = Criterion Continuous Concentration; CL = confidence limit; EUCEQS = European Union Commission on Environmental Quality Standards; MAC = maximum allowable concentration; MEWQS = Mediterranean Environmental Water Quality Standards; SD = standard deviation.

Table 1-16. Mean and combined mean concentrations (pCi L^{-1}) of radionuclides (radium [Ra] 226 and Ra 228) in seawater from the 2014 Leviathan Field survey, with mean Levantine Basin Baseline data for comparison.

Station	Depth Stratum/depth (m)	Ra 226	Ra 228	Combined Ra 226 and Ra 228
J01	Near-surface / 95	0.13	0.18	0.31
	Mid-depth / 821	0.015	0	0.015
	Near-bottom / 1470	0.086	0.22	0.306
Levantine Basin Baseline Data[1] (Mean ± SD; Upper 99% CL)	Near-surface	0.13 ± 0.09; 0.36	0.2 ± 0.13; 0.54	0.25 ± 0.21; 0.79
	Mid-depth	0.17 ± 0.1; 0.43	0.16 ± 0.1; 0.42	0.31 ± 0.16; 0.72
	Near-bottom	0.13 ± 0.1; 0.39	0.16 ± 0.13; 0.50	0.29 ± 0.19; 0.78

[1] Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to December 2013; updated 20 August 2014.
CL = confidence limit; SD = standard deviation.

1.8.1.2 Sediment Quality

Key Findings:

- 79 stations were sampled during the Background Monitoring Survey. Sediment samples were analyzed for grain size, total organic carbon (TOC), metals, hydrocarbons (total petroleum hydrocarbons, TPH; polycyclic aromatic hydrocarbons, PAHs), radionuclides, and polychlorinated biphenyls (PCBs).

Proposed Project:

- Existing information presented in CSA (2016) is deemed sufficient for assessment purposes.

Sediment Total Organic Carbon

Sediment TOC concentrations within the Leviathan Field are provided in CSA (2016).

Key Findings:

- Sediment TOC concentrations were low and uniform (0.43% ± 0.05%) throughout the Leviathan Field. TOC concentrations were within the 99% CL of the Leviathan Field mean and also within the 99% CL of the LBB for sediment TOC.

Proposed Project:

- Sediment TOC concentrations throughout the survey region were low (0.39% ± 0.05%) and were below the LBB 99% CL. Sediment TOC concentrations reported during the 2020 Survey were significantly lower than those reported during the 2014 survey ($F_{1,70} = 27.03$; $P < 0.0001$); however, it is unlikely that these differences are biologically relevant (Marine Ventures International, Inc., 2021b).

Sediment Metals

Sediment metal concentrations within the Leviathan Field are provided in CSA (2016).

Key Findings:

- Metal concentrations generally below effects range low (ERL), except for nickel, which exceeds the effects range median. Arsenic, copper, and nickel are within the upper 99% confidence limit of the LBB and occur naturally in high concentrations (**Table 1-17**).
- Selenium and silver concentrations generally were not detectable within the Leviathan Field (more than 84% were non-detects).
- Metals with concentrations above detection limits were within the 99% CL of the LBB (e.g., Al, As, Be, Cr, Cu, Fe, Hg, Ni, V, Zn).
- Metals that were found to have some concentrations above the 99% CL of the LBB were antimony (0.2 to 1.8 parts per million [ppm]).

- Barium is not considered toxic to marine organisms. Concentrations were elevated in grid cells containing the Lev-2 (12,263 ppm) and Lev-4 (8,218 ppm) wellsites. Elsewhere, concentrations ranged from 113 to 375 ppm.
- Cadmium concentrations ranged from below the detection limit (0.16 ppm) to 1.04 ppm.
- Cadmium concentrations within the Leviathan Field were below the effects range median (ERM) value (9.6 ppm) and effects range low (ERL) value (1.2 ppm) for cadmium and therefore do not pose a threat to the environment.
- Lead concentrations ranged from 11.9 to 39.3 ppm and were generally within the 99% CL. A single high was located near Lev-2 (46.7 ppm). Lead concentrations are not expected to negatively affect the environment.
- Thallium concentrations reached a maximum of 2.8 ppm in this region. Due to the distance from previous drilling or anthropogenic activities, elevated concentrations likely reflect natural concentrations.

Proposed Project:
- Lev-3: Concentrations of total metals (excluding barium) at most stations were generally similar to concentrations of both the 2014 Leviathan Field EBS and LBB averages. Exceptions were at stations in the 25-m (L3|001 and L3|003) which had elevated concentrations of both lead and mercury relative to the other stations sampled during the current survey and past survey averages. (Marine Ventures International, Inc., 2019).
- Lev-3: Elevated levels of barium were found in the top 0.3 cm of all seafloor sediments throughout the survey region. This finding indicates that the dispersion of barium from the Lev-3 drilling activities was quite broad. However, these findings also indicate that the depth of deposition was very shallow and generally limited to sediment depths 0.3 to 1.3 cm of seafloor at most stations located ≥200 m from the wellhead. This broad dispersion, but extremely shallow deposition, is likely due to the transport of some mud particles along the seafloor by weak bottom currents.
- Lev-3: Overall, results from the Lev-3 Post-Drill Survey indicate that sediment quality for most parameters were similar to the 2014 Leviathan Field EBS and LBB averages. Some metals exhibited elevated concentrations; these impacts are not expected to negatively impact the benthic habitat on a regional scale.
- Lev-7: Concentrations of total metals (excluding barium) at most stations were generally similar to concentrations of both the 2014 Leviathan Field EBS and LBB averages. Exceptions were at some stations located 25-, 50-, and 150-m from the wellhead, which had elevated concentrations of antimony, copper, lead, and mercury relative to the other stations sampled during the current survey and past survey averages. These findings indicate potential impacts due to drilling activities by the presence of heavy metals (typically found in drilling muds) in the seafloor sediments in close proximity to the wellhead; however, these metals were not found to be elevated elsewhere within the survey area (Marine Ventures International, Inc., 2019)
- Lev-7: Elevated levels of barium were found in the top 0.3 cm of all seafloor sediments throughout the survey region. This finding indicates that the dispersion of barium from the Lev-7 drilling activities was quite broad. However, these findings also indicate that the depth of deposition was very shallow and generally limited to sediment depths 0.3 to 1.3 cm of seafloor at most stations located ≥200 m from the wellhead.
- Lev-7: Post-Drill Survey indicate that sediment quality for most parameters were similar to the 2014 Leviathan Field EBS and LBB averages. Some metals exhibited elevated concentrations (i.e., barium) some sediment disturbances along with drill muds and cuttings. However, these impacts are confined to areas close to the Lev-7 wellhead and are not expected to negatively impact the benthic habitat on a regional scale.

- Lev-8: Concentrations of metals (with the exception of barium) during the Post-Drill Survey at most stations were generally similar to concentrations of both the 2014 Leviathan Field EBS and LBB means. Antimony was an exception to this observation as elevated concentrations were found at 12 of the 41 stations. Elevated concentrations of lead were also detected at nine different stations between the 25- and 200-m. Results suggest that drilling and completion activities had an effect on sediment lead and antimony concentrations around the Lev-8 well in close proximity to the wellhead. Adverse effects on biological communities due to lead's low bioavailability are not considered unlikely, and antimony has not set environmental benchmarks (CSA Ocean Sciences Inc., 2023).
- Lev-8: Elevated concentrations of barium indicating that the dispersion of barium from the Leviathan-8 drilling activities was quite broad. This broad dispersion, with differences in deposition depth, is likely due to both the transport of some mud particles along the seafloor by weak bottom currents and the settlement of barite laden muds from near-surface discharges in the vicinity of the wellhead (**Figure 1-26**).
- Concentrations in 2020 which were less or similar to 2014 Survey results: antimony ($F_{1,70} = 1.85$; $P = 0.07$), copper ($F_{1,70} = 1.14$; $P = 0.26$), iron ($F_{1,70} = 1.39$; $P = 0.17$), nickel ($F_{1,70} = 1.27$; $P = 0.21$), thallium ($F_{1,70} = 1.22$; $P = 0.22$), vanadium ($F_{1,70} = 1.90$; $P = 0.06$), and zinc ($F_{1,70} = 0.64$; $P = 0.52$) during the 2020 Survey were not significantly different from samples collected during the 2014 survey. Comparative interpolated maps for these parameters are provided in CSA (2020; Figures 8 to 14). Sediment concentrations of beryllium ($F_{1,70} = 2.71$; $P = 0.009$) and chromium ($F_{1,70} = 8.11$; $P < 0.0001$) were significantly lower than samples collected during the 2014 survey (Marine Ventures International, Inc., 2021b).
- Concentrations in 2020 which were greater than 2014 Survey results: Sediment concentrations of barium ($F_{1,70} = 3.84$; $P = 0.0003$), mercury ($F_{1,70} = 6.82$; $P < 0.0001$), and lead ($F_{1,70} = 2.35$; $P = 0.02$) were significantly greater than samples collected during the 2014 survey. Comparative interpolated maps for these parameters comparing 2014 and 2020 concentrations are provided in **Figures 1-27** to **1-29**.
- It should be noted that Lev-2 and Lev-4 were drilled prior to the 2014 Leviathan Field EBS and therefore results from that survey around those wells should not be considered indicative of the overall lease area prior to disturbance. As a result, Figures 1-27 through 1-29 should be viewed in this context. It would not be scientifically sound to compare environmental metrics from areas that were sampled prior to disturbance with those that were sampled after disturbance. The 2014 Survey is the earliest available baseline information, but it should be noted that several wells were drilled prior to the 2014 Survey and therefore the 2014 data cannot be considered indicative of an undisturbed area.

Table 1-17. Mean (± standard deviation) total metals concentrations (ppm unless noted otherwise) in sediments collected from the Leviathan Field in 2014 and 2020. Metals concentrations in seafloor sediments of the Levantine Basin (pre-drill and environmental baseline surveys conducted prior to December 2013), effects range low (ERL) and effects range median (ERM) values (Buchman, 2008), and metals concentrations found in drilling muds and barite used at Tamar SW-1 (in the nearby Tamar Field) are provided for comparison. Selenium and silver concentrations were generally below primary analytical laboratory detection limits and, therefore, are not presented in the table.

Location	Aluminum (%)	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Iron (%)	Nickel	Lead	Antimony	Thallium	Vanadium	Zinc	Mercury
2020 Leviathan Field	5.7 ± 0.28	18.34 ± 0.93	527.06 ± 728.69	0.61 ± 0.13	< 0.16	34.55 ± 6.61	56.39 ± 2.17	3.99 ± 0.2	56.74 ± 2.41	20.62 ± 3.77	0.52 ± 0.04	0.33 ± 0.02	91.28 ± 4.72	68.82 ± 3.19	0.049 ± 0.007
2014 Leviathan Field	5.7 ± 0.74	16.82 ± 2.63	337.82 ± 1338.81	0.63 ± 0.17	< 0.16	45.59 ± 6.29	54.25 ± 5.95	4.04 ± 0.4	54.23 ± 6.67	17.76 ± 4.39	0.46 ± 0.18	0.44 ± 0.39	86.35 ± 9.83	66.87 ± 5.73	0.04 ± 0.007
Levantine Basin Baseline (LBB) Mean	6.85 ± 1.64	19.32 ± 3.81	173.4 ± 30.1	1.16 ± 0.5	0.18 ± 0.07*	65.4 ± 23.52	62.85 ± 13.84	5.09 ± 1.02	67.58 ± 16.49	22.35 ± 10.38	0.62 ± 0.25	0.43 ± 0.17	119.1 ± 31.3	91.6 ± 41.4	0.04 ± 0.01
99% Confidence Limit of Levantine Basin Baseline (LBB) Mean	11.1	29.1	251.1	2.45	0.36*	126.1	98.6	7.72	110.1	49.1	1.27	0.86	199.9	198.5	0.06
ERL	N/A	8.2	N/A	N/A	1.2	81	34	N/A	20.9	46.7	N/A	N/A	N/A	150	0.15
ERM	N/A	70	N/A	N/A	9.6	370	270	N/A	51.6	218	N/A	N/A	N/A	410	0.71
Barite	N/A	20	N/A	N/A	1.6 ± 0.6	8	121	N/A	7	165	N/A	N/A	N/A	109	N/A

N/A = data not available.
*An extrapolation method (Croghan and Egeghy, 2003) was used to determine mean, standard deviation, and 99% confidence limit due to the large number of non-detects in the relevant data sets.

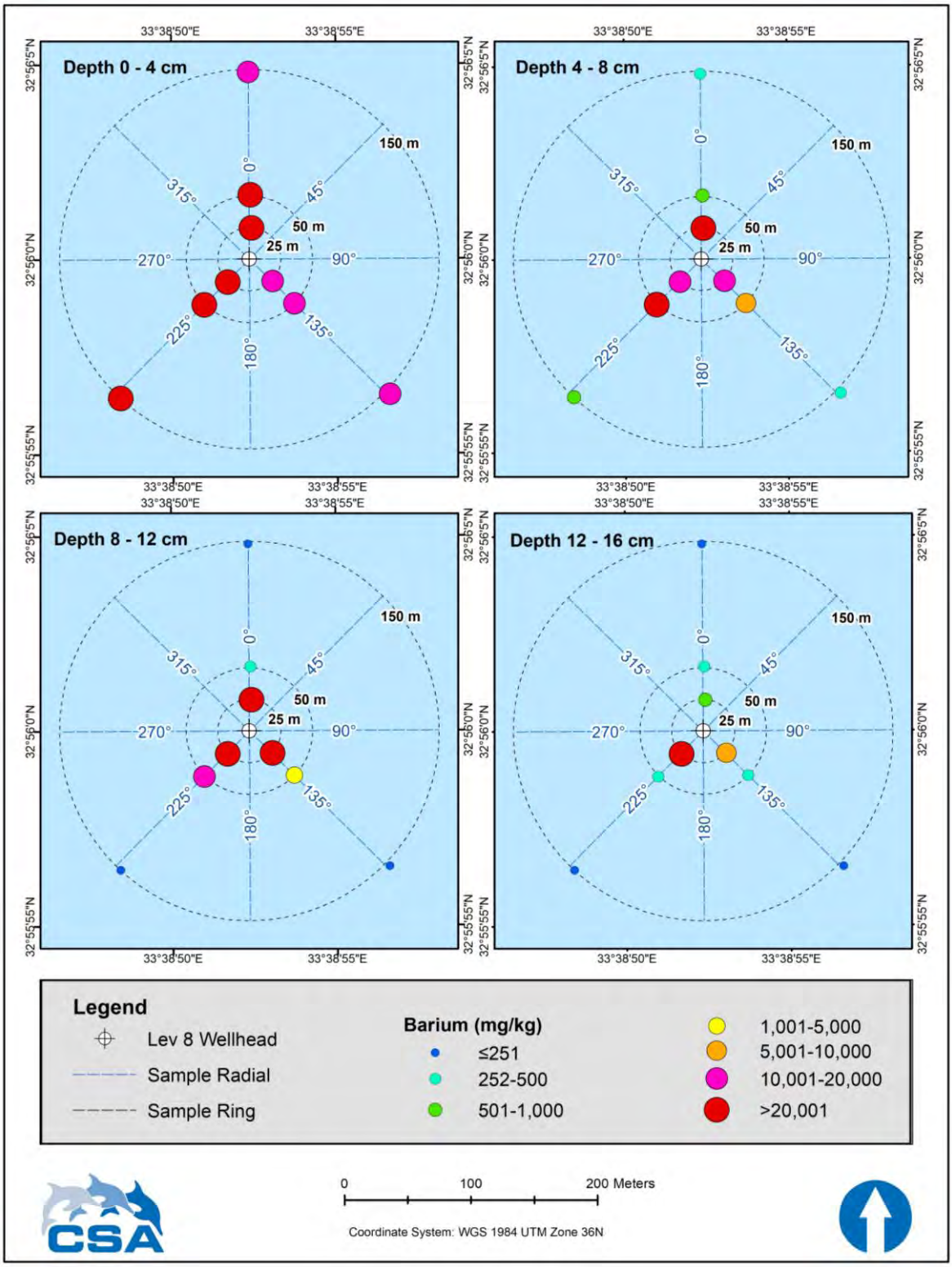


Figure 1-26. Spatial distribution of barium concentrations (mg kg^{-1}) within top sediments and sub-seafloor sediments collected at stations located ≤150 m from the Leviathan-8 wellhead during the Leviathan-8 Post-Drill Survey. Blue symbols indicate sediment barium concentrations that are under the Levantine Basin Baseline upper 99% confidence limit (i.e., 251 mg kg^{-1}).

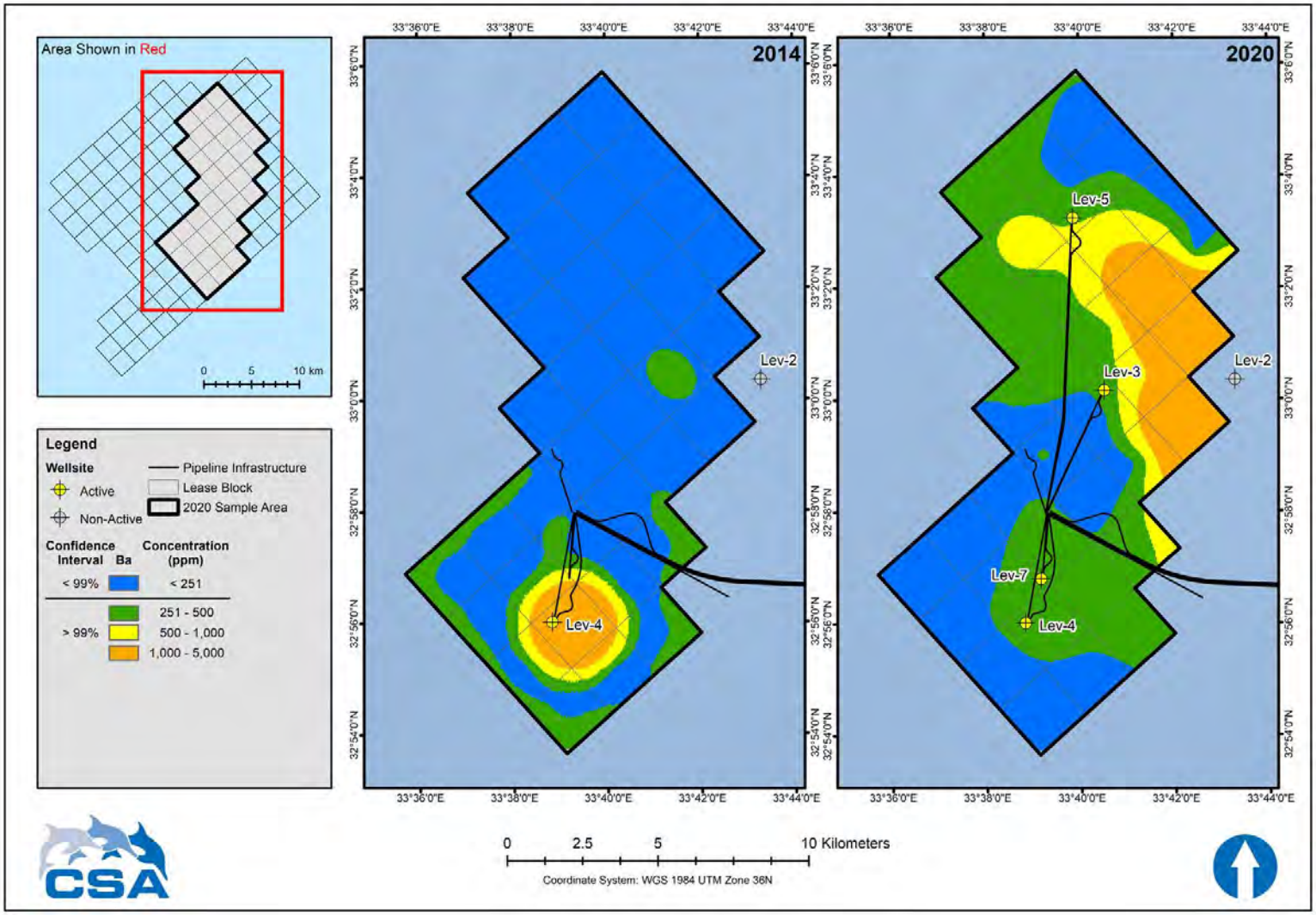


Figure 1-27. Seafloor sediment barium (Ba) concentrations within the Leviathan Field, 2014 Environmental Baseline Survey versus 2020 Monitoring Survey. Seafloor sediments within the Leviathan Field that have natural concentrations of barium relative to the offshore Israel Levantine Basin region are shaded blue. 2014 data were collected after drilling several wells in the Leviathan Field.

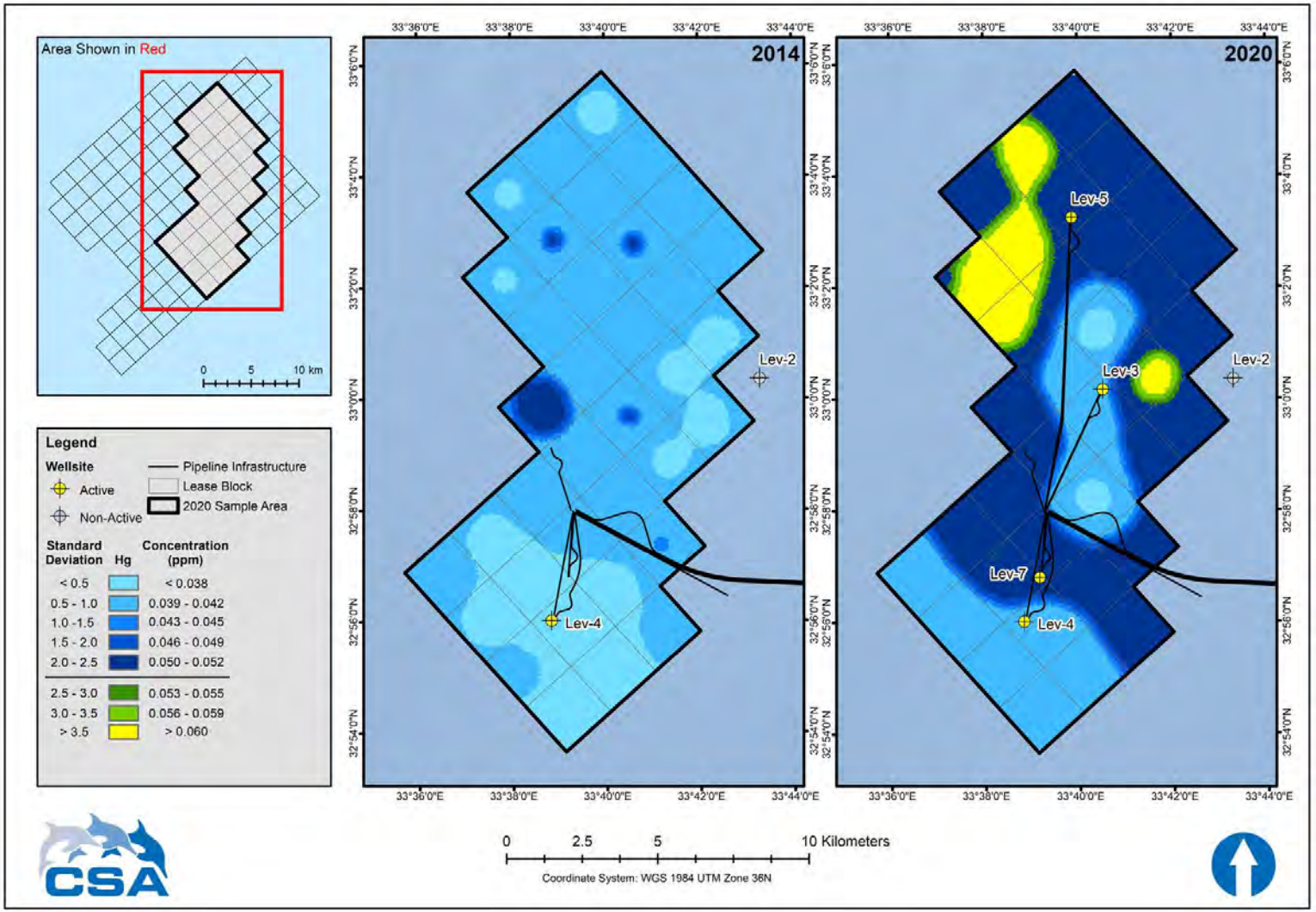


Figure 1-28. Seafloor sediment mercury (Hg) concentrations within the Leviathan Field, 2014 Environmental Baseline Survey versus 2020 Monitoring Survey .Seafloor sediments within the Leviathan Field that have natural concentrations of mercury relative to the offshore Israel Levantine Basin region are shaded blue. 2014 data were collected after drilling several wells in the Leviathan Field.

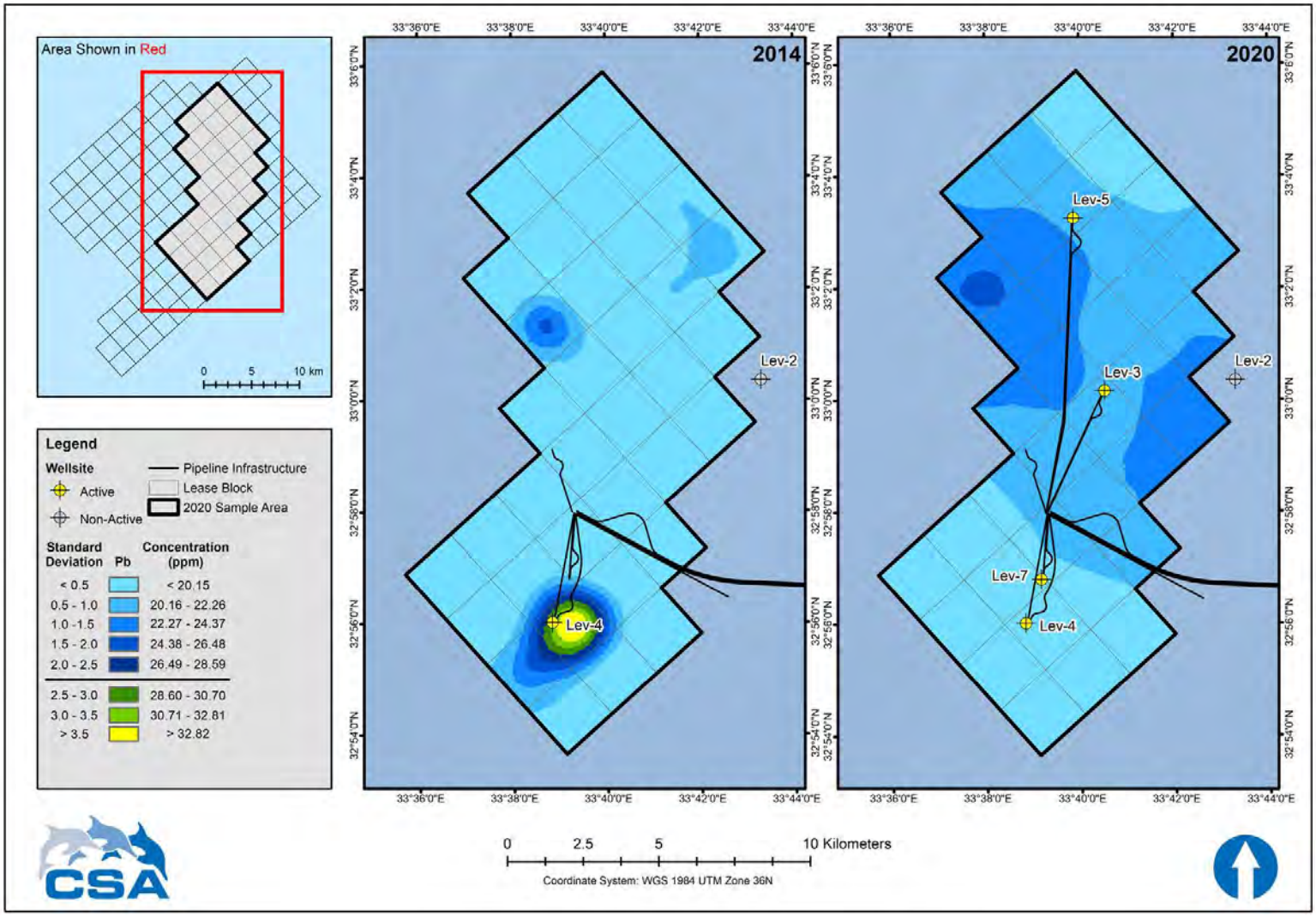


Figure 1-29. Seafloor sediment lead (Pb) concentrations within the Leviathan Field, 2014 Environmental Baseline Survey versus 2020 Monitoring Survey. Seafloor sediments within the Leviathan Field that have natural concentrations of lead relative to the offshore Israel Levantine Basin region are shaded blue. 2014 data were collected after drilling several wells in the Leviathan Field.

Sediment Hydrocarbons

Sediment hydrocarbon concentrations within the Leviathan Field are provided in CSA (2016) and Marine Ventures International (2021b).

Key Findings:

- Hydrocarbons were analyzed further to determine concentrations of the 16 United States Environmental Protection Agency (USEPA) priority pollutant PAHs. Mean (± SD) PAH concentrations in strata sampled during the Leviathan Field Development Survey are summarized in **Table 1-18**.
- Sediment TPH concentrations during the 2014 survey ranged from 4.0 to 27.1 ppm. TPH concentrations throughout the entire survey area were within the 99% CL of the LBB of 21.85 ppm.
- During the 2020 survey, TPH concentrations within the Leviathan Field ranged from 6.0 to 24.0 ppm, with a mean (± SD) of 15.45 ± 3.7 ppm. There was no significant difference in sediment TPH concentrations between surveys ($F_{1,70} = 1.12$; $P = 0.27$). A comparative interpolated map for TPH is provided in **Figure 1-30**.
- The analytical laboratory used previously to analyze sediment hydrocarbons prior had a reporting limit of 50 ppm. TPH concentrations in these grid cells were below the laboratory's method reporting limit; the usual substitution of half the method reporting limit was not utilized because this value was above the 99% CL.
- Studies have characterized TPH concentrations between 15 and 50 ppm as "slightly polluted" and concentrations greater than 200 ppm as "heavily polluted." The Leviathan Field would be classified as either ambient or slightly polluted because several grid cells have TPH concentrations above 15 ppm. Despite this determination, there is no threat to the environment due to the fact those terms a highly qualitative.
- PAHs were analyzed only in samples that had a TPH concentration above the 95% CL of the LBB at the time of sample submission to the laboratory (15.9 ppm). Individual and total PAH data are available from 44 grid cells within the Leviathan Field (27 from previously sampled grid cells).
- A 99% CL for the LBB of individual PAHs is not provided because many of the LBB samples had individual PAH concentrations below detection limits.
- Total PAHs concentration was below the 99% CL for the LBB (115.8 parts per billion [ppb]) and was well below the ERL (4,022 ppb) and ERM (44,702 ppb) values for total PAHs in marine sediments.
- A Fossil Fuel Pollution Index (FFPI) ratio of 0 to 0.25 indicates PAH assemblages dominated by pyrogenic sources, while a ratio of approximately 0.25 to 0.49 is indicative of intermediate PAH assemblages containing a mix of pyrogenic and petrogenic sources; a ratio of 0.5 to 1.0 is indicative of PAH assemblages dominated by petrogenic sources.
- The FFPI ratios for the Leviathan Field from the 2014 survey are summarized in **Figure 1-31**. Hydrocarbons from sediments from the Leviathan Field are from a mix of pyrogenic and petrogenic sources. Elevated FFPI ratios between 0.25 and 0.5 were found in undeveloped and developed grid cells, indicating that this is due to natural variation in the region.
- Hydrocarbons from the Leviathan Field represent a mix of pyrogenic and petrogenic sources. Elevated FFPI ratios between 0.25 and 0.5 were found in undeveloped and developed grid cells, indicating that this is due to natural variation in the region.

Proposed Project:

- TPH concentrations within the Leviathan Field ranged from 6.0 to 24.0 ppm, with a mean (± SD) of 15.45 ± 3.7 ppm during 2014 and ranged from 6.0 to 24.0 ppm, with a mean (± SD) of 15.45 ± 3.7 ppm in 2020. TPH concentrations throughout the entire survey area were within the 99% CL of the Leviathan Field mean of 27.25 ppm and the LBB 99% CL of 21.85 ppm. There was no significant difference in sediment TPH concentrations between surveys (Marine Ventures International, Inc., 2021b).

Table 1-18. Mean (± standard deviation) U.S. Environmental Protection Agency priority and total polycyclic aromatic hydrocarbons (PAHs) concentrations (in parts per billion) of samples with high total petroleum hydrocarbons (TPH) concentrations in the Leviathan Field. Bolded numbers indicate PAHs that exceed the Levantine Basin Baseline mean.

Location	Number of Grid Cells	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Anthracene	Phenanthrene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(kj)fluoranthene	Benzo(a)pyrene	Indeno(123cd)pyrene	Dibenz(ah)anthracene	Benzo(ghi)perylene	Total PAHs
Leviathan Field	27*	2.9 ± 3.5	0.2 ± 0.2	1.6 ± 3.3	**3.5 ± 5.38**	0.5 ± 0.6	**8.5 ± 7.4**	**3.6 ± 2.9**	2.2 ± 1.32	1.0 ± 0.5	1.5 ± 0.6	**3.1 ± 1.1**	1.2 ± 1.0	0.9 ± 0.5	2.1 ± 0.7	0.5 ± 0.2	1.9 ± 0.7	**69.2 ± 41.1**
Levantine Basin Baseline Mean		3.2 ± 1.2	1.8 ± 1.6	1.9 ± 1.6	2.9 ± 1.3	1.9 ± 1.6	5.0 ± 4.0	3.0 ± 1.0	2.6 ± 1.0	2.2 ± 1.3	2.5 ± 1.0	3.0 ± 0.9	2.1 ± 1.3	2.2 ± 1.3	2.6 ± 0.9	2.0 ± 1.4	2.6 ± 0.9	55.4 ± 23.4

* Eight of the 27 grid cells contained or were adjacent to the Leviathan-2, Leviathan-3, and Leviathan-4 wellsites.

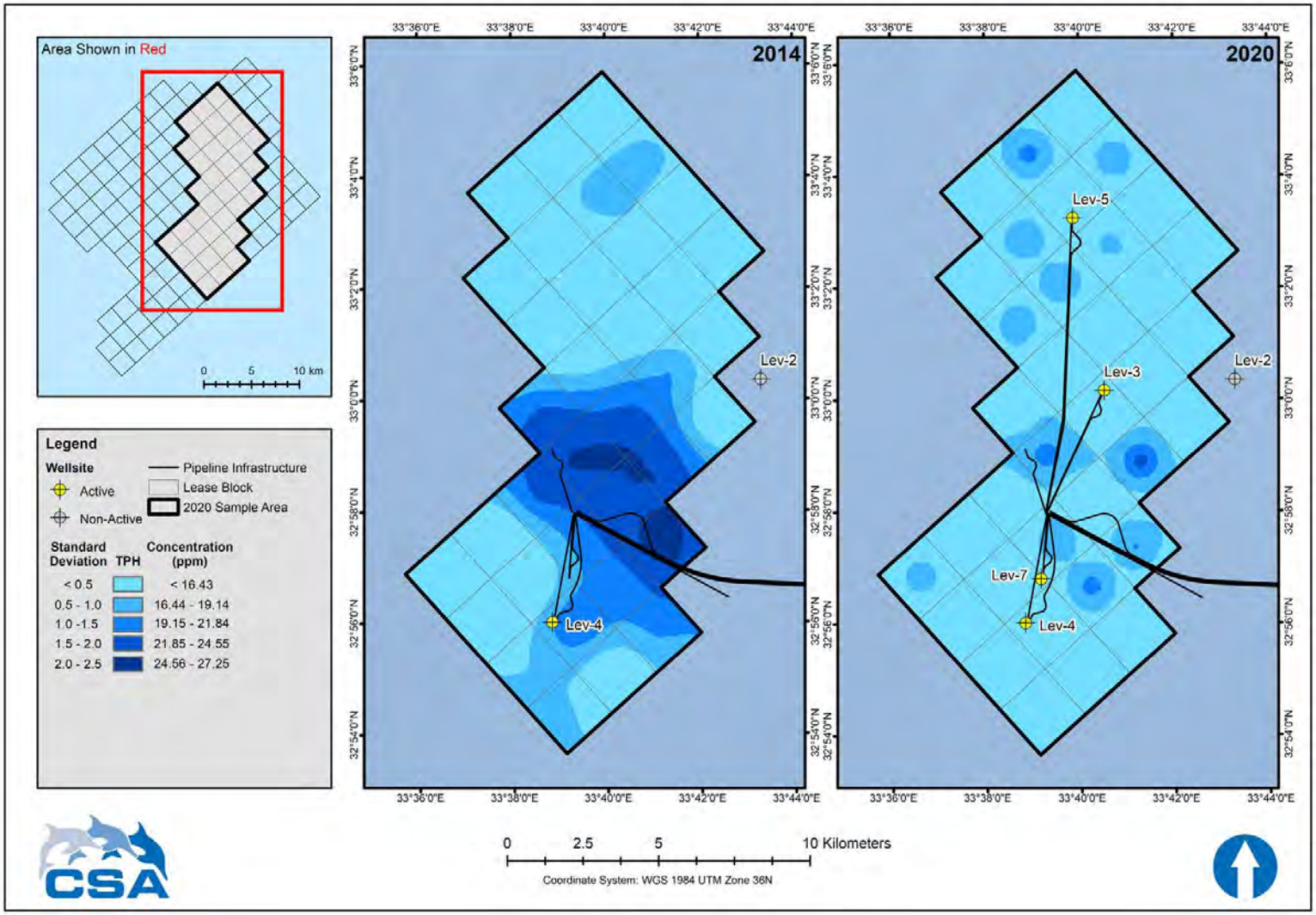


Figure 1-30. Seafloor sediment total petroleum hydrocarbon (TPH) concentrations within the Leviathan Field, 2014 Environmental Baseline Survey versus 2020 Monitoring Survey. Seafloor sediments within the Leviathan Field that have natural concentrations of TPH relative to the offshore Israel Levantine Basin region are shaded blue.

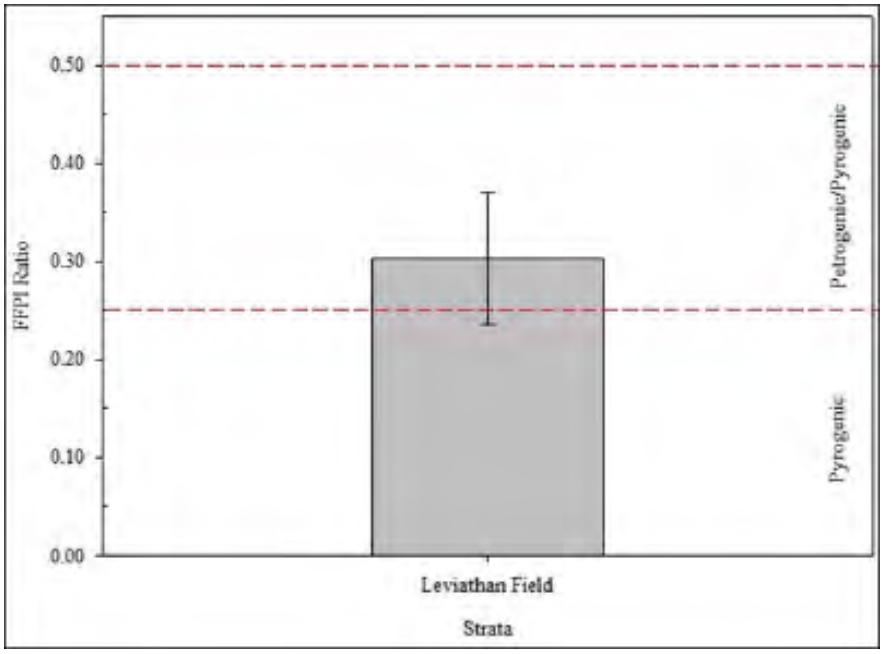


Figure 1-31. Mean (± standard deviation) Fossil Fuel Pollution Index (FFPI) ratios from samples with high total petroleum hydrocarbons (TPH) concentrations within the Leviathan Field sampling grid. The red dashed lines indicate the boundary between sediments that are of pyrogenic (0 to 0.24) or a mix of petrogenic and pyrogenic (0.25 to 0.5) origins (From: CSA Ocean Sciences, 2016).

Sediment Radionuclides

Sediment radionuclide concentrations within the Leviathan Field are provided in CSA (2016).

Key Findings:

- 10% of all sediment stations were sampled for radionuclides, with four stations located in the Leviathan Field during the 2020 survey (**Table 1-19**).
- Ambient radium concentrations in most soils and rocks are approximately 0.5 to 5.0 picocuries per gram (pCi g^{-1}) of total radium. Ambient concentrations of Th 228 in sediments range from 0.36 to 1.93 pCi g^{-1}.
- The USEPA established a protective health-based level for radium and thorium of 5 pCi g^{-1} at the sediment surface as a threshold for the remediation (cleanup) of the top 15 cm of soil. Mean radium and thorium concentrations within the Leviathan Field survey area were well below this threshold.

Proposed Project:

- Ambient radium concentrations in most soils and rocks are approximately 0.5 to 5.0 pCi g^{-1} (Marine Ventures International, Inc., 2021b).
- Average radium and thorium concentrations within the Leviathan Field were well below this remediation threshold. Average radium and thorium concentrations were generally similar to the LBB concentrations.

Table 1-19. Concentrations (pCi g^{-1}) and mean concentrations of radionuclides (radium [Ra] 226, Ra 228, and thorium [Th] 228) in sediment from the Leviathan Field (2020 survey) and mean 2014 survey concentrations and Levantine Basin Baseline data for comparison.

Location	Station	Ra 226	Ra 228	Th 228
Leviathan Field	E03	0.86	0.6	0.63
	G03	0.8	0.33	0.5
	H06	0.58	0.76	0.7
	H07	0.91	0.5	0.55
	2020 Leviathan Field Mean	0.79 ± 0.15	0.55 ± 0.18	0.60 ±0.09
	2014 Leviathan Field Mean	0.35 ± 0.08	0.68 ± 0.28	0.53 ±0.06
Levantine Basin Baseline (LBB)[1] (Mean ± SD; upper 99% CL)		0.42 ± 0.12; 0.73	0.57 ± 0.22; 1.14	0.61 ± 0.08; 0.82

[1] Mean calculated from pre-drill and environmental baseline surveys conducted by CSA prior to December 2013; updated 20 August 2014.
CL = confidence limit; Ra = radium; SD = standard deviation.

Sediment Polychlorinated Biphenyls (PCBs)

Sediment polychlorinated biphenyl (PCB) concentrations within the Leviathan Field are provided in CSA (2016).

Key Findings:
- 10% of all sediment stations sampled in the Leviathan Development Program were sampled for 44 PCB congeners. Of that representative sample, eight stations were in the Leviathan Field. PCBs were not detected from the eight sediment samples from the Leviathan Field sampling grid.

Proposed Project:
- There are no known recent published papers which outline PCB concentrations near the Leviathan Field. Existing information presented in CSA (2016) is deemed sufficient for assessment purposes.

1.8.2 Total Suspended Particulates

Key Findings:
- During the Background Monitoring Survey, turbidity was consistently low throughout the water column ranging from 0.03 NTU at the surface to 0.19 NTU near the bottom, consistent with prior CSA findings (**Figure 1-32**).

Proposed Project:
- Total Suspended Solids (TSS) values averaged 4.7 ± 0.49 mg L^{-1} in near-surface water, 5.56 ± 1.24 mg L^{-1} at mid-depth, and 5.3 ± 2.51 mg L^{-1} in the near-bottom.
- Turbidity was consistently very low throughout the water column, similar to values observed during the 2014 Survey, ranging from 0.08 NTU in surface waters to approximately 0.06 NTU near the bottom (2014 values were 0.03-0.19 NTU) (Marine Ventures International, Inc., 2021b).

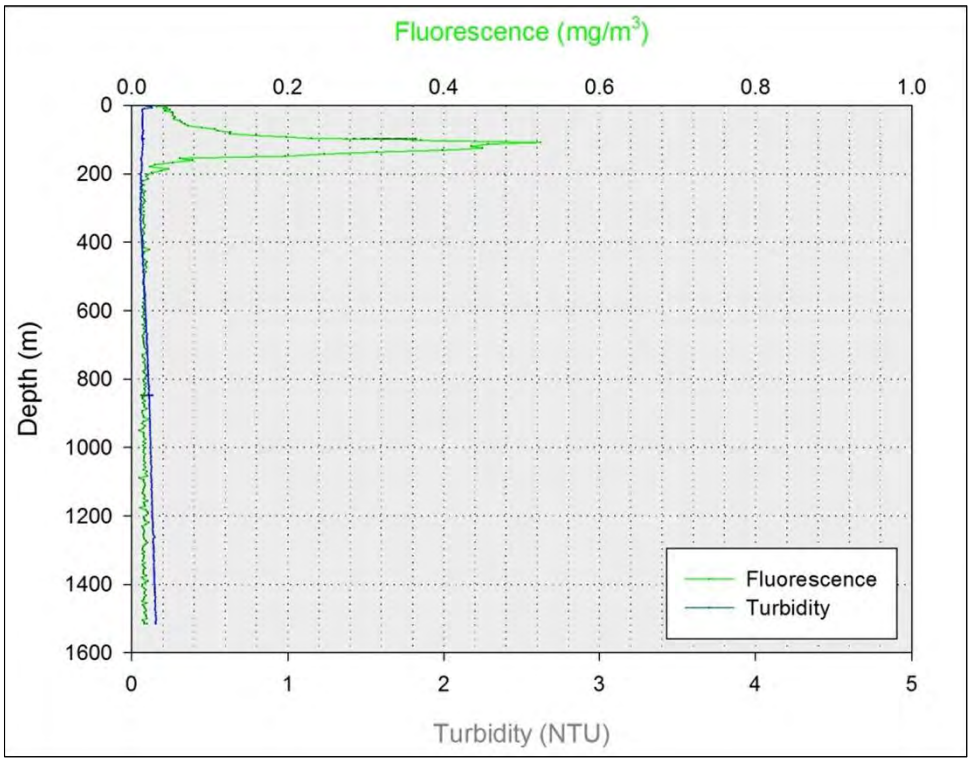


Figure 1-32. Representative fluorescence and turbidity water column profiles for Station F05 in the Leviathan Field survey area, collected on 2 May 2014.

1.8.3 Chlorophyll/Fluorescence

Key Findings:

- Fluorescence was highest in the photic zone (less than 200 m), with a DCM at 95 m. Diel vertical migration of phytoplankton has been observed in response to changing light intensities. Fluorescence was high in shallow depths at midday, reaching a maximum value of 0.98 mg/m^3. Findings of the Background Monitoring Survey are consistent with previous hydrographic profiles conducted by CSA in the region (**Figure 1-33**).

Proposed Project:

- Fluorescence, which provides an indication of chlorophyll concentration within the water column, reached maximum values (deep chlorophyll maximum) at a water depth of approximately 62 m. Daily fluctuations were observed in fluorescence intensity across the top 200 m of the water column, indicating a diel pattern of vertical migration by phytoplankton in response to changing light intensities.

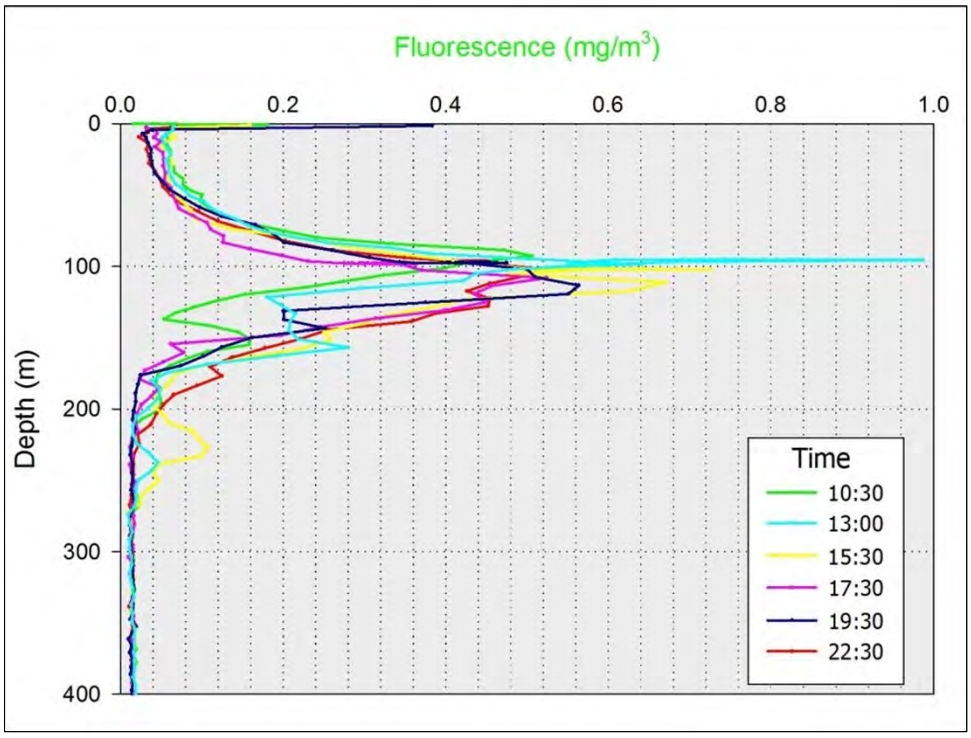


Figure 1-33. Fluorescence water column profile for Station F05 in the Leviathan Field survey area collected on 2 May 2014. Each colored line represents a different time of day for the survey area. Fluorescence, providing an estimate of phytoplankton biomass, was high at shallow depths around midday (light blue line), followed by a deepening and weakening later in the day.

1.8.4 Water Column Properties

1.8.4.1 Hydrography

Key Findings:

- Previous hydrographic profiles conducted by (CSA, 2015b) showed that environmental conditions at depths below approximately 200 m are uniform with temperatures of approximately 13.8°C, salinities of approximately 38.8 PSU, and DO saturation at approximately 70%. Seasonal effects alter conditions in depths shallower than 200 m (**Figure 1-34**). It should be noted that while the photic zone is often referred to as the top 200 m of the water column, the depth of the photic zone can vary based on regional weather conditions, turbidity, water temperature, and other factors.
- Dissolved oxygen concentrations collected in May 2014 were highest in the upper mixed layer with a maximum DO level of 6.98 mg/L and 98% saturation below 95 m, a minimum DO level of 5.45 mg/L and 67% saturation at 576 m, and a slight increase in DO concentrations near the bottom (i.e., 5.74 mg/L and 70.6% saturation) (**Figure 1-35**).
- Hydrographic profiles conducted in the Leviathan Field in May 2014 showed the first signs of seasonal stratification in the upper surface waters (less than 200 m). Temperature reached a maximum of 21.03°C at the surface and 13.72°C at a depth of 915 m. Salinity was 39.32 PSU at the surface and stabilized at 38.77 PSU from the base of the permanent halocline (**Figure 1-36**).
- Previous hydrographic profiles conducted by CSA in the region indicated that environmental conditions at depths below 200 m are uniform, with DO saturation at approximately 70%.

Proposed Project:

- Water temperature reached a maximum of approximately 20.6°C at the surface, decreased through the thermocline before reaching a minimum of approximately 13.77°C at a depth of 1,025 m, and slightly increased near the bottom to 13.8°C. A maximum salinity of 39.4 was recorded near the surface and gradually stabilized with increasing water depth to 38.8 at the seafloor (Marine Ventures International, Inc., 2021b).
- DO in the water column increased slightly below 568 m to approximately 5.76 mg L^{-1} and 71% saturation near the bottom. Water temperature at all depths, salinity, and dissolved oxygen values were nearly identical to those recorded during the 2014 Survey (Marine Ventures International, Inc., 2021b).

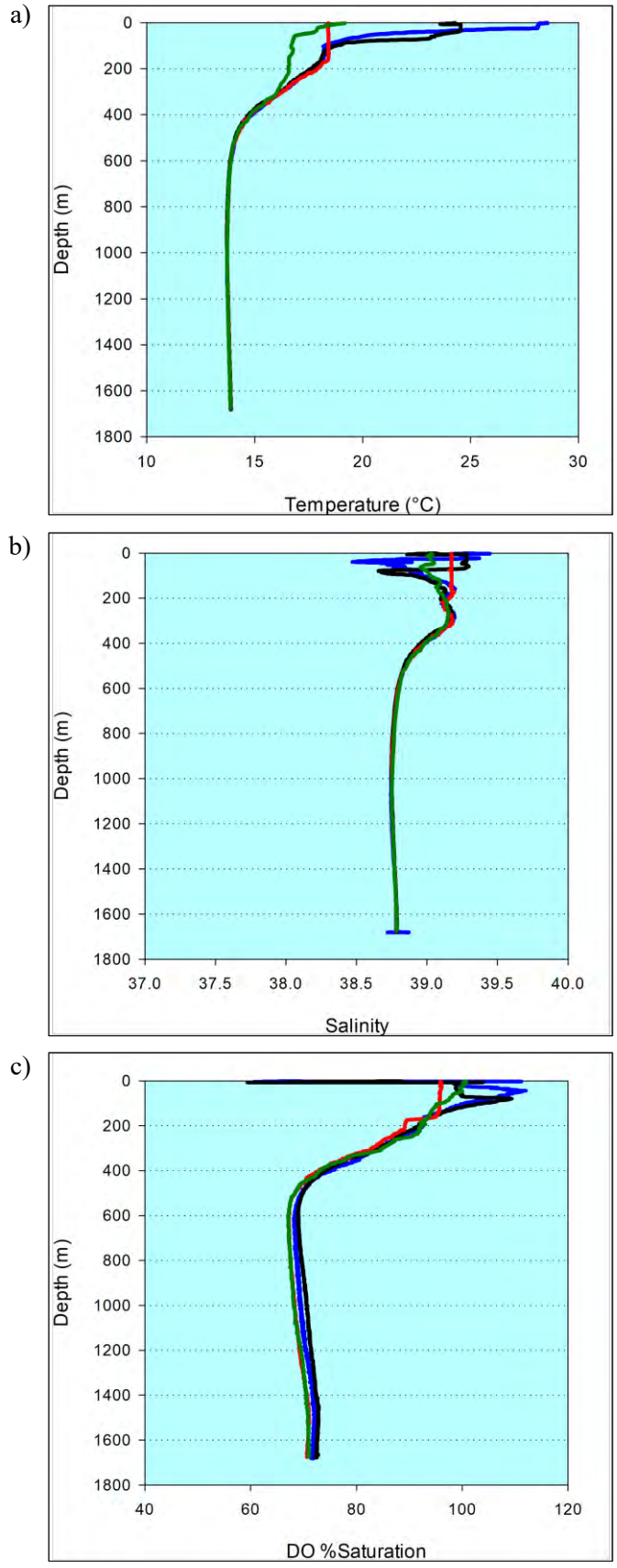


Figure 1-34. Seasonal hydrographic profiles from the Leviathan 2 wellsite for a) temperature, b) salinity, and c) dissolved oxygen. Comparison of autumn (black), summer (blue), winter (red), and spring (green) (Adapted from: CSA, 2015b).

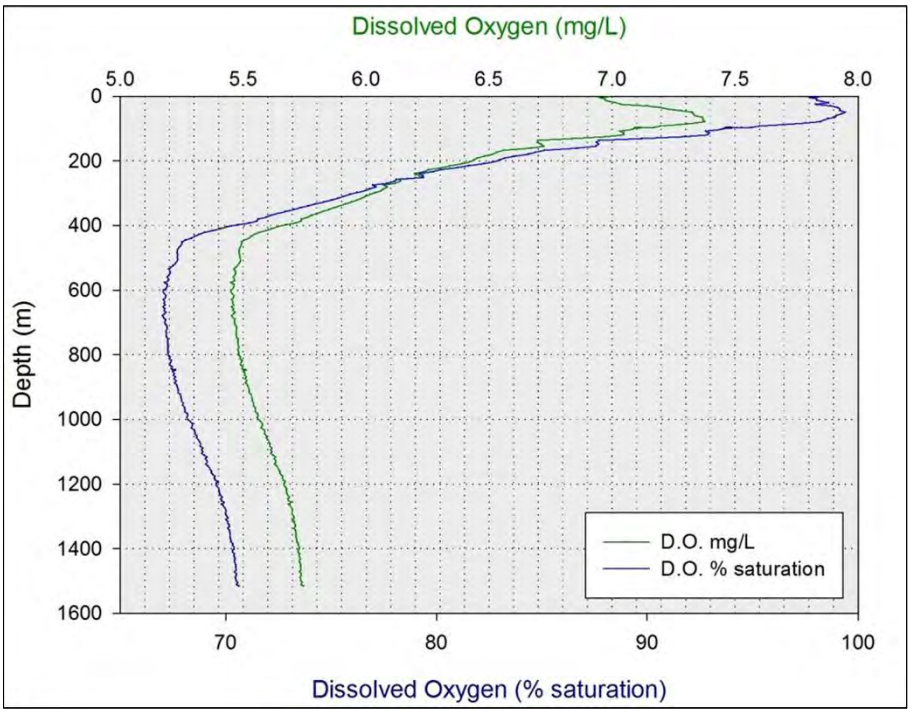


Figure 1-35. Representative temperature and salinity profiles for Station F05 in the Leviathan Field survey area, collected on 2 May 2014.

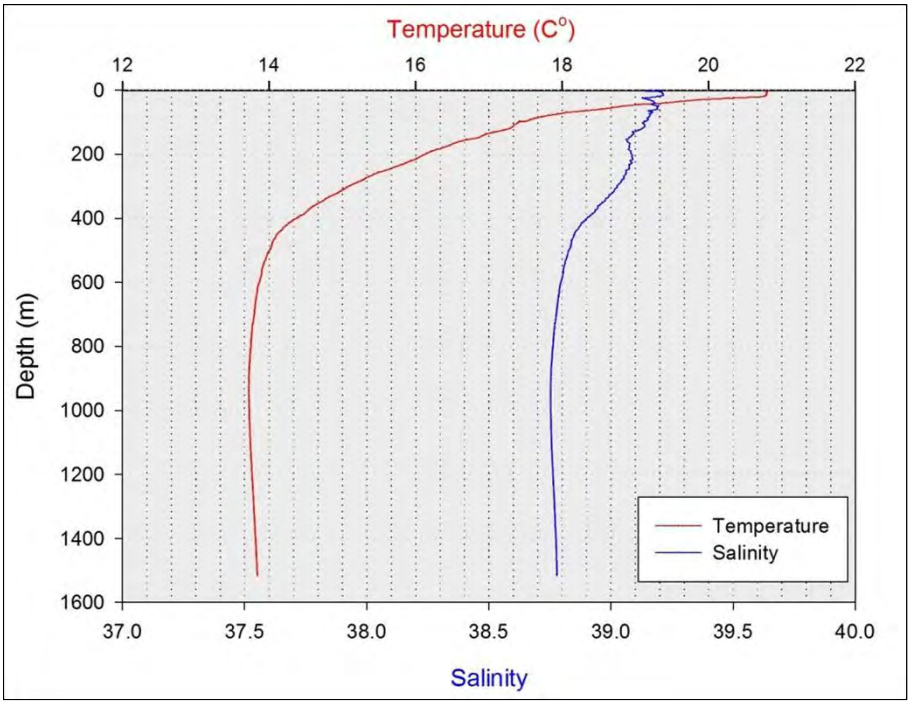


Figure 1-36. Representative dissolved oxygen profiles for Station F05 in the Leviathan Field survey area, collected on 2 May 2014.

1.8.5 Sediment Quality – EBS

Results of the EBS sampling efforts in the Leviathan Field were summarized previously; see **Section 1.8.1.2** and supporting **Tables 1-17** through **1-19** and relevant figures.

1.9 CULTURE AND HERITAGE SITES

CSA (2016) and Genesis (2016) previously provided a discussion for Cultural and Heritage Sites (see Section 1.8 of the CSA [2016] document and Section 1.8 of the Genesis [2016] document).

Key Findings:
- Geoscience Earth & Marine Services (GEMS) conducted seafloor, shallow geologic, and archaeological assessments in the Leviathan Field.
- High-resolution sub-bottom profiler, side-scan sonar, and multibeam bathymetry and backscatter data were collected by an autonomous underwater vehicle (AUV) for this assessment.
- The archaeological assessment delineated 397 unidentified side-scan sonar contacts, 38 of which were interpreted to represent possible cultural resources with potential archaeological significance.
- All of the information about side-scan sonar contacts that may represent wreck sites with high potential for historical or archaeological significance was submitted to the Marine Archaeology Unit at Israel Antiquities Authority for further assessment and evaluation.

Proposed Project:
- All drilling activity to be performed in the Leviathan development framework shall maintain a security distance of at least 305 m from any archaeological sites (per the accepted Gulf of Mexico standard ref: BOEM NTL No. 2005-G07, January 1, 2005, United States Department of the Interior – Minerals management Service – Gulf of Mexico Region). It should be noted in the EIA document that all of the material required, in accordance with the guidelines, shall be sent to the Israel Antiquities Authority's Marine Archaeology Unit.

1.10 METEOROLOGY AND AIR QUALITY

1.10.1 Existing Meteorological Conditions

CSA (2016) and Genesis (2016) previously provided a discussion for Meteorology and Air Quality (see Section 1.9.1 of the CSA [2016] document and Section 1.9.1 of the Genesis [2016] document).

Key Findings:
- No site-specific meteorological data are available from the Leviathan Field area.
- Israel's subtropical location between 29° and 33° N latitude generally brings long, hot, dry summers and short, cool, rainy winters, as modified locally by altitude and latitude.
- The cold period (December to March) is characterized by the low circulation associated with intense cyclogenetic activity (Kallos et al., 1993; Kassomenos et al., 1995).
- The warm period (June to September) is characterized by high circulation where the North Atlantic lows pass over Europe and only edges of the fronts reach the northeastern part of the Mediterranean.

- During the warm period, the entire Mediterranean region is occupied by anticyclonic activity and large-scale subsidence. This period of the year is highly controlled by the balance between the North Atlantic anticyclone and the monsoon activity over the Indian Ocean and the Middle East. During the transitional seasons of spring (April to May) and autumn (October to November), the synoptic circulation varies between cold and warm types.

Proposed Project:
- Existing information presented in CSA (2016) and Genesis (2016) is deemed sufficient for assessment purposes.
- Data from 2024 recorded highest daily air temperatures ranging from approximately 18°C in January to 35°C in June, July, and August (Weatherspark, 2025).
- Haifa receives an annual mean rainfall of 539 mm, with the greatest amounts during the cold period (December to March) and virtually no precipitation during the warm period (June to September) (Weatherspark, 2025).

1.10.2 Special Meteorological Conditions

There are no special meteorological conditions within or adjacent to the Leviathan Field that might create dispersion conditions that could result in high concentrations of air pollutants in the vicinity of the Leviathan Expansion Project.

1.10.3 Air Quality

CSA (2016) previously provided a discussion for Meteorology and Air Quality (see Section 1.9.2 of the 2016 document).

Key Findings:
- No site-specific meteorological data are available for the Leviathan Field area.
- Given the distance of the Leviathan area from shore (120 km), air quality is expected to be good.
- There are no known special meteorological conditions that might cause conditions of dispersal that will give rise to high air pollution concentrations in the Application Area.
- Three major synoptic weather types are conducive to short-term air quality problems in coastal Israel (Dayan and Levy, 2002):
    - Red Sea Trough: 29% occurrence, mainly during autumn; brings light winds with hot/dry air.
    - Anticyclone: 25% occurrence, mainly in spring; leads to stagnation caused by weak pressure gradient over Israel.
    - Shallow Persian Trough: 20% occurrence, mainly during summer; leads to subsidence and stabilization of the atmosphere.

Proposed Project:
- Existing information presented in CSA (2016) is deemed sufficient for assessment purposes. All fuel used for the project will have a sulfur percentage of less than 0.1%, and all vessels will comply with MARPOL Annex VI regulations.

1.11 NOISE

CSA (2016) and Genesis (2016) previously provided a discussion for Noise (see Section 1.10 of the CSA [2016] document and Section 1.10 of the Genesis [2016] document).

Key Findings:
- There are no site-specific measurements of underwater noise in the Application Area.
- Shipping noise (frequencies below 300 Hz) from propellers (most dominant), thrusters, machinery, and hydrodynamic noise (hull movement) are likely to be the main contributors of noise for the area (Wenz, 1962; Ross, 1976; Hildebrand, 2009; McKenna et al., 2012).

- Ambient noise measured in the shallow waters offshore Haifa exhibited characteristics of medium to heavy shipping noise (Potter et al., 1997).

Proposed Project:
- Existing information presented in CSA (2016) and Genesis (2016) is deemed sufficient for assessment purposes.

1.12 INFRASTRUCTURE AND MARINE TRANSPORTATION SYSTEM

1.12.1 Telecommunications Cables

CSA (2016) and Genesis (2016) previously provided a discussion for Telecommunications Cables (see Section 1.11.1 of the CSA [2016] document and Section 1.11.1 of the Genesis [2016] document).

Key Findings:
- All of the drill sites are more than 1 km away from the nearest cable (**Table 1-20**).
- A MedNautilus submarine telecommunications cable passes through the middle of the Leviathan Field in a west-northwest to east-southeast direction and is part of a regional fiber optic network connecting the Mediterranean region to Western Europe and the United States
- The north-south oriented MINERVA cable shown is a subsystem of MedNautilus. All of the drill sites are more than 1 km away from the nearest cable.

Proposed Project:
- No new fiber optic cables have been installed in the Leviathan infield area since Phase 1 of the Leviathan Development was completed. One of the proposed flowlines will cross the MedNautilus cable (**Figure 1-37**).

Table 1-20. Minimum distances to the nearest telecommunications cable and existing wellsites for each proposed drill site.

Drill Site	Proximity to Telecommunication Cables		Proximity to Existing Wellsites	
	Nearest Cable	Minimum Distance (km)	Nearest Existing Wellsite	Minimum Distance (km)
Leviathan-10	MedNautilus	1.01	Leviathan-3	3.31
Leviathan-11	MedNautilus	2.00	Leviathan-3	2.70
Leviathan-23	MedNautilus	6.79	Leviathan-8	2.83

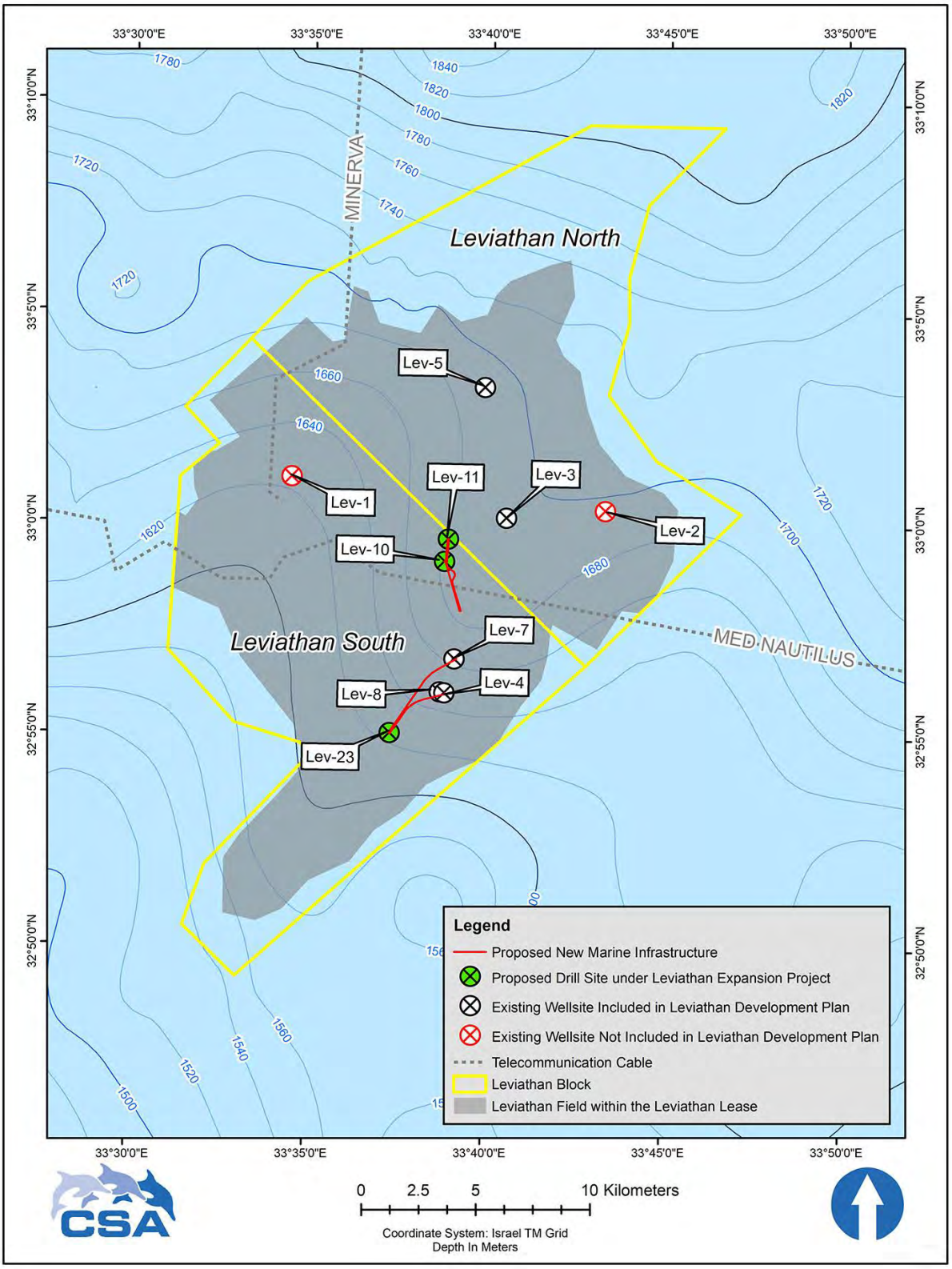


Figure 1-37. Locations of existing marine infrastructure (telecommunications cable and previous drill sites) in relation to existing wellsites and the three proposed drill sites and proposed marine infrastructure under the Leviathan Expansion Project.

1.12.2 Shipping Lanes

CSA (2016) and Genesis (2016) previously provided a discussion for Shipping Lanes (see Section 1.11 of the CSA [2016] document and Section 1.11.2 of the Genesis [2016] document).

Key Findings:

- The Leviathan Field is not located within a shipping lane. The nearest lanes are those approaching the port of Haifa.

Proposed Project:

- Existing information presented in CSA (2016) and Genesis (2016) is deemed sufficient for assessment purposes.

Chapter 2: Location and Technological Alternatives and the Justifications for the Selected Alternative

2.1 GENERAL

CSA (2016) provided a description of general activities planned for Leviathan Field drilling and completion operations and provides a breakdown of specific EIA sections which addressed preferred locations and potential alternatives (see Section 2.1 of the CSA (2016) document). Genesis (2016) provided a discussion of the original Leviathan Field development plan regarding infrastructure installation. New information for the proposed Leviathan Expansion Project is detailed below under individual entries for the proposed project.

Key Findings:

- CML (previously NEML) proposed to conduct well drilling and completion activities in the Leviathan Field. This chapter explained the options that were evaluated in selecting the initial well locations and drilling technology.

CML has, during the course of engineering for the Leviathan Expansion Project, reconsidered those options pertaining to future wells and have matured decisions on location of such future wells, the approaches and the technologies used to develop the wells.

2.2 LOCATION ALTERNATIVES

2.2.1 Well Location Alternatives

CSA (2016) provided a description Overview and Application, as originally planned and a breakdown of proposed well locations and alternatives; the rationale for well locations was presented in Section 2.2.1 of the 2016 document. New information for the Leviathan Expansion Project is outlined below.

Proposed Project:

- The proposed CML development plan for the Leviathan Field includes drilling and completion of three new wells, as well as the installation of subsea production trees. The well locations were selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, and appraisal. The specific locations of the wells also considered shallow hazard evaluations and avoidance of potential archaeological contacts.
- The number and routing of the three new LEP infield flowlines and two new infield umbilicals were selected to enable and support production from the three new wells, while following the same proven philosophies and guiding location and route decision making principles adopted for the initial Leviathan Field development. These include minimizing number of crossings, occupying the smallest land-use footprint and therefore minimizing impact to seabed by selecting most direct routes, avoiding sensitive communities and sites.

CSA (2016) provided a description of the Proposed Development program, as presented in Section 2.2.2 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- In order to optimize gas production and minimize water influx, the following philosophy was used by NEML (now CML):

Proposed Project:

- CML adhered to the same philosophy used previously (in 2016) during its selection of the new drill sites (i.e., targeting formations containing maximum gas reserves, with limited to no associated water).

2.2.2 Subsea Infrastructure Location Alternatives

No alternatives were considered in establishing the general layout of the Leviathan Expansion Project subsea facilities and routing of flowlines and umbilicals; the same principal drivers as used on legacy Leviathan project were employed; 1) use of the most direct flowline and umbilical routes; 2) minimize the number of crossings; 3) minimize footprint the new facilities occupy while allowing for future developments; and 4) use existing subsea (legacy Leviathan) infrastructure to the maximum extent practical.

2.2.3 Completion Philosophy and Details of Well Planning

Figure 2-1. Schematic section through the northern well cluster.

Figure 2-2. Schematic section through the southern well cluster.

2.2.4 Well Clearance and Environmental Sensitivity

CSA (2016) provided a description of the Well Clearance and Environmental Sensitivity for the drilling and completion of wells under the 2016 program; see Section 2.2.4 of the 2016 document. New information for the proposed Leviathan Expansion Project is provided below under the proposed project.

Key Findings:

- The proposed location and borehole trajectory of each individual Leviathan Field development well was selected, and the well drilling program was designed to include considerations minimizing the risk of encountering the following shallow hazards:
  - Seafloor instability – The selected locations were in relatively flat areas, located away from any seafloor channel or fault scarp;
  - Shallow faulting – The locations avoided all areas of shallow faulting at or near the seafloor; and
  - Anomalies within salt – The proposed locations were screened, using seismic interpretation, to avoid areas of significant intra-salt deformation.
- Gardline Surveys Inc. (2010, 2015) conducted geohazards surveys of the Leviathan Field and subsequently performed individual geohazard assessments for each proposed drill site and an area surrounding each (i.e., a 2,000 m radius) based on 3D seismic data. Site-specific well clearance letters were prepared and submitted as part of the application for a marine discharge permit (Discharge to Sea Permit) for each individual well. The seafloor sediments were believed to be composed of silts and clays with interbedded sands, which were expected to become firmer with increasing water depth.
- An enlarged area encompassing the entire Leviathan Field was studied to define the original drill site locations, from which the proposed locations were set to avoid potential gas hazards.
- The Leviathan Field drill sites were chosen to avoid active seafloor channels, shallow faulting, and potential shallow gas hazards associated with amplitude anomalies and low-angle slump escarpments or other seafloor topographic elements. The final location for each proposed drill site was adjusted to avoid deeper faults proximal to the original wellbore. The choice of drill sites effectively avoided intersection with small faults in the shallow, post-salt section and allowed for the setting of two successive casing points in relatively clean salt that was expected to be clean of clastic interbeds. All of these considerations helped to minimize the safety, environmental, and drilling risks at each of the proposed drill site locations.
- Additional criteria cited by NEML (now CML) in the "Guidelines for Preparation of Environmental Impact Document" included:
  - Structural analysis issues; the size of the field and the location of the target stratum – these issues were considered as part of the geological evaluation as described in **Sections 2.2.1** to **2.2.3**;
  - Landslides and liquefaction – these and other potential geohazards were evaluated on the basis of the geohazards assessment as described in the preceding paragraphs of this section.
  - Marine reserves – none were present in the Application Area;
  - "Regions defined as special regions such as ridges, canyons or deep coral reefs, sponges, clams or other sedentary organisms" – none of these regions were present in the Application Area (see benthic communities discussion in **Section 1.7.1**);
  - "Proximity to towns and residential areas, visibility and appearance from the coastline" – this was deemed not relevant due to the distance from shore (122 km for the nearest well);
  - "Habitats of animals in danger of extinction" – there were no specific "critical" habitats for endangered or threatened species in the Application Area. Endangered or threatened species that might have been present in the region were discussed in **Section 1.7.2** and were included in the impact analysis in Chapter 4;
  - Shipping lanes – There were no shipping lanes identified in the Leviathan Field; the nearest shipping lanes noted were those approaching the port of Haifa (see **Section 1.3**). Therefore, shipping lanes did not factor into the selection of drill sites;

- Infrastructure, communications and energy lines – known regional infrastructure proximal to the drill sites included 1) a MedNautilus telecommunications cable, which runs through the middle of the field; and 2) the currently "as drilled" Leviathan subsea wells (Lev-1, Lev-2, Lev-3, Lev-4, Lev-5, Lev-7 and Lev-8) (see **Section 1.12**). The drill sites were selected to avoid any physical impacts to the telecommunications cable; all of the drill sites were located more than 1 km away from the nearest cable. No seafloor-disturbing activities were to be conducted near the telecommunications cable and no impacts were expected (see Chapter 4);
- Oceanographic current regime – the local oceanographic current regime for offshore Israel was considered in the design criteria for drillship and support vessels, but there were no significant spatial differences in the oceanographic current regime within the Leviathan Field. Therefore, it was not a factor in selecting individual drill sites; and
- Fish reproduction zones and times; fishing areas – there were no fish reproduction zones or fishing areas in the Leviathan Field.

Proposed Project:
- New site clearance letters have been received by CML for each of the three proposed drill sites outlined in the Leviathan Expansion Project. In addition, clearance letters for the three new infield flowlines and two new umbilicals have also been developed.

2.3 TECHNOLOGICAL ALTERNATIVES

CSA (2016) provided a description of Technological Alternatives considered at the time the EIA was prepared (see Section 2.3 of the 2016 document). New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Technological alternatives were evaluated including drillship, drilling technology, the drilling mud program, and cuttings treatment technology.
- Technological subsea development alternatives, including route and equipment site selection, installation methods, and testing and pre-commissioning methods, were evaluated to ensure that the new infrastructure is safe, uses the smallest land-use footprint, and minimizes the days offshore required for installation and testing activities.

Proposed Project:
- Managed Pressure Drilling (MPD) will be evaluated for use during drilling of the Leviathan Expansion Project wells. This would be the first application by CML in Israel, if utilized. MPD is defined by the American Petroleum Institute as an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. This technique helps in mitigating risks and costs associated with drilling wells that have narrow downhole environmental limits by proactively managing the annular hydraulic pressure. MPD can be particularly useful for drilling in depleted reservoirs by maintaining a constant bottom hole pressure and minimizing additional pressure acting on the formation utilizing lower mud weights and compensating with surface back pressure to reduce chance of lost circulation.
- Design of subsea facilities supporting the development of the three new wells remains largely unchanged in comparison with design of existing Leviathan facilities. CML is evaluating alternative methods for flowline installation including the use of the Reel-lay flowline installation method for the infield flowlines and is evaluating an alternative dry pre-commissioning method.
- Reel-lay installation method involves pre-fabrication of all flowlines onshore, at an existing spool bases, followed by reeling the flowlines onto the installation vessel reel and sailing the vessel to installation location where the flowlines will be installed onto the seabed. Reel-lay is a well-known, proven, standardized and proceduralized installation methodology. It has some advantages including shorter vessel time in the field and good flowline fabrication quality. A key disadvantage is the long-distance vessel transit between the pipe spool bases (located in North Sea ports) to the Leviathan Field area.

- Alternatively, subsea flowlines may be installed by a combination of S-lay and J-lay installation method as previously used in Leviathan Field.
- Dry pre-commissioning is being evaluated by CML as an alternative to most commonly used pre-commissioning methodology involving flooding, pigging and cleaning, gauging, pressure testing and preservation of installed flowlines as was used for the existing Leviathan flowlines. Dry pre-commissioning is a novel methodology, eliminating the need to flood, clean, gauge and pressure test as-installed flowline by applying increased rigor during pipeline design, fabrication and installation controls to ensure the as-installed flowline is fit for purpose. The advantage of this methodology is in reduced offshore scope therefore improving safety and efficiency while reducing emissions and discharges into the environment.

2.3.1 Drilling Vessel, Blowout Preventer, Drilling Muds/Fluids

2.3.1.1 Type of Drilling Rig

CSA (2016) provided a description of the Type of Drilling Rig proposed (see Section 2.3.1 of the 2016 document). New information for the Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Well control equipment was rated at 10,000 psi capacity; and
- An 18¾-inch blowout preventer (BOP) system with dual annulars and 4 ram-type preventers was also proposed.

Proposed Project:
- A drillship for the Leviathan Expansion Project drilling and completion activities will be used and selected at a later date during the tendering process. The proposed drillship is expected to be with similar capabilities to that used for drilling the Lev-8 well.
- Based on the technical requirements for the drilling program, CML determined that a dynamic positioning (DP) drillship is preferred with the following general specifications:
  - Maximum drilling depth capability in excess of 10,700 m;
  - Minimum working water depth capability greater than 1,700 m;
  - Well control equipment rated at >10,000 psi capacity;
  - 18¾-inch 10K blowout preventer (BOP) system with dual annulars and 4 ram-type preventers;
  - Four mud pumps;
  - Bulk storage of cement and of barite;
  - Fluid storage for active and reserve pits and additional storage of brine;
  - Pipe and tubular handling for all drill pipe, casing, and tubing required for the project; and
  - Experience with completion and well-testing operations.

2.3.1.2 Drilling Technology

CSA (2016) provided a description of Drilling Technology (see Section 2.3.2 of the 2016 document). New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- **Rotary steerable systems:** Designed to drill vertically or directionally with continuous rotation from the surface, eliminating the need to slide a steerable motor. With a steerable drilling system, penetration rates are improved because there are no stationary components to create friction that reduces efficiency and anchors the bottom hole assembly (BHA) in the hole. The flow of cuttings past the BHA is enhanced because annular bottlenecks are not created in the wellbore. State of the-art rotary steerable systems have minimal interaction with the borehole, thereby preserving borehole quality. The most advanced systems exert consistent side force similar to traditional

stabilizers that rotate with the drill string or orient the bit in the desired direction while continuously rotating at the same number of rotations per minute as the drill string. They offer precise steering control that maximizes reservoir contact for increased production. The technology reduces the uncertainty of drilling away from the target, due to deviation prone sections (salt sections). The precision steering system can be combined with polycrystalline diamond compact bits, modular motors, near-bit sensors, measurement while drilling and logging while drilling tools. Based on real time formation evaluation, better reservoir navigation decisions can be made.

- **Polycrystalline diamond compact bits:** Provide superior directional control, longer run life, improved rate of penetration, enhanced durability, and better drilling efficiency. The synthetic diamond disks shear the rock with a continuous scraping motion. Polycrystalline diamond compact bits are effective at drilling shale formations, especially when used in combination with oil-based muds.
- **Modular motors:** Positive displacement drilling motors that use hydraulic horsepower of the drilling fluid to drive the drill bit. Mud motors are used extensively in jetting in conductor casing and directional drilling operations.
- **Near-bit sensors:** Placed below rotary steerable systems can accurately pick a casing point with bit only 2.5 m below. The data are transmitted to the surface along with other logging while drilling data further up in the BHA without any signal detection issues. This helps steer the hole section to the best place in less time.
- **Measurement while drilling (MWD):** Provides evaluation of physical properties, usually including pressure, temperature, and wellbore trajectory in 3D space, while extending a wellbore. MWD is now standard practice in offshore directional wells. The measurements are made downhole, stored in solid-state memory for some time and later transmitted to the surface. Data transmission methods vary from company to company, but usually involve digitally encoding data and transmitting to the surface as pressure pulses in the mud system. These pressures may be positive, negative, or continuous sine waves. LWD tools use similar data storage and transmission systems, with some having more solid-state memory to provide higher resolution logs after the tool is tripped out than is possible with the relatively low bandwidth, mud pulse data transmission system.
- **Logging while drilling (LWD):** Provides measurements of formation properties during the excavation of the hole or shortly thereafter, through the use of tools integrated into the BHA. LWD has the advantage of measuring properties of a formation before drilling fluids invade deeply. Further, many wellbores prove to be difficult to measure with conventional wireline tools. Timely LWD data can be used to guide well placement so that the wellbore remains within the zone of interest or in the most productive portion of a reservoir.

Proposed Project:

- A similar scope of drilling technologies is expected for the Leviathan Expansion Project.

2.3.1.3 Blowout Preventer Technology

CSA (2016) provided a description of Blowout Preventer Technology (see Section 2.3.4 of the 2016 document). New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- As noted in CSA (2016), the leaseholder at the time (NEML; now CML) and the drillship's owner engaged in a comprehensive inspection and testing of the drillship's subsea BOP system to ensure compliance with the U.S. Bureau of Safety and Environmental Enforcement (BSEE) regulations. The inspection and testing were witnessed and certified by a third-party surveyor.

Proposed Project:

- See **Section 3.2.4**.

2.3.1.4 Drilling Mud Selection and Cuttings Treatment Technology

CSA (2016) provided a description of Drilling Mud Selection and Cuttings Treatment Technology (see Section 2.3.3 of the 2016 document). New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- At the time of preparation of CSA (2016), all but one of NEML's (now CML) wells offshore Israel had been drilled using water-based mud (WBM). A deep hole portion of Lev-1 was drilled using mineral oil-based mud (MOBM) with the cuttings transported onshore.
- WBM has been used worldwide in offshore drilling for more than 50 years.
- WBM is inefficient and has resulted in large amounts of operational inefficiency (approximately 15% to 20% longer time to drill wells).
- To make WBM technically viable, NEML (now CML) needed to add a large number of specialty chemicals (e.g., glycols, bactericides, potassium, and special shale inhibitors) that have increased the complexity of managing the drilling program in an environmentally responsible manner.
- Use of MOBM could result in a reduction of as much as 20% of the time required to drill due to increased rates of penetration, reduced hole-stability issues, and fewer electronic failures currently experienced with the use of salt-saturated WBM.
- NEML's (now CML) preferred option for the Leviathan Field Development Program is to use MOBM due to increased operational efficiency, shale inhibition, wellbore stability, and lubricity while reducing drilling time and chemical usage.
- mud system (**Appendix E**), a high-performance invert emulsion fluid system developed by Baroid (a product service line of Halliburton) with ExxonMobil Chemical's as the base fluid is NEML's (now CML) preferred MOBM option for the Leviathan Field Development Program.

Proposed Project:

- CML intends to use a similar drilling mud program as employed during the drilling of Lev-8. Specifically, this will include the following main stages:

- WBM cuttings disposal will be to the seafloor, with the amount of cement designed to reach the seafloor with a target to minimize excess; and
- Cuttings from the oil-based mud sections will not be discharged at the seabed or overboard at the drillship. All MOBM cuttings throughout the entire Leviathan Expansion Project drilling campaign are expected to be shipped to shore via skip and ship tanks for disposal. Any MOBM cuttings treatment on board the drillship will be evaluated once the drillship is identified and a drilling fluids company is contracted.

Currently, CML anticipates using a base fluid similar to for the mud system (**Appendix E**).

2.3.2 Infrastructure Components

CML expects to use similar infrastructure components as were previously installed for Phase 1 of the Leviathan Field Development and no new alternatives were considered. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Proposed Project:
- The Leviathan Expansion Project will optimize Leviathan production capabilities by installing three new subsea wells, with associated production trees, flowlines, jumpers, infield umbilicals, communication distribution units and flying leads. The new wells will be connected to the existing M1 manifold through new or existing flowlines. Additional information on the proposed infrastructure is presented in **Section 3.2.8**.
- Technological alternatives (e.g., dry pre-commissioning) are discussed in **Section 2.3.4**. Dry pre-commissioning is a novel methodology, eliminating the need to flood, clean, gauge and pressure test as-installed flowlines by applying increased rigor during pipeline design, fabrication and installation controls to ensure the as-installed flowline is fit for purpose. Several advantages include improving safety and efficiency and reducing emissions and discharges into the environment. CML continues to evaluate the potential for this alternative within the Leviathan Expansion Project.

2.3.3 Hazardous Materials

Hazardous materials are discussed in **Section 3.5**, including specific materials required for select applications, as well as references to storage, safety levels, risks, emissions, leaks detection abilities and treatment.

2.3.4 Alternative Selection

While the selection of the most appropriate alternatives for the Leviathan Expansion Project was based on efficient installation and operation of project components to maximize production, the CML approach was driven primarily by their corporate policies regarding environmental protection. CML priorities to help protect the environment included responsible design, development, operations and retirement of assets through the entire life cycle of the project. By considering potential environmental risks during planning, CML intended to enhance environmental performance by identifying and selecting alternatives which allow for the prevention or mitigation of potential environmental impacts. CML's Operational Excellence Management System (OEMS) environment focus area promotes systematic consideration of business risks and environmental performance alongside stakeholder expectations. Impacts and mitigation measures are addressed in **Chapter 4**.

2.3.5 Flowline Installation Methodology

In addition to S-lay flowline installation methodology previously used on legacy Leviathan Project, J-Lay and the Reel-lay flowline installation methodologies are currently being evaluated by the Leviathan Expansion Project. Use of such alternative installation methodologies would entail the use of purpose-built installation vessels.

2.3.6 Flowline Pre-commissioning Methodology

A second area where use of alternative methodologies is being considered is the flowline pre-commissioning. Instead of traditional pre-commissioning involving flooding, cleaning, gauging, hydrotesting, dewatering and drying, a dry pre-commissioning methodology is being evaluated, eliminating the need for flooding and hydrostatic testing by enhanced quality assurance and control during design, manufacturing and installation.

2.4 SUMMARY

CSA (2016) provided a summary of the major topics addressed in this section (see Section 2.4 of the 2016 document). New information for the Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- In CSA (2016), Table 2-3 provided a summary of major findings pertinent to well location alternatives, drillship, drilling technologies, drilling mud programs, cuttings treatment technology, and blowout preventer selection.

Proposed Project:

- For Leviathan Expansion Project drilling and completion, a summary of the well location alternatives, drillship, drilling technologies, drilling mud program, cuttings treatment technology, blowout preventer selection, and flowline installation and pre-commissioning is provided in **Table 2-1**. A summary of subsea infrastructure installation alternatives, including location, infrastructure components, and installation and pre-commissioning options, is also presented in **Table 2-1**.

Table 2-1. Summary of alternatives for well and subsea infrastructure location, drillship, drilling technologies, drilling program, muds and cuttings treatment, blowout preventer selection, and infrastructure components, installation, and pre-commissioning for the Leviathan Expansion Project.

Subject	Proposed Action	Alternatives Evaluated and Ratings		Reference
Well locations	CML's development plan includes the identification of three well locations which were selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and appraisal.	**RATING: Acceptable** The number and location of wells was selected to satisfy early production needs, provide optimal drainage of gas, and provide reservoir surveillance. Initial well locations have been selected based on the interpretation of seismic and geophysical survey data as well as results from previous exploratory and appraisal wells in the region. Geohazards and environmental factors were considered.		Section 2.2.1 Section 3.2
Subsea infrastructure location	CML intends to use the most direct flowline and umbilical routes, minimize the number of crossings, minimize the seafloor footprint while allowing for future developments, and using existing infrastructure to the maximum extent practical.	**RATING: Acceptable** No additional alternatives were considered for infrastructure location, given the merits of the proposed action.		Section 2.2.2
Type of drillship	One drillship will be used to conduct the drilling and completion operations. CML has not selected the specific drillship, but plans to use a DP3 drillship (e.g.,).	**DP Drillship or DP Semisubmersible** **RATING: Acceptable** A DP drillship or semisubmersible can meet CML's specifications.	**Moored Semisubmersible** **RATING: Less Suitable** A moored semisubmersible would be less practical in these water depths and would create additional environmental impacts due to seafloor disturbance.	Section 3.2.2
Drilling technology	The initial drilling plan includes vertical and sidetrack (directional) wells. The new wells are planned as vertical wells where possible but directional where required to avoid shallow hazards. Key drilling technologies include rotary steerable systems, polycrystalline diamond compact bits, modular mud motors, near-bit sensors, measurement while drilling, and logging while drilling.	**RATING: Acceptable** The design of individual wells will be based on CML's evaluation of reservoirs and is intended to satisfy early production needs, result in optimal drainage of gas, and provide reservoir surveillance. Drilling technologies will be selected based on CML's experience as most suitable for the safety and efficiency of the drilling program.		Section 3.2

Table 2-1. (Continued).

Subject	Proposed Action	Alternatives Evaluated and Ratings		Reference
Cuttings treatment and disposal	CML proposes to discharge WBM cuttings to the ocean at each of the drill sites.	**Offshore Disposal** **RATING: Acceptable**		Section 2.3.1 Section 3.6.2 Appendix E
	Cuttings from the MOBM portion of each well will be transferred to a supply vessel and into skip and ship tanks to be taken to land for disposal.	**Onshore Disposal** **RATING: Acceptable** MOBM cuttings will be transferred to a supply vessel and processed for land-based disposal. The cuttings would need to be disposed of at the Ramat Hovav or other certified waste site in Israel, or exported to a recycling facility in a nearby country (e.g., Cyprus). The cuttings would contribute to filling up the Ramat Hovav or similar facility.		
Drilling mud selection	CML plans to use a combination of water-based mud (WBM) and mineral oil-based mud (MOBM).	**WBM and MOBM Combination:** **RATING: Acceptable** This alternative will allow CML to drill efficiently while maintaining proper well control, rheological control, inhibition capability, and lubricity. The MOBM system was selected based on its technical performance and environmental characteristics.	**WBM Only:** **RATING: Less Suitable** Using WBM exclusively would be less efficient, extend drilling time, and would require the use of numerous specialty chemicals.	Section 2.3.1 Section 3.6.2 Appendix E
Blowout preventer (BOP) technology	CML and the drillship's owner will engage in a comprehensive inspection and testing of the drillship's subsea BOP system to ensure compliance with the U.S. Bureau of Safety and Environmental Enforcement (BSEE) guidelines in this regard.	**RATING: Acceptable** The BOP specifications to be selected will be based on best industry practice and reflect CML's commitment to safety throughout the drilling program.		Section 2.3.1 Section 3.2.5
Infrastructure components	CML expects to use similar infrastructure components as were previously installed for Phase 1 of the Leviathan Field Development and no new alternatives were considered.	**RATING: Acceptable** CML will optimize Leviathan production capabilities by installing three new subsea wells, with associated production trees, flowlines, jumpers, infield umbilicals, communication distribution units and flying leads.		Section 2.3.2
Flowline installation and pre-commissioning	CML is reviewing different options for flowline installation, and is considering the viability of dry pre-commissioning.	**Rating: Likely Acceptable** The installation methodology, whether it be S-lay, J-lay, or Reel-lay, or some combination thereof, will be based on best industry practice and will reflect CML's commitment to safety throughout the flowline installation program.		Section 2.3.3

Chapter 3: Describing the Operations Resulting from Implementing the Application

3.1 GENERAL

This chapter describes CML's plans to conduct well drilling and completion activities for the initial expansion of gas production and development in the Leviathan Field offshore Israel (Leviathan Expansion Project). CML's expansion plan includes the drilling and completion of three wells, associated wellheads, and subsea production trees, as well as the installation of three (3) new infield flowlines, two (2) new infield production control umbilicals, flying leads, and associated subsea structures to expand the existing subsea distribution system for these three (3) additional wells. Key considerations:

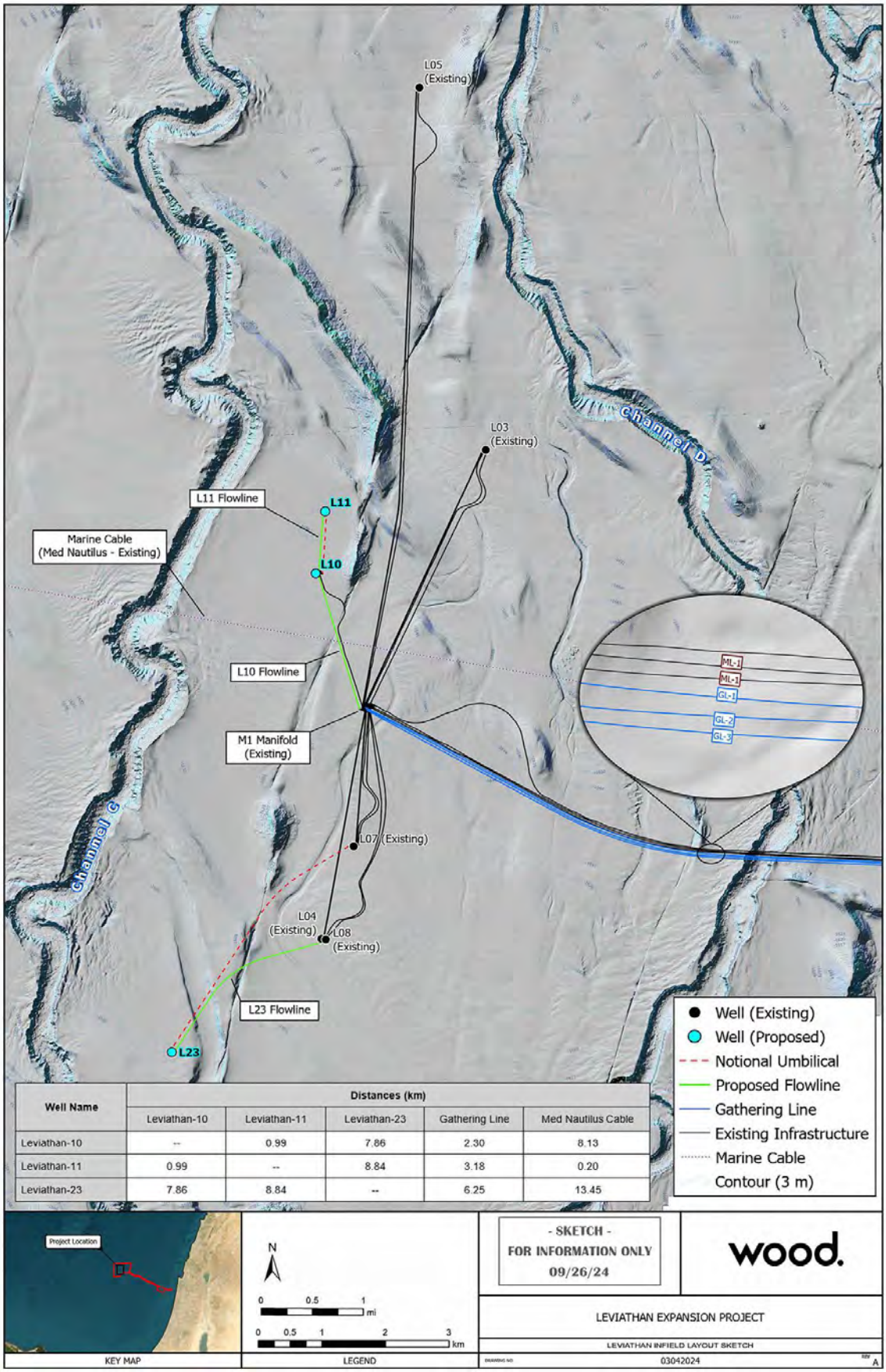
- The well locations were selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and appraisal;
- The final number and lengths of the new infield flowlines were optimized where possible by tie-ins to the existing flowlines (new IFL-23 flowline into existing IFL-4), and by comingling the production from Lev-10 and Lev-11 into a single infield flowline (IFL-L10) from the Lev-10 well to the manifold; and
- The final number and lengths of the new umbilicals were similarly optimized by tie-in to existing umbilicals:
    - New IUMB-L11 umbilical into the existing IUMB-L9 umbilical; and
    - New IUMB-L23 umbilical into the existing Lev-6 umbilical.

The original LPP jacket was designed to accommodate the installation of a Regional Export Module (REM) to increase the nameplate capacity of the LPP to 2.1 BSCFD after installation. The REM will be installed as part of the Leviathan Expansion Project. The REM is planned as a 2-level module approximately 40 m wide × 69 m long with an estimated lift weight of approximately 10,000 tons. The REM is designed to be installed offshore as a single lift by a Semisubmersible Crane Vessel (SSCV). Environmental assessments of the LPP modifications are part of a separate process applicable to assets built within the Israeli Territorial Waters and are not part of the scope of this work.

3.2 DESCRIPTION OF THE APPLICATION

3.2.1 General

CML plans to drill and complete three new wells (Lev-10, Lev-11, and Lev-23) targeting gas strata within the Leviathan Field and installation of associated infield subsea infrastructure (**Figure 3-1**).



Well Name	Distances (km)				
	Leviathan-10	Leviathan-11	Leviathan-23	Gathering Line	Med Nautilus Cable
Leviathan-10	--	0.99	7.86	2.30	8.13
Leviathan-11	0.99	--	8.84	3.18	0.20
Leviathan-23	7.86	8.84	--	6.25	13.45

Figure 3-1. Locations of the three proposed Leviathan Expansion Project wells and proposed subsea infrastructure in relation to existing infrastructure in the Leviathan Field.

3.2.1.1 Vessels and Aircraft

A single drillship is proposed for the drilling and completion operations. CML has not selected the specific drillship, but plans to use a DP3 drillship (e.g.,).

The drilling program will be supported by three MMC-887 Class platform supply vessels (PSV; e.g.,) operating out of the port of Haifa with an average of four trips (one-way) per week. The vessels range in overall length from 83.8 m to 87.9 m, with maximum draft ranging from 6.1 m to 6.8 m, and accommodations ranging from 26 to 52 people. Helicopter support, including 24/7 medical evacuation services, will be provided by a Sikorsky S-76C++ medium sized commercial utility helicopter operated out of Haifa Airport with an average of 10.5 round-trip flights per week. Standby cover will be provided by the supply vessels when available in the field.

The subsea infrastructure installation will be conducted using a pipeline installation vessel (e.g.,) capable of S-Lay, J-Lay, or Reel-Lay operations, or a combination thereof. The subsea infrastructure installation program will be supported by multiple vessels, including a supply/standby vessel (e.g.,), a multi-purpose construction vessel (e.g.,), a light construction vessel equipped with a remotely operated vehicle (ROV) (e.g.,), and a crew change vessel (e.g.,). Support operations for subsea infrastructure installation are expected to operate out of Limassol, Cyprus.

Specifications for example project vessels and aircraft are provided in **Appendix F**.

3.2.1.2 Production Infrastructure

The Leviathan Expansion Project includes the installation of subsea infrastructure, including:

- Three subsea wells (Lev-10, Lev-11 and Lev-23) with subsea production trees (XT-L10, XT-L11 and XT-L23);
- Three 14-inch infield flowlines: IFL-10 (2.3 km), IFL-11 (1.0 km) and IFL-23 (3.1 km);
- Six flowline end terminations (PLETs);
- One Intermediate Jumper Structure (IJS) to facilitate connecting the IFL-10 PLET to the existing Leviathan Gathering Manifold;
- Two infield umbilicals: IUMB-L11 (1.0 km) and IUMB-L23 (4.7 km). Note that the umbilical to well Lev-10 was installed during Phase 1 as Infield Umbilical IUMB-L9;
- Two communication distribution units (CDUs);
- Seven jumpers (three 8-inch jumpers, two 12-inch jumpers and two 14-inch jumpers); and
- Flying leads including Electrical Flying Leads (EFLs), Optical Flying Leads (OFLs), Hydraulic Flying Leads (HFLs), and Flexible Flying Leads (FFLs).

3.2.1.3 Infield Flowlines and Umbilicals

Leviathan Expansion Project infield production flowlines will link the new subsea wellheads to the existing infield gathering manifold. For the new three production wells, flowlines will run from the new subsea trees to the existing infield gathering manifold or will be tied into the subsea production system by daisy chaining new flowlines into the existing infrastructure, through spare tie-in points on the infield flowline Pipeline End Terminations (PLETs). Retrievable Wet Gas Flow Meter Modules (WGFMMs) will be installed on the well-end infield flowline PLETs for monitoring by the tree-mounted SCMs. The WGFMMs will be installed after the PLETs are installed.

The new infield flowlines will be of 14-inch diameter and of rigid pipe construction. The total new flowline length for the new three (3) development wells will be 6.4 km, with the longest individual flowline measuring 3.1 km. Each infield flowline will feature a PLET at each end. PLETs will facilitate the installation of tie-in jumpers to connect the flowline to the subsea tree at one end, and to the new IJS (which will be subsequently tied to the existing infield gathering manifold using a rigid jumper) or existing PLET at the other.

Several of the new infield PLETs (upstream of the infield gathering manifold) will be designed with a spare tie-in hub to enable future tie-ins (e.g., connection of new flowlines or subsea production trees in the future. The new PLETs will be designed to accommodate either integral or non-integral foundations that may include mudmats, piles or a combination thereof. The foundation type will be selected once the installation vessel is confirmed as it greatly depends on vessel capabilities and installation equipment features.

Infield flowline pipe will be manufactured in pipe joints (typically 12 m in length) at an out of country pipe mill. The pipe will be either picked up by the pipeline installation vessel at the pipe manufacturing facility, or it will be shipped to a regional shore base or pipe stalking yard for storage until it is required at the infield location or assembled into pipe stalks and spooled onto the Reel-Lay vessel. If stored at a shore base, the flowline pipe joints will be transported from shore base to the pipeline installation vessel by a supply vessel.

The two (2) new infield umbilicals will deliver hydraulic and electrical controls signals, MEG, and chemicals from to the new subsea production trees. Infield umbilicals will be multi-cored electrohydraulic systems with a total of six electrical power cores and 14 super-duplex stainless-steel tubes for conveying hydraulic fluids and chemicals. All cores and tubes will be bundled into a single infield umbilical with a high-density polyethylene protective outer coating. The infield umbilicals will include spare tubes, power and communication for future developments.

3.2.1.4 Other Planned Infrastructure

Two new CDUs will be installed, located close to the infield gathering manifold. All new infield umbilicals will feature UTAs at each end to enable tie-in (by flying leads) to the relevant structures. A total of 4 new UTAs will be installed with each installed on a mudmat foundation.

Flying leads will be used to connect the new CDUs and the new production trees to the UTAs located at the ends of the infield umbilicals. This will enable hydraulic actuation of the subsea production tree-mounted valves and chemical injection into the production fluids.

Infield tie-in jumpers (here in referred to as jumpers) will connect the new infield flowline PLETs to the new subsea trees, new intermediate jumper structure (which is then connected to the existing infield gathering manifold via a jumper), and to existing PLETs. All jumpers will be of rigid steel pipe construction. Due to the project water depth all jumpers will be designed for diverless connection with ROV support. Following fabrication, jumpers will likely be filled with MEG to an extent practical with the remaining jumper volume allowed to free flood with seawater during installation. Following installation, the jumper connections will be leak tested, and then the jumper flushed with the selected preservation/hydrate inhibition medium to displace seawater and protect the internal surfaces from seawater corrosion and biogenic growth.

Jumpers will be fabricated and subsequently transported to the infield location by either cargo barge, supply vessel or on the deck space of the MPCV used to install them. Due to the project water depth and benign seabed conditions, jumper protection (in the form of concrete mattresses) or mid-point anchoring is not required and as such will not be used.

3.2.2 Production Drilling

3.2.2.1 Drilling Target

CML plans to drill and complete three new wells (Lev-10, Lev-11, and Lev-23) targeting gas strata within the Leviathan Field. Once drilled and completed, the new wells will be placed on production.

3.2.2.2 Number of Drill Sites and Distances

Three new wells will be drilled. Their coordinates and distances to the nearest shorelines, Rosh Carmel, and Hadera, are presented in **Table 1-1** and depicted in **Figure 1-10** (**Section 1.3**).

3.2.2.3 Drilling Platform

One drillship will be used to conduct the drilling and completion operations. CML has not selected the specific drillship but plans to use a DP drillship (**Figure 3-2**) that would not require the use of anchors to maintain position and will mobilize to the Leviathan Field under its own power. Representative drillship specifications are provided in **Appendix F**.



Figure 3-2. Example of a dynamic positioning (DP) drillship.

3.2.2.4 Number of Drilling Platforms

One drillship is expected to be used for drilling all three of the proposed drill sites under the Leviathan Expansion Project.

3.2.2.5 Drill Site and Well Depths

3.2.3 Description of the Drilling Process

3.2.3.1 Drilling Processes and Stages

The general steps for drilling each of the new wells (Lev-10, Lev-11, and Lev-23) are as follows:

Figure 3-3. Representative schematic diagram for completion of the Leviathan Expansion Project wells.

3.2.3.2 Depth of Drilling by Time

Figure 3-4. Time vs. depth plot for drilling the Leviathan-10, Leviathan-11, and Leviathan-23 wells (Provided by CML).

3.2.3.3 Future Development Stages of the Field

Future plans for the development of the Leviathan Field have not been finalized. Future environmental impact assessments and permit applications will address plans once decided upon by CML.

3.2.3.4 Gantt Chart of Drilling Operations

Figure 3-5 shows the sequence of proposed drilling and completion activities. **Figure 3-5** is presented as representative; wells may not be sequential and may not be drilled in the order shown. This schedule may be modified based on project delivery or CML drilling commitments.

All three wells will be drilled sequentially (approximately 82 days each) and temporarily abandoned pending completion. Completion activities will follow sequentially after all three wells are drilled and are expected to require approximately 40 days per well. The total time for drilling and completing all three wells is estimated to be 366 days.

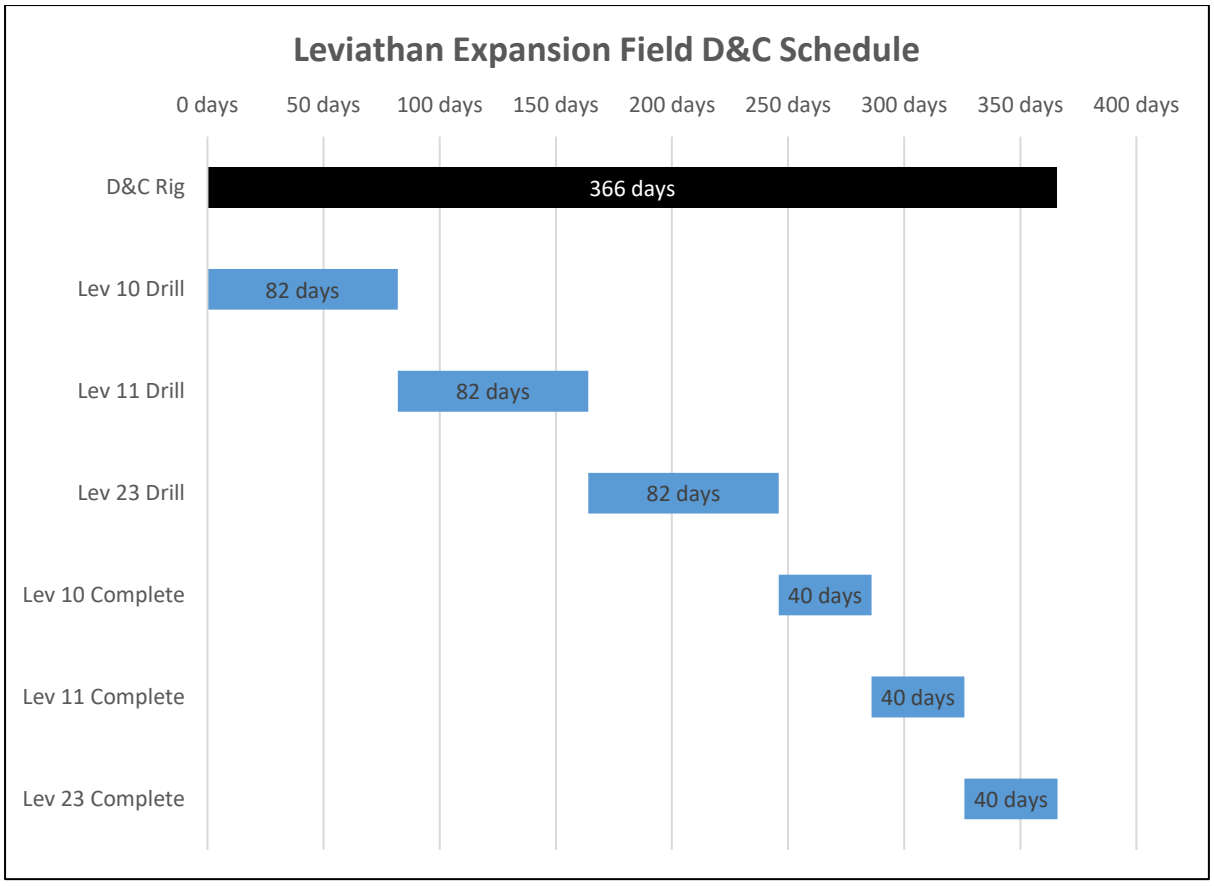


Figure 3-5. Schedule for drilling and completion activities for the Leviathan Expansion Project. Drilling and completion sequencing, as shown, is tentative, may not be sequential, and may change depending on various factors as outlined in text.

3.2.4 Hydrocarbon Blowout Prevention

3.2.4.1 Blowout Prevention Device

CML will use safe drilling practices during its activities in the Leviathan Field. Best industry practice will be used during all drilling phases (e.g., setting of BOP; cementing of concrete between bore and protective pipe). CML has not selected a specific drillship, and detailed BOP specifications vary depending on the drillship. A typical blowout preventer (BOP) stack is shown in **Figure 3-6**. Final BOP selection will depend on the drillship selected. CML's drillship tender will include the following specifications:

- Minimum well control equipment rated at 10,000 psi capacity; and
- 18¾-inch BOP system with dual annulars and four ram-type preventers (**Figure 3-6**).

CML and the drillship's owner will engage in a comprehensive inspection and testing of the drillship's subsea BOP system to ensure compliance with the U.S. Bureau of Safety and Environmental Enforcement (BSEE) regulations. The inspection and testing will be witnessed and certified by a third-party surveyor.

In deeper offshore operations with the wellhead just above the mudline on the seafloor, there are four primary ways by which a BOP can be controlled:

- Electrical Control Signal – sent from the surface through a control cable;
- Acoustical Control Signal – sent from the surface based on a modulated/encoded pulse of sound transmitted by an underwater transducer;
- ROV Intervention – remotely operated vehicles (ROVs) mechanically control valves and provide hydraulic pressure to the stack (via "hot stab" panels); and
- Dead Switch/Auto Shear – fail-safe activation of selected BOPs during an emergency or if the control power and hydraulic lines have been severed.

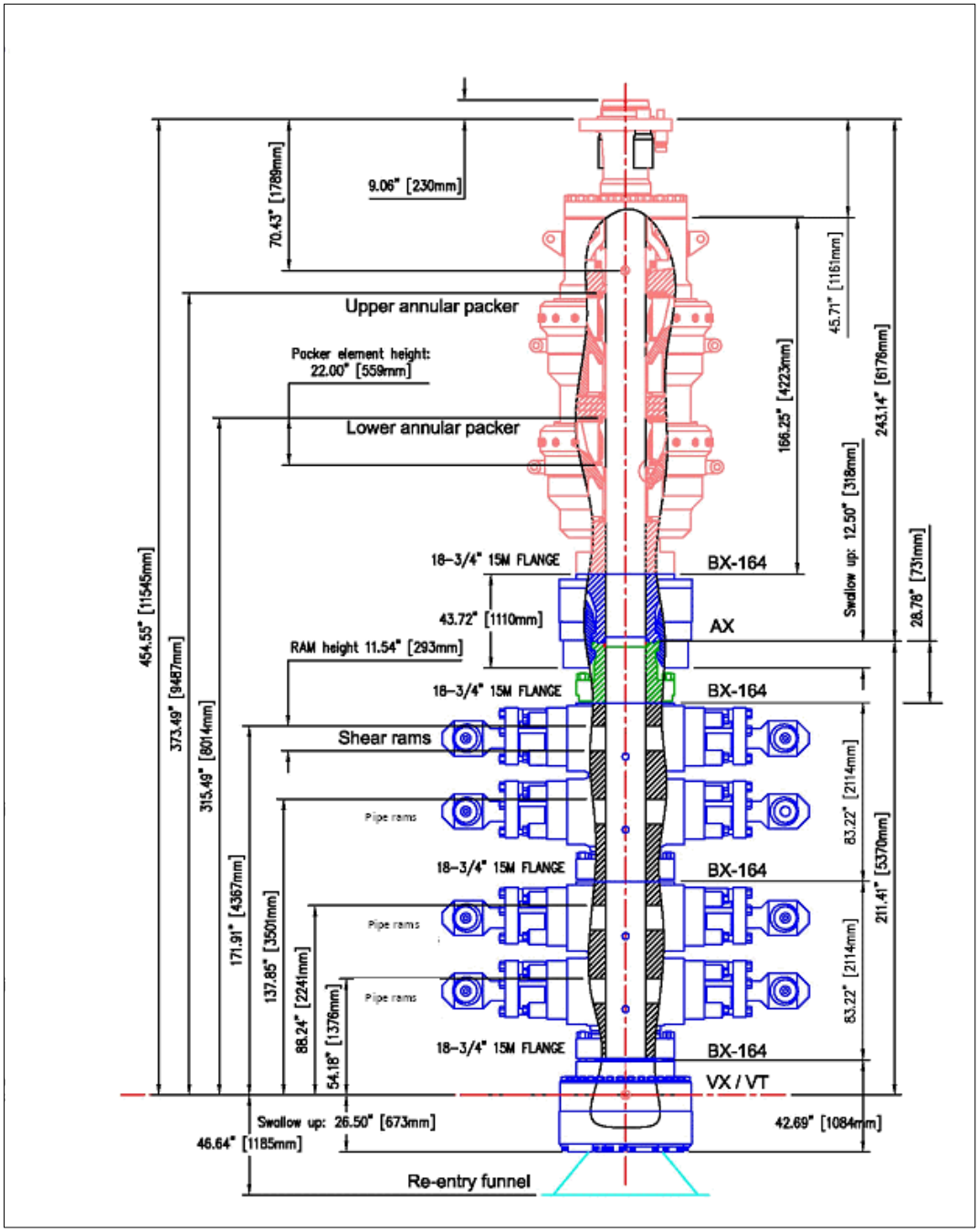


Figure 3-6. Typical blowout preventer (BOP) stack.

Two control pods are provided on the BOP for redundancy. Electrical signal control of the pods is primary; acoustic ROV intervention and dead-man controls are secondary.

An emergency disconnect system (EDS) separates the drillship from the well in case of an emergency. The EDS is intended to automatically trigger the dead-man switch, which closes the BOP as well as kill and choke valves. The EDS may be a subsystem of the BOP stack's control pods or separate.

Pumps on the drillship normally deliver pressure to the BOP stack through hydraulic lines. Hydraulic accumulators are on the BOP stack enable closure of BOPs even if the BOP stack is disconnected from the drillship.

CML has committed to operating in Israel per BSEE regulations, unless superseded by Ministry of Energy (MoE) regulations. The BSEE specifications for maximum anticipated surface pressure (MASP) are derived from 30 CFR 250.414 (f) (2) (vi), as follows: *"The design criteria considered for the well and for well control include… Anticipated surface pressures, (which for purposes of this section are defined as the pressure which can reasonably be expected to be exerted upon a casing string and its related wellhead equipment)."*

It is left to the operator to calculate the MASP and to include in the Application for Permit to Drill the assumptions, formulas, and results. The MASP calculations and results accepted by BSEE are reported as the lesser of the pressures calculated using two methods:

1. Pore Pressure Method ($MASP_{pore)}$: This calculation assumes the well is partially unloaded to gas and equals the maximum expected pore pressure at the bottom of the open hole less the hydrostatic head of the gas column and the mud column from the bottom of the hole to the "surface."
2. Fracture Gradient Method ($MASP_{frac}$): This calculation assumes the well is completely unloaded to gas and equals the fracture pressure at the deepest exposed casing or liner shoe less the hydrostatic head of the gas from that shoe to the "surface."

The corresponding maximum anticipated wellhead pressure (MAWP) is equivalent to MASP plus gas hydrostatic from surface to the wellhead. The maximum required casing and blind shear ram surface test pressure will be equivalent to the MASP plus 500 psi or 70% of the minimum internal yield pressure ($MIYP_{70}$) of the casing being tested less mud weight vs. pore pressure at the previous shoe difference at the wellhead, casing top or shoe, whichever is less. For production casing strings, the casing test pressure will be determined by the completion requirements. The maximum required surface BOP pressure test will be equivalent to the MASP plus 500 psi less mud weight vs. seawater hydrostatic difference at mud line. Test pressures are not to exceed 70% of the annular rating or 100% of the ram rating at seafloor conditions.

3.2.4.2 Three-Way Diverter Device

CML has not selected a specific drillship, and detailed BOP specifications vary depending on the drillship. A BOP stack was shown in **Figure 3-6**. Once selected, CML will inform MoE of the specifications associated with the three-way diverter device. As noted previously, CML and the drillship owner will engage in a comprehensive inspection and testing of the subsea BOP system to ensure compliance with BSEE regulations, with inspection and testing to be witnessed and certified by a third-party surveyor.

3.2.4.3 Further Means for Dealing with a Blowout

CML's Oil Spill Contingency Plan (OSCP) provides detailed information about the response capabilities and methods that CML would use to minimize the potential for significant impacts from a blowout. The drillship contractor will also implement oil spill prevention methods as part of its Shipboard Oil Pollution Emergency Plan (SOPEP).

3.2.5 Casings and Cementing

3.2.5.1 Casings

Figure 3-7 shows a representative wellbore schematic for the Lev-10, Lev-11, and Lev-23 wells. The basis of the well and casing design for the future Leviathan development wells is as follows:

Figure 3-7. Representative wellbore schematic for the Leviathan Expansion Project.

3.2.5.3 Well Construction and Cementing

Well cementing is described in **Section 3.2.5.2**. Durations of the main stages of drilling are presented in **Table 3-1**.

Table 3-1. Approximate durations of drilling for each well section (interval) for a representative Leviathan Expansion Project well.

3.2.5.4 Cementing Materials

Estimated volumes of well cement products consumed and remaining in the wells are presented in **Table 3-2**.

Table 3-2. Estimated per-well cement products consumed and remaining in the well for a representative Leviathan Expansion Project well.

3.2.5.5 Cementing Quality

Cement Laboratory Testing

Laboratory testing is a critical element in successful well cementing. Unless specifically indicated, all cement testing procedures shall adhere to the latest version of the cement service provider's Global Laboratory Best Practices.

Formation Integrity Test

The purpose of a Formation Integrity Test is to determine the competence of the primary cement job and the competence of the formation below the casing shoe. A Formation Integrity Test will be performed after running and cementing each casing string, cleaning out the rathole section, and drilling 3 m of new formation below the casing shoes. If a leak-off pressure is obtained that is lower than anticipated and the equivalent mud weight is less than that required to safely drill to the next casing depth, consideration will be given to squeezing the casing shoe. Subsequent re-testing should verify if the primary cement job was ineffective or if the formation fracture gradient was lower than anticipated. Lift pressures will be monitored for indication of cement placement in the production casing and a cement bond log or equivalent will be run if required to confirm cement bond and top of cement.

Casing Test Pressures

Casing tests will be conducted as per 30 CFR 250. Casing pressure tests shall be conducted to the MASP plus 500 psi or $MIYP_{70}$ of the casing being tested less mud weight vs. pore pressure at the previous shoe difference at the wellhead, casing top or shoe, whichever is less. For production casing strings, the casing test pressure will be determined by the completion requirements. If necessary, a Cement Bond Log may be run on the production casing string to confirm the cement bond and the top of the cement.

3.2.6 Testing the Drilling String

No drill string testing will be conducted on any of the three Leviathan Expansion Project wells.

3.2.7 Production Tests

Production tests are not planned as part of the Leviathan Expansion Project.

3.2.8 Subsea Field Development

3.2.8.1 Subsea Production Infrastructure

Planned Subsea Infrastructure

Planned subsea infrastructure was previously described in **Sections 3.2.1.3** and **3.2.1.4**.

Infrastructure Installation Procedures

A Multi-Purpose Construction Vessel (MPCV) will be used for jumper installation. An example of an MPCV is the . Installation will be supported by the use of ROVs and an associated Light Construction Support Vessel (LCSV), which will be equipped for ROV deployment and recovery capabilities. An example of such a vessel is the .

3.2.8.2 Pipelines

Actions Required to Lay Pipelines

An option to use the Reel-lay installation method for the subsea flowlines is being evaluated. Reel-lay installation method involves pre-fabrication of the flowlines onshore, in one of existing spool bases by welding the line pipe into long strings of pipe referred to as pipe stalks. Subsequently, upon Reel-lay vessel arrival at the spool base, pipe stalks are reeled onto the installation vessel reel and the vessel sailed to installation location, where the flowlines are installed onto seabed. Reel-Lay is a well-known, proven, standardized and proceduralized installation methodology.

Flowlines will be installed dry on the seabed by a dynamically positioned pipeline installation vessel. The method of installation may be by J-Lay, S-Lay, Reel-Lay or a combination of methods. The pipeline installation is expected to require between 20 and 40+ days depending on the selected installation method. Specifications of an example pipeline installation vessel are presented in **Appendix F**. A schematic of the subsea infrastructure layout was presented in **Figure I-1**. Due to the water depth (>1,600 m), no trenching or burial of infield lines is required.

Pre-Commissioning

After installation, the new subsea infrastructure will be pre-commissioned prior to establishing production operations. The infield flowlines will be flooded, cleaned, gauged, hydrotested, and dewatered with nitrogen and MEG, the jumpers will be leak tested and packed with MEG, the umbilicals and flying leads will be tested. The new subsea infrastructure will be subjected to periodic maintenance and asset integrity operations (e.g., inspection) in line with the existing infrastructure and its operation. Flowline and jumpers pre-commissioning include the following main steps:

Flowlines:

- Flood, Clean, and Gauge – Treated seawater is introduced into the flowlines by way of subsea pumping and pushed through the flowline. An in-line inspection (ILI) pig run launched from and then received at the infield flowline PLETs is being evaluated by the Project to inform the initial flowline internal pipe condition and wall thickness. If selected, such in-line inspection would be conducted at an opportune time before flowline dewatering.

- Hydrotesting – Treated and filtered seawater are pumped into the flowline to pressurize it up to the required testing pressure, verifying that the pipe is in good order along its entire length and that it can withstand the required operating pressures.

- Dewatering – The treated seawater is pushed out of the pipeline by the propulsion of pigs along with the use of MEG, which has the purpose of absorption of water residue in the pipeline. After the pipeline is emptied, it is filled with compressed nitrogen in order to completely dehydrate it.

Jumpers:

- Prior to Installation – The jumpers will likely be filled with MEG to the extent practical.

- During Installation – Any remaining jumper volume not filled with MEG will be allowed to free flood with seawater.

- After Jumper Installation – The subsea connectors will be leak tested.

- After Leak Testing – The jumpers will be flushed with the selected preservation/hydrate inhibition medium to displace any seawater that entered the jumper during installation. This will protect the internal surfaces from seawater corrosion and biogenic growth jumpers will be flushed with MEG prior to locking them down to displace any water during installation.

3.2.8.3 Laying Other Infrastructure

Other than the infrastructure described in **Section 3.2.8**, no other infrastructure is proposed to be laid as part of the Leviathan Expansion Project.

3.3 NOISE AND LIGHT POLLUTION

3.3.1 Mechanical Equipment and Noise Levels

3.3.1.1 Drilling Rig and Installation Vessel

CSA (2016) provided a discussion of the noise from the drillship; see Section 3.4.1 of the 2016 document. Noise was also addressed in Section 4.3 of the Genesis (2016) document, including modeling of noise and noise attenuation from a representative pipelay vessel.

Key Findings:
- Drilling noise is typically low and continuous, with most energy below 1 kHz (Richardson et al., 1995).
- Greene (1987) found that the sound generated by a semisubmersible drillship did not exceed local ambient levels beyond 1 km, although weak tones were detectable up to 18 km away.
- Sound from Leviathan Field drilling activities was referenced by Genesis (based on Miles et al., 1987) using a drillship and was found to have a peak sound pressure level (SPL) of 177 dB re 1 µPa.

Proposed Project:
- Non-impulsive noise from subsea installation is expected to be similar to non-impulsive noise from the drillship and supply vessels; no unique impacts are expected from installation activities.
- Roberts and Elliott (2017) note that vibration from activities such as drilling or pile driving have the potential to cause behavioral or physical changes for marine species. Other researchers (e.g., Dannheim et al., 2020; He et al., 2023) have concluded, based on their synthesis of available data, that noise or vibration might affect local populations of fish or benthic invertebrates, although it is acknowledged that overall implications from these anthropogenic vibration sources are not well understood.
- CML will rely on the summary information regarding drilling and drillship noise, as outlined in CSA (2016).

3.3.1.2 Supply Vessels

CSA (2016) provided a discussion of the noise from supply vessels; see Section 3.4.2 of the 2016 document. Genesis (2016) addressed support vessel noise (Section 3.3.1).

Key Findings:
- Broadband source levels for most small ships (a category that would include support vessels) are in the range of 170 to 180 dB re 1 µPa at 1 m (Richardson et al., 1995).
- Most of the energy is in frequencies below 100 to 200 Hz, but broadband sounds may include acoustic energy at frequencies as high as 100 kHz.

- Propeller cavitation is usually the dominant noise source.
- Support vessels are considered transient sound sources as they move between the shore base and the drillship.

Proposed Project:
- No new information has been identified. CML will rely on the summary information regarding supply vessel noise, as outlined in CSA (2016).

3.3.1.3 Underwater Noise from Helicopters

CSA (2016) provided a discussion of Underwater Noise from Helicopters; see Section 3.4.3 of the 2016 document.

Key Findings:
- Received SPLs (in water) from a Bell 212 helicopter flying at altitudes of 152 m (500 ft) were 109 dB re 1 µPa with an estimated source level of 149 dB re 1 µPa (Richardson et al., 1995).
- Penetration of noise into the water column is greatest directly below the aircraft.
- Duration of underwater sound from a helicopter passing at an altitude of 152 m may be detectable for only 38 seconds at 3 m depth and for 11 seconds at 18 m depth (Richardson et al., 1995).

Proposed Project:
- No new information has been identified. CML will rely on the summary information regarding helicopter noise, as outlined in CSA (2016).

3.3.2 Light

3.3.2.1 Drilling Rig and Installation Vessel

Lighting on offshore facilities serves a variety of purposes, including navigational and worker safety, but concern over the potential effects of artificial light at night (ALAN) on the marine environment has increased in recent years. While not a fixed platform, the drillship and installation vessel will be equipped with operational and navigational lighting.

3.3.2.2 Supply Vessels

Supply and support vessels operating either during drilling and completion activities or during subsea infrastructure installation operations will emit light during nighttime operations. Unlike the drillship which will be stationary, or the installation vessel which will be stationary or moving slowly, support vessels will transit between the project area and shore base, with limited time remaining on station in the Leviathan Field.

3.4 AIR QUALITY

3.4.1 Sources of Air Pollutants

Emission sources during the Leviathan Expansion Project are anticipated to result from internal combustion engines on the drillship, support vessels, installation vessel, and helicopters. Estimated emission rates are presented in **Section 3.4.2**.

3.4.2 Pollution Emission Rates

3.4.2.1 Emissions from Drilling Rig

The drillship will produce emissions from internal combustion engines, including carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x; inclusive of SO_2), volatile organic compounds (VOCs), and particulate matter (PM), as well as greenhouse gases (GHGs) including carbon dioxide,

methane (CH_4), and dinitrogen oxide/nitrous oxide (N_2O). Emissions were estimated using a worksheet developed by BOEM (2020) based on USEPA AP-42 emission factors and using fuel usage from prior drilling campaigns for the drillship. Support vessel emissions during drilling and completion are presented in **Section 3.4.2.2**, with emissions calculations based on relative horsepower ratings at 75% load for drilling- and completion-related support vessels.

Table 3-3 shows the estimated emissions on a per-well basis for two categories of activities: 1) drilling of the wells (82 days per well) and 2) well completion (40 days per well) from a representative DP drillship operating 24 hours per day for the duration of each well activity. Total emissions were also calculated based on the estimated number of days that the drillship would be operating for each activity (**Table 3-4**). As discussed in **Section 3.2.3**, drilling operations for all three Leviathan Expansion Project wells are estimated to require a total of 246 days; completion operations for all three new wells are estimated to require 120 days. The total time for drilling and completing all three Leviathan Expansion Project wells is estimated to be 366 days.

Table 3-3. Estimated per well air pollutant emissions from a single drillship for drilling and completion activities on a single well, Leviathan Expansion Project.

Activity	Duration (days)	Emissions (metric tonnes/well)									
		CO	NO_x	SO_x	VOCs	PM2.5	PM10	CO_2	CH_4	N_2O	GHGs
Drilling	82	30.38	193.70	0.12	5.57	4.73	4.88	13,242	0.08	0.58	13,243
Well Completion	40	14.82	94.49	0.06	2.72	2.31	2.38	6,460	0.04	0.29	6,460
Total, Single Well	122	45.20	288.18	0.18	8.29	7.04	7.26	19,702	0.12	0.87	19,703

Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet and using actual fuel usage data (i.e., 60 m^3 per day) for the drillship operating 24 hours per day. CO_2, CH_4, and N_2O emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + CH_4 + N_2O.
CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; N_2O = dinitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

Table 3-4. Total estimated air pollutant emissions from a drillship for drilling and completion of all three wells during the Leviathan Expansion Project.

Activity	Total Duration (days)	Total Estimated Emissions (metric tonnes)									
		CO	NO_x	SO_x	VOCs	PM2.5	PM10	CO_2	CH_4	N_2O	GHGs
Drilling	246	91.1	581.1	0.4	16.7	14.2	14.6	39,727	0.2	1.8	39,729
Well Completion	120	44.5	283.5	0.2	8.2	6.9	7.1	19,379	0.1	0.9	19,380
Total, All Wells	366	135.6	864.5	0.5	24.9	21.1	21.8	59,106	0.3	2.6	59,109

Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet and using actual fuel usage data (i.e., 60 m^3 per day) for the drillship operating 24 hours per day. CO_2, CH_4, and N_2O emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + CH_4 + N_2O.
CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; N_2O = dinitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

3.4.2.2 Emissions from Support Vessels during Drilling

The drilling program will be supported by three MMC-887 Class platform supply vessels operating from the port of Haifa; specifications of example vessels are provided in **Appendix F**. Each supply vessel is expected to make two round-trips per week between Haifa and the drillship for a total of 105 trips per supply vessel. Total emissions were calculated using the BOEM worksheet for each supply vessel based on the estimated total number of days the vessels would be operating and assuming that each vessel operates a maximum of 16 hours/day when in use (**Table 3-5**). Emissions were calculated using maximum horsepower ratings, adjusted to 75% maximum load.

Table 3-5. Total estimated air pollutant emissions from supply vessels during drilling and completion of a single well and all three wells during the Leviathan Expansion Project.

Supply Vessel	Operating Days	Total Estimated Emissions (metric tonnes)									
		CO	NO_x	SO_x	VOCs	PM2.5	PM10	CO_2	CH_4	N_2O	GHGs
Single Well											
	35	15.46	98.54	0.06	2.83	2.41	2.48	6,737	0.04	0.30	6,737
	35	14.05	89.55	0.05	2.57	2.19	2.26	6,122	0.04	0.27	6,123
	35	14.30	91.19	0.06	2.62	2.23	2.30	6,235	0.04	0.28	6,235
Total	105	43.80	279.28	0.17	8.03	6.82	7.03	19,093	0.11	0.84	19,094
All Three Wells											
	105	46.37	295.61	0.18	8.50	7.22	7.44	20,210	0.12	0.89	20,211
	105	42.14	268.65	0.16	7.72	6.56	6.77	18,367	0.11	0.81	18,368
	105	42.91	273.58	0.17	7.87	6.68	6.89	18,704	0.11	0.83	18,705
Total	315	131.41	837.84	0.51	24.09	20.47	21.10	57,280	0.34	2.53	57,283

Each vessel was assumed to operate for 16 hours/day for 105 days (2 round-trips per week; 17 weeks per well). Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet and using maximum horsepower ratings, adjusted to 75% maximum load. CO_2, CH_4, and N_2O emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + CH_4 + N_2O.
CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; N_2O = dinitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

3.4.2.3 Emissions from Helicopters during Drilling

Helicopter support will be provided by a Sikorsky S-76C++ operated from Haifa Airport; specifications are provided in **Appendix F**. It has been estimated that the helicopter will make 10.5 round-trips per week between Haifa and the drillship.

Table 3-6 provides an estimate of air pollutant emissions resulting from helicopter flights based on published emissions estimates for a Sikorsky S-76C++ helicopter (Rindlisbacher and Chabbey, 2015). Assuming a cruising speed of 226 km/hour and a 250 km round-trip flight distance, each round trip is assumed to require approximately 1.5 hours of flight time plus one landing-takeoff cycle. With 10.5 weekly round-trips, there will be approximately 558 trips during the entire program (366 days, or approximately 53 weeks).

Table 3-6. Estimated pollutant emissions from helicopters during drilling operations (Sikorsky S-76C++) based on emissions calculations by the Swiss Federal Office of Civil Aviation (From: Rindlisbacher and Chabbey, 2015).

Source	Fuel Usage (kg)	Emissions (kg)			
		NO_x	HC	CO	PM
Single LTO Cycle	50.0	0.311	0.624	0.801	0.0097
One Hour of Flight	324.5	2.56	1.28	1.56	0.074
Single Round-Trip (LTO + 1.5 hours)	536.8	4.151	2.544	3.141	0.121
Total (entire program, 558 round-trips; 10.5 trips per week for approximately 53 weeks)	299,534	2,316	1,420	1,753	67.5

CO = carbon monoxide; HC = hydrocarbons; LTO = landing-takeoff; NO_x = nitrogen oxides; PM = particulate matter.

3.4.2.4 Emissions from Production Testing

Production tests are not expected to occur as part of the drilling and completion portion of the Leviathan Expansion Project.

3.4.2.5 Emissions from Installation and Support Vessels during Infrastructure Installation

Infrastructure installation will be supported by a pipeline installation vessel, a multi-purpose construction vessel (MPCV), a light construction vessel (LCV), a supply/standby vessel, and a crew

change vessel. The estimated number of working days, projected activities, fuel consumption per day, and total fuel consumption for each vessel are presented in **Table 3-7**.

Table 3-7. Estimated number of working days, projected activities, fuel consumption per day, and total fuel consumption for installation activities during the Leviathan Expansion Project.

Vessel Type	Operating Days	Activity	Fuel Consumption (Metric tonnes per day)	Total Fuel Consumption (Metric tonnes)
Pipeline Installation Vessel	43	1	65	2,789
Supply/Standby Vessel	211	All	15	3,159
Multi-Purpose Construction Vessel	117	2,3,4,5,6	25	2,925
Light Construction Vessel with ROV	23	7	15	351
Crew Change Vessel	156	All	10	1,560
			Total	10,784

Activity 1: Flowline and PLET Installation.
Activity 2: Jumper Installation.
Activity 3: Umbilical Installation.
Activity 4: Flying Leads Installation.
Activity 5: Flowline Testing and Pre-Commissioning.
Activity 6: Umbilical and Flying Leads Testing and Pre-Commissioning.
Activity 7: Pre-Lay Activities

Table 3-8 presents estimated total air pollutant emissions from installation activities during the Leviathan Expansion Project. Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet and using actual fuel usage data from previous campaigns for all installation-related vessels as presented in **Table 3-7**, above.

Table 3-8. Total estimated air pollutant emissions from infrastructure installation activities during the Leviathan Expansion Project.

Vessel Type	Total Estimated Emissions (metric tonnes)									
	CO	NO_x	SO_x	VOCs	PM2.5	PM10	CO_2	CH_4	N_2O	GHGs
Pipeline Installation Vessel ( )	20.30	129.46	0.08	3.72	3.16	3.26	8,850	0.05	0.39	8,851
Supply / Standby Vessel ( )	22.99	146.59	0.09	4.21	3.58	3.69	10,022	0.06	0.44	10,023
Multi-Purpose Construction Vessel ( )	21.25	135.48	0.08	3.90	3.31	3.41	9,262	0.05	0.41	9,263
Light Construction Vessel with ROV ( )	2.51	15.98	0.01	0.46	0.39	0.40	1,092	0.01	0.05	1,093
Crew Change Vessel ( )	5.67	36.13	0.02	1.04	0.88	0.91	2,470	0.01	0.11	2,470
Total	72.72	463.63	0.28	13.33	11.32	11.67	31,697	0.19	1.40	31,699

Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet and actual fuel usage data from previous campaigns for each vessel. Operating days were based on the previous table. CO_2, CH_4, and N_2O emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + CH_4 + N_2O.
CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; N_2O = dinitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

3.4.2.6 Emissions from Helicopters during Infrastructure Installation

Helicopter support will be provided by a S-76C++ helicopter operated from Haifa Airport; specifications are provided in **Appendix F**. It has been estimated that the helicopter will make approximately 30 round-trips between Haifa and the installation location. It was assumed that each round-trip will require approximately 4 hours of flight time plus one landing/takeoff cycle. **Table 3-9** provides an estimate of air pollutant emissions resulting from helicopter flights based on published emissions estimates for a Sikorsky S-76C++ helicopter (Rindlisbacher and Chabbey, 2015).

Table 3-9. Estimated pollutant emissions from helicopters during installation operations (Sikorsky S-76C++) based on emissions calculations by the Swiss Federal Office of Civil Aviation (From: Rindlisbacher and Chabbey, 2015).

Source	Fuel Usage (kg)	Emissions (kg)			
		NO_x	HC	CO	PM
Single LTO Cycle	50.0	0.311	0.624	0.801	0.0097
One Hour of Flight	324.5	2.56	1.28	1.56	0.074
Single Round-Trip (LTO + 4 hours)	1,348	10.551	5.744	7.041	0.306
Total (entire program, 30 round-trips)	40,440	316.53	172.32	211.23	9.18

CO = carbon monoxide; HC = hydrocarbons; LTO = landing-takeoff; NO_x = nitrogen oxides; PM = particulate matter.

3.4.3 Monitoring, Detection, and Maintenance Appliances

In December 2022, the 79th meeting of the Marine Environment Protection Committee (MEPC 79) adopted amendments to designate the Mediterranean Sea, as a whole, as an Emission Control Area (ECA) for sulfur oxides (SOx) and particulate matter, under MARPOL Annex VI. In such an ECA, the limit for sulfur in fuel oil used on board ships is 0.10% mass by mass (m/m), while outside these areas the limit is 0.50% m/m. The amendment is expected to enter into force on 1 May 2024, with the new sulfur limit taking effect from 1 May 2025. A summary of the MEPC 79 decisions is available on the International Maritime Organization (IMO) website. Once the limit takes effect, all project vessels entering the Mediterranean will comply with this amendment, as this becomes mandatory under Annex VI.

During drilling operations, methane and hydrogen sulfide will be monitored in the filtration room and the regenerated mud reception tubs. Any detection of methane or hydrogen sulfide during the course of any drilling must be documented and reported; bleed off emissions will be diverted to the poor boy degasser on the drillship and shall be reduced as far as possible.

3.4.4 Failures

CML does not anticipate any failures that would result in an increase in air pollutants to the environment.

3.4.5 Emergency Shutdowns

Emergency shutdown and their impact on air pollutant emissions will be discussed in CML's Air Emission Permit.

3.5 HAZARDOUS MATERIALS

A table of hazardous chemicals planned to be used is included in **Appendix G**, along with safety data sheets (SDSs) for each chemical. All hazardous chemicals will be handled in compliance with MARPOL requirements and Toxin Permit requirements, as well as drilling vessel and installation vessel procedures. CML will submit all applications for the environmental permits necessary and will comply with any restrictions or requirements of those permits, including the Toxin Permit.

Loading and offloading of chemicals will be in compliance with International Maritime Dangerous Goods (IMDG) code, as integrated into the drillship operator's guidelines for handling hazardous materials. Materials to be used in drilling (i.e., WBM, MOBM, and additives) are discussed in **Section 3.6.1**.

On the installation vessel, as well as aboard support vessels transporting hazardous materials, these materials will be handled in accordance with their Safety Data Sheet (SDS); handling requirements will be integrated into each set of vessel operator guidelines. All hazardous materials will be properly identified, stored, and handled, per SDS requirements and in such a manner that ensure no spill or discharge to sea. In addition, hazardous materials will be handled by vessel personnel according to SDS-based exposure limits. Hazardous materials storage areas will be designated on the pipelay and support vessels, located in areas isolated from other operations. Storage areas housing hazardous wastes will be maintained in clean condition (i.e., no residues or spilled materials on the container, floor, or surrounding area).

3.6 DISCHARGES

3.6.1 Discharge Sources – General

3.6.1.1 Background

CSA (2016) discusses discharges in Section 3.7, including discharge sources, quantities, frequency of discharge, and potential contingency materials. Discharges addressed include those resulting from drilling and completion and subsea infrastructure installation and commissioning activities. Genesis (2016) addressed routine discharges from project vessels (e.g., Section 5.2.3).

3.6.1.2 Discharge Sources and Discharge Generating Processes

Discharges to be released into the sea during drilling operations can be divided into several main groups:

- Drilling discharges, including drilling muds, cuttings, and excess cement;
- Routine discharges from the drillship (and support vessels, as appropriate), including sanitary and grey water, food wastes, cooling water, desalination brine (reverse osmosis concentrate water), bilge water, excess cement, oil-water separator discharges, and deck drainage;
- Routine discharges from the installation vessel (and support vessels, as appropriate), including sanitary and grey water, food wastes, cooling water, desalination brine (reverse osmosis concentrate water), bilge water, oil-water separator discharges, and deck drainage; and
- Discharges from pre-commissioning of infield subsea infrastructure.

A diagram showing major discharge sources, discharge types, and discharge pipe diameters for project vessels is shown in **Figure 3-8**. Most discharge points are typically located below sea level; drain outlets are typically located about 2.5 m above sea level.

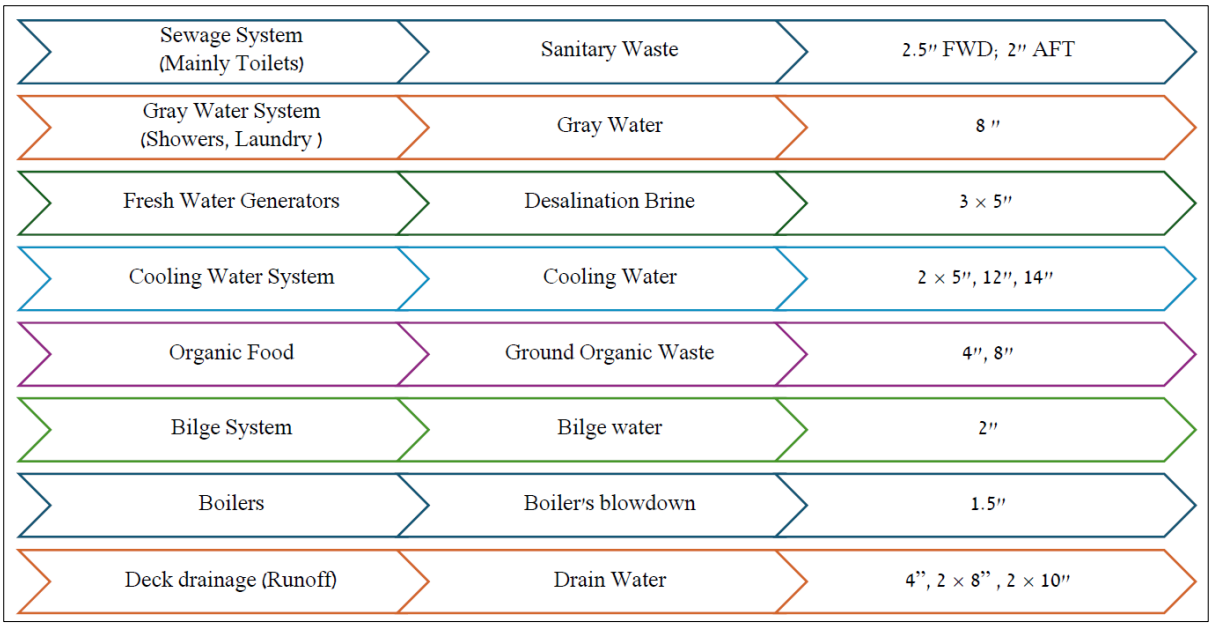


Figure 3-8. Simplified diagram showing major discharge sources, types, and pipe diameters for the Leviathan Expansion Project.

3.6.1.3 Discharge Treatment

CSA (2016) provided a discussion of routine Discharge Treatment; see Section 3.7.3.2 of the 2016 document. Genesis (2016) addressed routine discharges and available treatment methods; see Section 3.2.5.1).

Key Findings:

- The drillship and installation vessel, as well as support vessels, will comply with International Convention for the Prevention of Pollution from Ships (MARPOL), Annex I (oil pollution prevention), Annex IV (sewage pollution prevention), and Annex V (garbage pollution prevention) requirements as demonstrated by International Oil Pollution Prevention and International Sewage Pollution Prevention certificates and a DNV Statement of Fact.
- All sanitary waste will be treated using an IMO-approved sewage treatment unit which will comply with the applicable IMO effluent standards and performance tests for treatment efficiency specified in IMO Resolution MEPC.159(55).
- The Marine Environment Protection Committee (MEPC) standards shall be met for the following effluents: Thermotolerant Coliform Standard, Total Suspended Solids Standard, Biochemical Oxygen Demand and Chemical Oxygen Demand Standards, and pH. The sanitary system will also adhere to thresholds specified in the Discharge to Sea Permit.
- Organic or food wastes are generated from galley and food service operations; food wastes will be ground up in a garbage disposal unit prior to discharge (i.e., comminuted), in accordance with Annex V of MARPOL 73/78 requirements. Cooking oils will be separated from the organic food waste stream.
- Cooling water discharge effluent is expected to result in a temperature increase of no more than 3°C at the edge of the zone where initial mixing and dilution take place, typically considered to be 100 m from the point of discharge.
- Drainage from machinery spaces passes through an OWS prior to discharge and all discharges will meet MARPOL requirements for discharges from machinery spaces from fixed or floating platforms (MARPOL Annex I, Resolution MEPC 117[52]).

Proposed Project:

- No new information has been identified. CML will rely on the summary information regarding routine discharge treatment, as outlined in CSA (2016).

3.6.1.4 Additives

Tables with ecological information (e.g., toxicology, ecotoxicology, degradability, etc.) for drilling discharges, completion discharges, and pre-commissioning discharges that are expected during the Leviathan Expansion Project are presented in **Appendix H**. The chemicals in these tables are based on previous drilling campaigns or subsea infrastructure installation operations but are expected to be representative. Final selection of chemicals and concentrations will be completed prior to commencement of the project and will be presented in the Discharge to Sea Permit application.

Appendix G contains safety data sheets for chemicals expected to be used during the Leviathan Expansion Project; specific chemicals to be used will be presented in the Discharge to Sea Permit application.

3.6.1.5 Discharge Schedule

Total estimated discharges for drilling and completion and subsea installation are summarized in **Table 3-10**. Further details on project-related discharges (e.g., cement, WBM), as well as metals concentrations in the barite (e.g., Hg, Cd) will be presented in the Discharge to Sea Permit.

Table 3-10. Summary of estimated discharge frequencies, average daily rate, and total quantity for drilling and completion and subsea infrastructure installation operations (drillship and installation vessel only).

Source	Frequency	Average Daily Rate for Calculations	Total Quantity
Drilling/Completion Vessel: Leviathan-10, Leviathan-11, and Leviathan-23 wells (total duration = 366 days)[a]			
WBM and brine	Continuous	--	WBM: 24,106 metric tons
			Brine: 3,882 tons
Cuttings (WBM intervals)	Continuous	--	580 m^3
Cement [C]	Periodic	--	118 metric tons
Brine	Continuous	--	3,882 tons
Sanitary wastes	Periodic	74.9 m^3/day	27,377 m^3
Grey water	Continuous	55.0 m^3/day	20,130 m^3
Organic (food) waste	Periodic	0.3 m^3/day	101 m^3
Cooling water	Continuous	80,000 m^3/day	29,280,000 m^3
Desalination brine	Continuous	16.1 m^3/day	5,893 m^3
Deck drainage (runoff, washdown)	Periodic	845 m^3/day	309,270 m^3
Blowout preventer fluid	Periodic	--	10 m^3
Subsea Infrastructure Installation Vessel (total duration: 60 days)[b]			
Sanitary wastes	Periodic	135.7 m^3/day	8,140 m^3
Grey water	Continuous	99.8 m^3/day	5,985 m^3
Organic (food) waste	Periodic	0.5 m^3/day	30 m^3
Cooling water (est.)	Continuous	60,000 m^3/day	3,600,000 m^3
Desalination brine (est.)	Continuous	20 m^3/day	1,200 m^3
Deck drainage (runoff, washdown)	Periodic	72.2 m^3/day	4,332 m^3

[a] Average daily rate is based on an average of 220 persons on board ( ).
[b] Average daily rate is based on a maximum of 399 persons on board ( ).
[c] Most of the cement will be discharged at the wellbore, small quantities will be released from the rig's overboard line.
Note: Maximum amount of deck drainage per day is based on the maximum daily amount of rain that has fallen in Ashkelon between 2009 and 2024 (92 mm on 12 December 2013) multiplied by the estimated deck area; 9,141 m^2 for the ; 730 m^2 for the ; washdown water estimated at 5 m^3 per day.
WBM = water-based mud.

Support vessels operating in support of drilling and completion will discharge sanitary wastes (4,355 m^3), grey water (3,203 m^3), and food waste (16 m^3), with additional discharges from cooling water, deck drainage, and potentially desalination brine. Support vessels operating in support of subsea installation will discharge sanitary wastes (15,871 m^3), grey water (11,670 m^3), and food waste (30 m^3), with additional discharges from cooling water, deck drainage, and potentially desalination brine.

3.6.1.6 Discharge Technique

For the drillship, discharges occur through various pipes ranging from 1.5-inch to 14-inch diameter and are either gravity fed or pumped, with pipe orientation in a vertical, downward direction. Non-hazardous discharges, including deck drainage and bilge water, will pass through an oil detector and meet the 15-ppm threshold for total oil and grease (TOG). Cooling water is discharged through four discrete discharge pipes (diameters: two 5-inch, one 12-inch, and one 14-inch) at 5.95 m and 12 m below the sea surface. Brine from the potable water makers is discharged through one of three 5-inch diameter pipes either 5.1 m or 12 m below the sea surface. Treated sewage (black water) is discharged through either a 2.5-inch diameter pipe (forward) or a 2-inch pipe located at 12 m below the sea surface. Bilge water will be collected and treated in an oil-water separator, pass through an oil detector, and comply with the 15-ppm threshold for TOG.

Table 3-11. Types of routine discharges from a representative drillship (exclusive of drilling muds, cuttings, and cement) during Leviathan Expansion Project drilling and completion activities. Discharge pipe diameters are based on the drillship as a representative example.

Discharge Type	Discharge Frequency and Treatment	Discharge Pipe (using drillship as an example)	
		Pipe Diameter (in.)	Depth of outlet below sea level (m)
Sanitary Waste (Black Water)	Periodic; chlorinated in IMO-approved sewage treatment plan	2.5 FWD; 2 AFT	2 × 12 m
Grey Water	Continuous; no treatment	8	12
Desalination Brine	Continuous; diluted with water prior to discharge	3 × 5 inch	2 × 5.1 m; 12
Cooling Water	Continuous; no treatment	2 × 5 inch; 12; 14	2 × 5.95 m; 2 × 12 m
Organic Food Waste	Periodic; macerated to meet MARPOL requirements	4; 8	12
Bilge Water	Intermittent; passes through the OWS	2	12
Boiler Drainage Water	Intermittent; no treatment	1.5	12
Deck drainage (Runoff)	Continuous; drainage from machinery areas passes through OWS; no treatment for other deck drainage	4; 2 × 8 inch; 2 × 10 inch outlets; 2 × 10 inch U seal by-pass	+2.5

IMO = International Maritime Organization; MARPOL = International Convention for the Prevention of Pollution from Ships; OWS = oil/water separator.

For the subsea infrastructure installation vessel, discharge types are expected to be similar if not identical. Discharge frequency and treatment were outlined in **Table 3-10**. Discharge pipe locations and respective diameters for the representative installation vessel are currently unavailable. Depths of each respective discharge are expected to be similar to those outlined in **Table 3-11**.

3.6.1.7 Discharge Volumes

Estimated routine discharges from the drillship, exclusive of drilling muds and cuttings and cement, are summarized in **Table 3-12**. Well-specific discharge information will be provided to the MoEP in the Discharge to Sea Permit application. The table is based on actual discharge data from the drilling and completion of the Lev-8 well. Discharges will include sanitary waste, grey water, organic (food) waste, cooling water, desalination brine, bilge water, and deck drainage (runoff).

Table 3-12. Estimated routine discharges from the drillship during Leviathan Expansion Project drilling and completion activities (exclusive of drilling muds, cuttings, and cement).

Discharge Type	Maximum Daily Flow[1] (m^3/hour)	Estimated Discharge Data from Drillship			Estimated Total Quantities for Planned Drilling and Completion Activities (m^3)		
		Average Hourly (m^3/hour)	Average Daily (m^3/day)	Average Monthly (m^3/month)	Drilling Each New Well (82 days)	Completing Each Well (40 days)	Drilling and Completing All New Wells (Leviathan-10, Leviathan-11, and Leviathan-23)
Sanitary Waste (Black Water)	75 ($0.34 m^3$/ day/person)[2]	3.1	74.9	2,247	6,141	2,996	27,377
Grey Water	55 ($0.25 m^3$/ day/person)[2]	2.3	55.0	1,650	4,510	2,200	20,130
Desalination Brine[3]	16	0.7	16.1	483	1,321	644	5,895
Cooling Water[4]	80,000	3,333	80,000	2,400,000	6,560,000	3,200,000	29,280,000
Organic Food Waste	0.275 ($0.00125 m^3$/ day/person)[2]	0.01	0.3	8	23	11	101
Bilgewater	20	0.1	3.3	100	273	133	1,218
Boiler's Blowdown	0.5	0.01	0.3	8	21	10	93
Deck Drainage (Runoff[5] and Wash Water)	845	1.5	35.2	1,056	2,886	1,408	12,882

[1] Flow rates estimated based on pump/processing plants/daily consumption, etc.
[2] 220 people on board.
[3] Desalination Brine is not discharged directly over the side as the by-product of the water production. It is mixed / diluted with water by a vacuum in water maker. The ejector (vacuum) pump's capacity is 2×88 m^3/h during normal operations with two water makers running. Realistically ca 9 m^3 of brine is diluted with ca 4,224 m^2 of seawater prior to discharging over the side.
[4] There are no additives, including chlorine, in the cooling water.
[5] Maximum amount per day is based on the maximum daily amount of rain that has fallen in Ashkelon between 2009 and 2024 (92 mm on 12 December 2013) multiplied by the estimated deck area – 9,141 m^2, a total of 840 cubic meters per day.

During the subsea infrastructure pre-commissioning steps various chemicals will be utilized and discharged. Estimated volumes of the discharged chemicals are summarized in **Table 3-13**. If possible, these chemicals will be classified Gold under the Offshore Chemical Notification Scheme (OCNS) classification, which indicates that they present a relatively low hazard to the environment. Final chemical selection will be made during the detailed design phase of the project and submitted to MoEP approval as part of the Discharge to Sea Permit application. For this assessment, the chemicals stated in **Table 3-13** are considered as typical examples of chemicals that may be used in the project.

Table 3-13. Estimated volumes (m^3) of chemicals[1] to be discharged during infrastructure pre-commissioning activities.

Parameter	Leviathan-10	Leviathan-11	Leviathan-23	Total
Filtered and treated seawater	468	195	648	1,311
Mixture of anti-corrosive agent, dye, and biocide (	0.2	0.1	0.3	0.6
MEG (Flowline Dewatering)	6	3	8	17
Fresh Water (Flowline Desalination)	12	6	16	34
MEG + Dye (Jumpers)	30	20	20	70
Total Discharges from all sources + Contingency of 1 volume of the flowline	516	224	692	1,433

[1] Exact chemicals and concentrations will be submitted to the MoEP at a later stage as part of the application for the Discharge to Sea Permit.

3.6.1.8 Black Water and Grey Water

Estimated volumes of black water (sanitary wastes) and grey water (sinks, showers, etc.) are presented separately in **Table 3-14** for the drillship, support vessels (i.e., drilling and completion; subsea infrastructure installation), and subsea infrastructure installation vessel.

Table 3-14. Estimated volumes (m^3) of black water and grey water to be discharged during the Leviathan Expansion Project.

Source	Black Water (m^3)	Grey Water (m^3)
Drillship	27,377	20,130
Support Vessels – Drilling and Completion	4,355	3,203
Installation Vessel	8,140	5,985
Support Vessels – Installation	15,871	11,670

3.6.1.9 Discharge Quality

CSA (2016) provided a discussion of the quality of routine discharges; see Section 3.7.3.3 of the 2016 document.

Key Findings:

- Effluent quality data collected by NEML (now CML) during drilling of the Tamar SW-1 well in the Tamar Field are considered as representative for the proposed Leviathan Expansion Project activities (see Tables 3-37 to 3-39 in CSA, 2016).

Proposed Project:

- CML expects that effluent quality of routine discharges and drilling and completion discharges during the Leviathan Expansion Project will be similar to that during the will be similar to those from the recently drilled Leviathan-8 well (drilled in early 2023). Effluent quality data from the recent Leviathan-8 well drilling campaign are presented in **Appendix I**.

3.6.1.10 Alternatives to On-Site Discharge

CSA (2016) provided a discussion on the evaluation of the Alternatives to On-Site Discharge; see Section 3.7.5 of the 2016 document.

Key Findings:

- Available alternatives to on-site discharge of WBM and cuttings include injection or discharge into wellbores or subsurface formations and transport to shore for treatment and disposal; each come with their own set of environmental effects.

- CML has implemented a series of mechanisms and procedures to ensure that impacts to the marine environment from on-site discharge of WBM are minimized.
    - Alternatives to the on-site discharge of other routine effluents either are not practical, are limited, or increase safety concerns.

Proposed Project:
- MOBM and cuttings with adhering MOBM will be transported to shore for recycling or proper disposal.
- WBM and cuttings while drilling with WBM will be discharged at the seafloor as this section is drilled riserless and there is no conduit back to the drillship.

3.6.2 Drilling Mud and Cement Surplus

CSA (2016) provided a discussion of drilling and completion discharges, see Section 3.7.2 of the 2016 document.

Key Findings:
- A combination of WBM and MOBM were used to drill the Leviathan Field wells.
- WBM was used for the first two initial well intervals (before the marine riser is set).
- WBM and cuttings, as well as excess cement, were released at the seafloor.
- Once the marine riser was set, the remaining well intervals were drilled with MOBM which was collected and sent to shore for proper disposal.

Proposed Project:
- WBM cuttings will be discharged only at the seabed (no discharge of cuttings from the overboard lines).
- An effort will be made to purchase barite that contains a low concentration of metals; barite will have a low metals concentration and will comply with the discharge-to-sea permit thresholds for mercury and cadmium.
- MOBM cuttings will be collected and sent to shore for proper disposal (no discharge of MOBM or cuttings to the marine environment).
- No condensate will be discharged to sea under any circumstances.
- Preferably, additives to cement, brine, and WBM blends will be classified on the PLONOR list (considered by the OSPAR Commission to pose little or no risk to the environment) or gold-rated by the (OCNS).
- **Table 3-15** provides a representative drilling program including mud type and estimated discharge rates, volumes, and locations for each well interval.
- **Table 3-16** summarizes the estimated WBM products and seawater to be consumed and discharged during drilling; the final decision on chemicals selection will be presented in the Discharge to Sea Permit application.
- **Table 3-17** summarizes the estimated materials to be consumed and discharged during completion; the final decision on chemicals selection will be presented in the Discharge to Sea Permit application.
- **Table 3-18** provides the estimated per-well cement products to be consumed, discharged, and remaining in the well for a representative Leviathan Expansion Project well. The final decision on chemicals selection will be presented in the Discharge to Sea Permit application.

Table 3-15. Drilling program for a representative Leviathan Expansion Project well.

Section (Interval)	Hole Diameter (inches)	Target Interval Duration (days)	Cuttings Discharge		Drilling Fluid (Mud) Discharge		Mud Type	Release Location
			Vol. (m^3)	Rate (m^3/day)	Vol. (m^3)	Rate (m^3/day)		
			65	65	25	25	WBM	Seafloor, released continuously with cuttings
			515	130	18,000	4,500	WBM Brine	Seafloor, released continuously with cuttings
			N/A	N/A	N/A	N/A	MOBM	N/A
			N/A	N/A	N/A	N/A	MOBM	N/A
			N/A	N/A	N/A	N/A	MOBM	N/A
			N/A	N/A	N/A	N/A	MOBM	N/A
			N/A	N/A	N/A	N/A	N/A	

BOP = blowout preventer; MOBM = mineral oil-based mud; N/A = not applicable; WBM = water-based mud.

Table 3-16. Estimated per-well water-based mud (WBM) and seawater total material consumed (and discharged) during drilling for a representative Leviathan Expansion Project well.

Table 3-17. Estimated per-well cement products consumed, remaining in the well, and discharged for a representative Leviathan Expansion Project well.

Table 3-18. Estimated per-well brine total material consumed (and discharged) for a representative Leviathan Expansion Project well during completion.

Table 3-18. (Continued)

3.7 GEOHAZARDS

CSA (2016) discussed regional seismicity near the Leviathan Field; see Section 4.11 of the 2016 document.

Key Findings:

- There has been one recorded earthquake (magnitude 4.0) within approximately 40 km of the Leviathan Field since 1979.

Proposed Project:

- CML has considered seismic risk (including potential earthquakes) in developing the proposed drilling and completion program. CML's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including earthquakes.
- No environmental impacts from earthquakes are expected during the Leviathan Expansion Project.

3.8 WASTE

CSA (2016) provided a discussion of all wastes; see Section 3.8 of the 2016 document.

Key Findings:
- All wastes were handled and disposed of according to MARPOL and permit requirements.
- Wastes that could not be discharged overboard under MARPOL requirements were shipped to authorized waste disposal sites onshore in accordance with the regulations.
- The drillship managed the generation, storage, and disposal of all solid waste.
- Each identified waste stream was classified and handled as scheduled waste or non-scheduled waste and was segregated by type.
- Different waste streams were not mixed together, stored together, or managed in the same container.
- All containers had their lids, rings, covers, bungs, and other means of closure properly installed at all times except when waste was being added or removed.

Proposed Project:
- Based on previous drilling and completion campaigns, CML estimates that approximately 30 m^3 of solid wastes will be generated during the Leviathan Expansion Project.
- Wastes are anticipated to consist of cooking oil, incinerator ashes, and domestic, operational, plastic, and e-wastes.
- Based on previous subsea infrastructure installation campaigns, CML estimates that approximately 10 to 15 m^3 of solid wastes will be generated during the Leviathan Expansion Project.
- Similar to drilling and completion, the wastes expected to be generated during subsea infrastructure installation will include cooking oil, incinerator ashes, and domestic, operational, plastic, and e-wastes.

For solid waste, vessel-specific waste management plans (WMPs) will include provisions for 1) segregating solid wastes; 2) ensuring appropriate onboard storage; and 3) recycling or reuse, when practical. Solid waste generated during drilling and completion and subsea installation will comply with the requirements of MARPOL 73/78. Project vessels will comply with their individual WMPs, the latter of which will outline the procedures for collection, storage, processing, and proper disposal of waste.

In compliance with MARPOL 73/78, project solid waste will be managed as MARPOL Annex V waste (i.e., discharge at sea strictly prohibited). Solid waste, once separated and containerized/stored, will be periodically shipped to shore for transport to an appropriate waste facility (i.e., licensed facilities which comply with national regulations).

As part of each WMP, monitoring records will be maintained which will include types and quantities of waste generated; types and quantities of waste leaving the project area for recycling, recovery, or disposal; location of treatment or disposal facilities to which the wastes are transported; and, records of any accidental releases of solid waste.

Solid wastes onboard the drilling vessel will be treated in accordance with the IMO MEP 66 / 21, and in compliance with MARPOL Convention Annex VI (Regulation 16) under MEPC permit, and with local regulations and conditions set by the MoEP in the Toxin Permit for the drilling activity.

3.9 DECOMMISSIONING/ABANDONING WELLS AND INFRASTRUCTURE

Permanent well decommissioning and abandonment will occur at the end of the operational service life of the Leviathan Expansion Project wells. CML will follow regulations and best industry practice in its abandonment program, reflecting safety practices in place at the time of decommissioning. Prior to decommissioning and abandonment activities occurring, CML will develop a plan that will include a description of decommissioning project management and engineering, well plugging and abandonment, cleaning and flushing activities, disconnection of subsea and gathering systems, and removal of infrastructure, as required.

Key Findings:

- CSA (2016) discussed, in very general terms, future well abandonment and infrastructure decommissioning within the Leviathan Field; see Section 4.15 of the 2016 document. Genesis (2016) also discusses decommissioning in Section 5.2.11.

Proposed Project:

- No new information has been identified. CML will rely on the summary information regarding decommissioning/abandoning wells and infrastructure, as outlined in CSA (2016).
- A designated EIA for permanent decommissioning and abandonment of the Leviathan Expansion Project wells will be conducted prior to those activities occurring.
- For future decommissioning, the scope will include plugging and abandonment (P&A) of all wells, flushing of all subsea infrastructure, and the removal (or abandonment in place) of subsea infrastructure, as discussed below.

3.9.1 Well Decommissioning

During the preparation/planning phase, the abandonment activities will focus on data gathering to form the basis for well abandonment design, facilities front-end engineering, feasibility studies, risk assessments, environmental impact assessments, inventory planning, inspections, surveys, and budgets.

It is a common practice with global precedents in deep-sea environments to leave underwater well heads protruding from the seabed. The removal of production trees, production lines and peripherals will be evaluated and executed as defined in the detailed abandonment plan for each well. In general, underwater equipment at depths such as the Leviathan Field (>1,600 m) have minimal impact on health, safety and the environment. Any material removed would be reused, recycled or disposed of in appropriate facilities.

3.9.2 Infrastructure

After Cease of Production (CoP), the subsea infrastructure must be freed of hydrocarbons and hazardous materials to make the equipment and pipework safe for deconstruction and transportation, or to be left in place, depending upon a comparison of various decommissioning options. The cleaning program depends on the specific needs of the facility, equipment, and lines at the time of abandonment. Isolation and freeing of hydrocarbons, depressurization of the system, purging, draining, and flushing of all process, utility, and service systems associated with the decommissioned infrastructure and equipment will be performed to regulatory standards and industry best practices. Requirements will depend on how the facility was operated and maintained. The cleaning standards, however, will follow environmental permits and national, regional, or local regulations. If cleanliness levels are unspecified by regulation, CML will set a minimum cleanliness level, which may be specified in parts per million, flushing until clean returns.

Chapter 4: Evaluating the Expected Environmental Impacts of Implementing the Application, and the Means of Prevention or Mitigation

This chapter evaluates the environmental impacts of CML's proposed drilling and completion activities in the Leviathan Field, as well as the installation of flowlines and other subsea infrastructure. The issue of well control and integrity are addressed elsewhere in this document. Detailed BOP specifications are provided in **Section 3.2.3.1**. The detailed casing design and testing are described in **Section 3.2.3.2**. CML's methods for risk assessment and management are summarized in **Section 5.2**.

The impact assessment includes both routine activities and accidental events. The topics in the impact analysis are those specified in the "Guidelines for Preparing the Environmental Impact Assessment in the Israeli Exclusive Economic Zone (EEZ) – Leviathan Expansion Project" issued 09 January 2025 (MoE and MoEP, 2025; **Appendix A**). The following definitions are used:

- **Aspect** – an element of an organization's activities or products or services that can interact with the environment (International Organization for Standardization, 2004; ISO 14001);
- **Resource –** a component of the natural or human environment that could be affected by any aspect of an organization's activities; and
- **Impact –** any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects (International Organization for Standardization, 2004).

The following aspects and resources were included in the analysis:

Aspects:

- Seafloor disturbance;
- Drilling discharges;
- Routine discharges;
- Air emissions;
- Safety and protection;
- Noise hazards;
- Light disturbances;
- Waste and marine debris;
- Support vessel traffic;
- Helicopter traffic;
- Accidental fuel release; and
- Accidental condensate release from well loss of containment

The first step in the impact analysis was a screening assessment to identify the resources potentially affected by each aspect. **Table 4-1** shows a matrix of potential interactions between aspects and resources. Each interaction indicates a potential impact to be analyzed.

The next step was to analyze each potential impact by describing and quantifying each impact to the extent practicable. This step included an assessment of the "consequence" (severity) and likelihood of each impact.

Finally, the overall environmental risk posed by each impact was assessed using a risk matrix that combines aspect likelihood and impact consequence (**Table 4-2**). The likelihood of each aspect (considering all of the identified management and mitigation measures) was given a score between 1 and 5 based on the definitions in the matrix. The consequence of each potential environmental impact was also rated on a scale of 1 to 5. Each cell in the matrix (i.e., each intersection of likelihood and consequence) was calculated as the product of likelihood and consequence. These risk values were grouped into three color-coded risk categories: Low, Moderate, and High.

Table 4-1. Impact matrix showing potential interactions between aspects and resources. A bullet symbol in a cell indicates a potential impact to be analyzed, and numbers indicate the section number(s) where the impact is analyzed. Impact significance determinations are found (in tabular form) in the final subsection of each numerical entry noted below.

Aspect	Air Quality	Water Quality	Sediment Quality	Benthic Communities	Marine Mammals	Sea Turtles	Seabirds and Migratory Birds	Fishes	Fishing and Marine Aquaculture	Culture and Heritage Sites	Marine Transportation and Infrastructure	Coastal Habitats and Infrastructure
Seafloor disturbance	--	● 4.5.1.2	● 4.5.1.1	● 4.5.1	--	--	--	--	--	● 4.6.1	--	--
Drilling discharges	--	● 4.5.2.3	● 4.5.2.4	● 4.5.2.4	--	--	--	● 4.5.2.3	--	● 4.6.2	--	--
Routine discharges	--	● 4.5.3.1	--	--	● 4.5.3.2	● 4.5.3.2	--	● 4.5.3.1	--	--	--	--
Air emissions	● 4.7.1.1	--	--	--	--	--	--	--	--	--	--	--
Safety and protection zones	--	--	--	--	--	--	--	--	● 4.11.1.1	--	● 4.12	--
Noise hazards	--	--	--	--	● 4.4.2	● 4.4.3	--	● 4.4.4	--	--	--	--
Light hazards	--	--	--	--	--	● 4.3.1.1	● 4.3.1.2	● 4.3.1.3	--	--	--	--
Waste and marine debris	--	● 4.5.6.1	● 4.5.6.1	● 4.5.6.1	● 4.5.6.2	● 4.5.6.2	● 4.5.6.4	● 4.5.6.3	--	--	--	--
Support vessel traffic	--	--	--	--	● 4.5.4.1	● 4.5.4.2	--	--	● 4.11.1.2	--	--	--
Helicopter traffic	--	--	--	--	● 4.5.5.1	● 4.5.5.1	● 4.5.5.2	--	--	--	--	--

Table 4-1. (Continued).

Aspect	Air Quality	Water Quality	Sediment Quality	Benthic Communities	Marine Mammals	Sea Turtles	Seabirds and Migratory Birds	Fishes	Fishing and Marine Aquaculture	Culture and Heritage Sites	Marine Transportation and Infrastructure	Coastal Habitats and Infrastructure
Accidental fuel spill	●	●	--	--	●	●	●	●	●	●	●	●
	4.2.4	4.2.4			4.2.4	4.2.4	4.2.4	4.2.4	4.11.1.3	4.2.4	4.2.4	4.2.4
	4.7.2	--			--	--	--	--	--	4.6.3	--	--
Accidental condensate loss of containment	●	●	●	●	●	●	●	●	●	●	●	●
	4.2.4.1	4.2.4.2	4.2.4.3	4.2.4.3	4.2.4.4	4.2.4.5	4.2.4.6	4.2.4.7	4.11.1.3	4.2.4.9	4.2.4.10	4.2.4.11
	4.7.1.2	--	--	--	--	--	--	--	--	4.6.3	--	--

Table 4-2. Risk assessment matrix for impact analysis.

Consequence				LIKELIHOOD				
				1	2	3	4	5
				Rare	Unlikely	Possible	Likely	Almost Certain
			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 company history. Additional safeguards are required.
Severity		Environment	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 Severe	Adverse permanent impacts on key ecosystem functions and services in larger natural habitats (e.g., restitution time more than 5 years).	Heat Map	5	10	15	20	25
4	Severe	Adverse impact on ecologically valuable natural habitats (e.g., restitution time 2 to 5 years).		4	8	12	16	20
3	Medium	Adverse impacts on a significant part of habitats (e.g., restitution time 1 to 2 years).		3	6	9	12	15
2	Minor	Adverse short-term impact on natural habitats.		2	4	6	8	10
1	Insignificant	No or very limited impact on natural habitats. No impact on population level, only on individual organism level.		1	2	3	4	5

Overall risk is rated as ___ = Low, ___ = Moderate, or ___ = High.

4.1 ESTIMATING POTENTIAL IMPACTS ON THE MARINE ENVIRONMENT

4.1.1 Production Drilling

4.1.1.1 Range of Impact

Details regarding production drilling were presented in **Section 3.2.2**. The proposed drillship will not employ anchors, effectively eliminating any potential anchor-related impacts to the seafloor. The drilling of each well will disturb an area at each drill site, including the physical penetration of sediments at the borehole, and the release of WBM at each drill site. Localized water and sediment quality impacts are also expected as a result of WBM and cuttings released from the wellbore (see **Section 4.5.2**).

4.1.1.2 Degree of Impact

WBM deposition typically extends 10 m or more from the drill site, with a conservative estimate of 20 m. Using this conservative radial distance, the area of seafloor potentially affected by drilling at a single drill site is 1,257 m^2; total area affected by drilling and completion operations is expected to be approximately 3,771 m^2.

4.1.1.3 Proximity to Sensitive Resources

No protected areas, nature reserves, or culture and heritage sites are located within the area of impact resulting from drilling and completion operations.

4.1.1.4 Mitigation Measures

There are no alternatives or mitigation measures available relevant to the subsea release of WBM at the wellbore. MOBM cuttings will not be discharged on-site; they will be containerized and shipped to shore for proper disposal. Additional discussion of muds and cuttings discharges and associated mitigation measures is presented in **Section 4.5.2**.

4.1.1.5 Muds and Cuttings Discharge Modeling

Drilling discharge dispersion modeling was conducted using the Leviathan-9 drill site as a representative location for the 2016 Leviathan Field EIA (CSA, 2016). Those results remain relevant for discharges that will occur during drilling of the Leviathan Expansion Project wells. The modeling was conducted using the model and the input data included the proposed well intervals and discharge quantities, site-specific current data from the Leviathan Field, and particle size data from CML. Discussion of the modeling parameters and results are presented in **Section 4.5.2.2**. The full muds and cuttings discharge modeling report is presented **Appendix K**.

4.1.1.6 Maximal Discharge Dispersion

Seasonal effects on muds and cuttings dispersion is discussed in **Section 4.5.2.2**. No other parameters (e.g., discharges at different water depths) were considered.

4.1.2 Production Tests

Production tests are not expected to occur as part of the drilling and completion or subsea infrastructure installation portions of the Leviathan Expansion Project.

4.1.3 Subsea Infrastructure and Pipelines

4.1.3.1 Infrastructure Footprint

As part of the Leviathan Expansion Project, CML will install subsea infrastructure as described in **Section 3.2.4**. Based on the proposed infrastructure to be installed, a total seafloor footprint of 6,018 m^2 may be disturbed during installation (**Table 4-3**). Impacts from the installation of subsea infrastructure are discussed in **Section 4.5.1**.

Table 4-3. Estimated seafloor footprint of proposed infrastructure for the Leviathan Expansion Project.

Proposed Subsea Infrastructure	Length (m)	Width (m)	No.	Estimated Seafloor Footprint (m^2)
IFL-L11 Flowline	943	0.37	1	352
IFL-L10 Flowline	2,249	0.37	1	840
IFL-L23 Flowline	3,121	0.37	1	1,166
PLET Lev-23A	15.5	13.0	1	202
PLET Lev-23B	15.5	13.0	1	202
PLET Lev-11A	14.0	12.0	1	168
PLET Lev-11B	14.0	12.0	1	168
PLET Lev-10A	14.0	12.0	1	168
PLET Lev-10B	15.5	13.0	1	202
IFL and PLET 20% contingency			20%	735
IUMB-L11 Umbilical	1,020	0.18	1	181
IUMB-L11 UTAs (2x)	7.0	4.5	2	63
IUMB-L23 Umbilical	4,700	0.18	1	832
IUMB-L23 UTAs (2x)	7.0	4.5	2	63
IUMB-L23 Crossings (3x)	16.0	8.0	1	128
IUMB-L11 and IUMB-23 Umbilicals 20% contingency			20%	253
Intermediate Jumper Structure	11.0	7.0	1	77
Intermediate Jumper Structure 20% contingency			20%	15
CDUs	6	4	2	48
Optical, Hydraulic and Electrical Flying Leads	150	0.03	27	122
Flexible Flying Leads	100	0.07	5	35
Distribution Contingency (20%)			20%	41
			Total	6,018

Flowline land take is based on the full 14 inch diameter of flowlines + 9 mm of insulation giving a land take per unit of 0.37 m^2/m.
Umbilical land take is based on the full 7 inch diameter of umbilical giving a land take per unit of 0.18 m^2/m.
OFL, HFL and EFL land take is based on average lengths of 150 m and 0.03 m diameter giving a land take of 0.03 m^2/m.
FFL land take is based on average lengths of 150 m and 0.07 m diameter giving a land take of .07 m^2/m.
Contingencies are applied to address present design maturity level.

4.1.3.2 Extreme Weather

Given the water depths in which the subsea infrastructure will be placed, extreme weather events will have no impact upon infrastructure stability.

4.1.3.3 Infrastructure Protection

Due to the project water depth and benign seabed conditions, as well as the absence of deepwater trawling activity in the Leviathan Field, jumper protection (in the form of concrete mattresses) or mid-point anchoring is not required and as such will not be used, as discussed in **Section 3.2.1.4**.

4.1.4 Production Platform

The LPP impacts to the local ecosystem have been evaluated as part of a prior impact assessment (Genesis, 2016). The LPP is not part of the Leviathan Expansion Project and will not be evaluated further in this assessment.

4.2 ENVIRONMENTAL IMPACT – OIL POLLUTION INCIDENT

4.2.1 Spill Scenarios

Two accidental spill scenarios were previously evaluated in the CSA (2016) document and remain relevant for the Leviathan Expansion Project: a fuel spill and a condensate spill from a well loss of containment. The fuel spill scenario assumed an instantaneous release of 8,415.6 m^3 from the drillship. The condensate spill scenario assumed a well loss of containment resulting in the release of continuing for a period of 30 days.

The probability of the two spill scenarios has not been calculated. However, both scenarios represent highly unlikely events. Historically, the loss of well containment (i.e., blowouts) are rare, and most do not result in spills. Based on North Sea data, the International Association of Oil & Gas Producers (2010) estimated the probability of a blowout during development drilling (deep gas wells) is 7×10^{-5} per well. Data from the U.S. Gulf of Mexico from 1992 to 2005 indicate that half of blowouts lasted less than half a day, and fewer than 10% of blowouts resulted in spilled oil (Minerals Management Service, 2007). These statistics were published prior to the *Deepwater Horizon* incident in 2010. However, following the *Deepwater Horizon* spill, Eckle et al. (2012) revisited the historic spill data in order to integrate the 2010 spill event into the worldwide database and to re-evaluate accident statistics. The authors concluded that the expected risk has not really been changed by the *Deepwater Horizon* incident. Since then, additional preventive procedures, including many safety and well control protocols have been implemented to make sure that safety and environmental integrity are not compromised by uncontrolled releases of hydrocarbons. Mitigation measures, including spill prevention and well control measures, are discussed in **Chapter 5**. Detailed BOP specifications are provided in **Section 3.2.4** and the design and testing of the casing to prevent a loss of well control are described in **Section 3.2.5**.

A large diesel spill, such as one releasing the entire fuel contents of a drillship, would also be a rare event. Historical data from the U.S. Gulf of Mexico include no such incidents from 1964 to 2010, with the volume of the largest platform or drillship-related diesel spill being approximately 238 m^3 (1,500 bbl) (Anderson et al., 2012). The most likely type of spill to potentially occur during offshore oil and gas activities is a small fuel spill (BOEM, 2012).

Trajectory modeling results for a fuel spill are available from modeling conducted by for the ML-1X drill site in the Leviathan Field. Modeling of a condensate spill was conducted by using the Leviathan-6 drill site as a release point. Spill trajectory modeling methods and results are presented in **Appendix J**.

4.2.2 Fuel Spill Modeling Results

The fuel spill scenario assumes the instantaneous release of the entire fuel supply of a drillship. Based on the *Atwood Advantage* as a representative example of a DP drillship, the spill volume was assumed to be 8,415.6 m^3. The spill was assumed to occur at the sea surface.

Modeling of a fuel spill was conducted using . Spill fate was modeled for 30 days from the beginning of the spill (**Appendix J**). The following four time periods representative of various climatic conditions were used in the model:

- Scenario 1 – 9 December 2010 to 8 January 2011, a period that included an extreme winter storm;

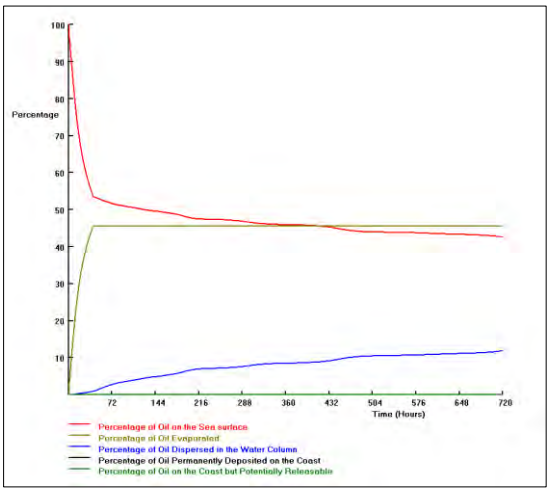
- Scenario 2 – 26 January to 25 February 2008, typical winter conditions;
- Scenario 3 – 17 July to 16 August 2008, typical summer conditions with persistent northwesterly winds and swell; and
- Scenario 4 – 25 September to 25 October 2007, autumn conditions typical of the transition seasons and including at least one episode of strong easterly to northeasterly wind.

The model includes a spill weathering component to estimate how much of the spilled volume would remain on the sea surface at various times following a spill. The weathering analysis does not take into account any spill response activities. CML's Oil Spill Contingency Plan (OSCP) provides detailed information about the response capabilities and methods that CML would use to minimize the potential for significant impacts. The drillship contractor will also implement oil spill prevention methods as part of its Shipboard Oil Pollution Emergency Plan (SOPEP).

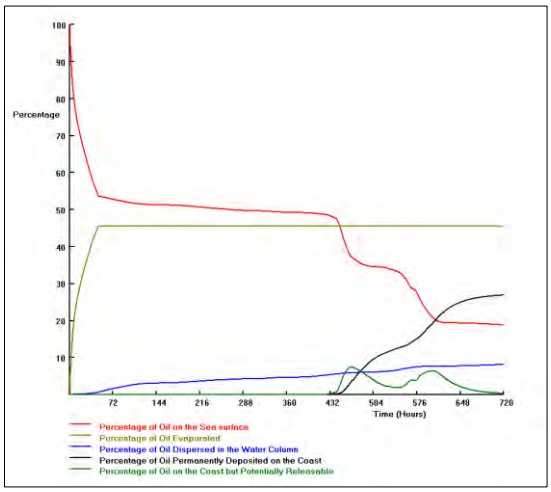
Table 4-4 and **Figure 4-1** summarize the modeling results for a fuel spill under the four scenarios. The model predicts that diesel fuel would evaporate rapidly, with approximately 45.6% of the spill evaporating in the first 42 to 55 hours in the four scenarios. A spill is predicted to reach the shoreline after 12 days under Scenario 4, after 20 or 21 days under Scenario 2 or 3, or essentially not at all under Scenario 1. At the end of 30 days, all four scenarios show 45.6% evaporation, from 0% to approximately 42% oil remaining on the sea surface, and between 2.5% and 11.9% dispersed. The percent of the spill volume deposited on the coastline ranges from 0.003% (Scenario 1) to 51.8% (Scenario 4), with impacts to the coastline of Israel, Cyprus, and Lebanon depending on the seasonal scenario. The total length of affected shoreline ranges from negligible to 220 km. Potential impact hotspots in Israel are Atlit, the southern coast of Haifa, parts of Haifa Bay, the Akko coast, and Rosh Hanikra.

Table 4-4. Trajectory and weathering model results at the end of 30 days for a fuel spill under four environmental scenarios.

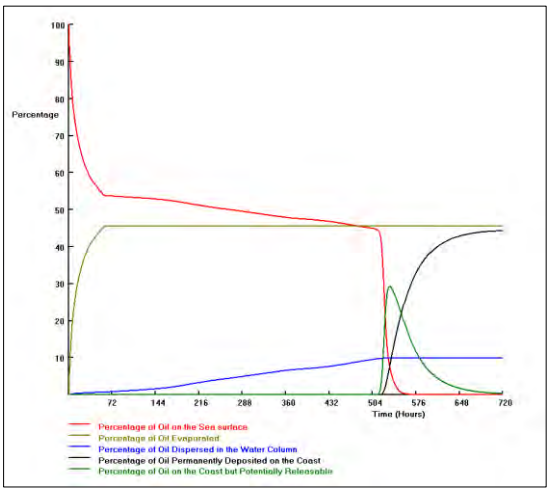
Scenario	Percent Evaporated	Percent on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspots
1 extreme winter storm	45.6	42.5	11.9	0.003	--	Negligible	Southern coast of Cyprus	Paphos, Cyprus (very limited impact)
2 typical winter conditions	45.6	18.8	8.2	27.2	20	220	Ashkelon to Beirut	Rosh Hanikra and southern Lebanon (typically 15–20 m^3/km; locally as high as 50 m^3/km)
3 typical summer conditions	45.6	0.0	9.8	44.6	21	61	South of Beirut	Jieh, Lebanon (typically 1 m^3/km, locally as high as 200 m^3/km at Jieh)
4 typical autumn conditions	45.6	0.02	2.5	51.8	12	110	Netanya to Israel-Lebanon border	Atlit, southern coast of Haifa, parts of Haifa Bay, Akko coast (typically 150 m^3/km, locally as high as 500 m^3/km)



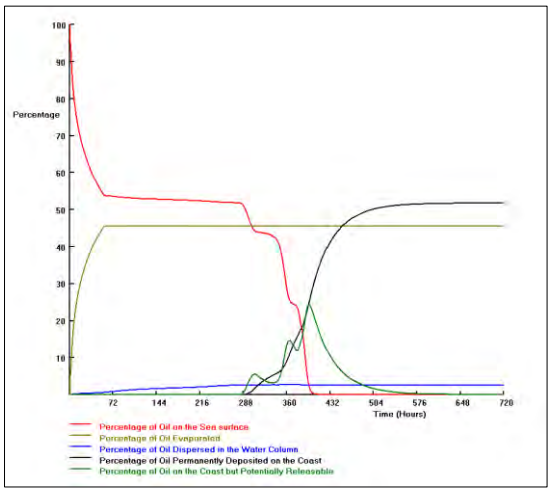
Scenario 1: Extreme winter storm.



Scenario 2: Typical winter conditions.



Scenario 3: Typical summer conditions.



Scenario 4: Typical autumn conditions.

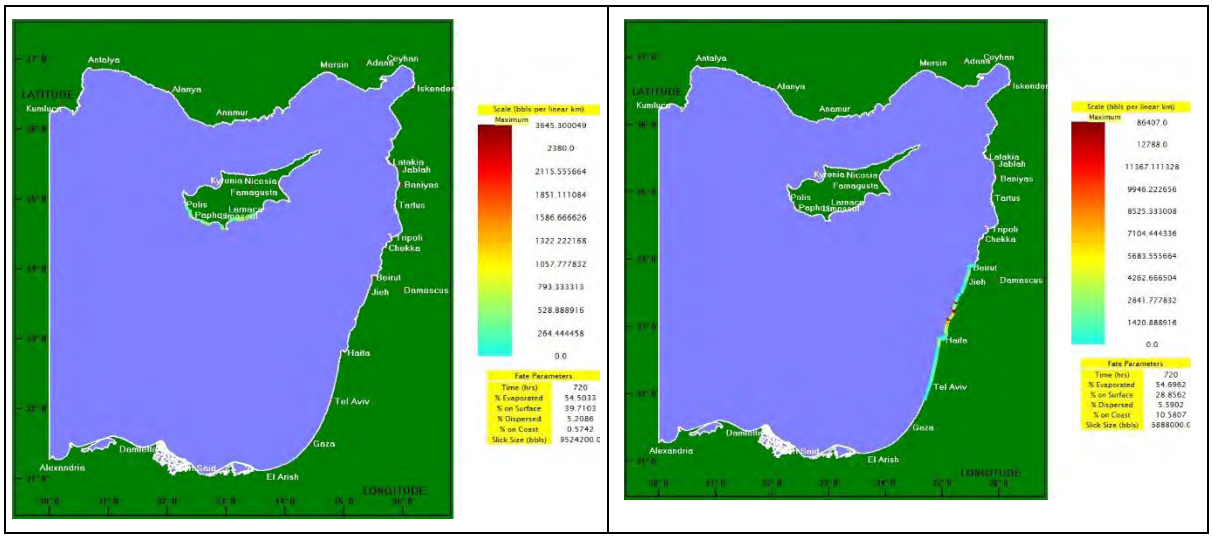


Figure 4-1. Spill fate parameters for the instantaneous fuel spill at a Leviathan Field wellsite for four different scenarios representing various climatic conditions.

Figure 4-2 shows the predicted extent and concentration of diesel fuel deposited on the coast for the four scenarios. In summary:

- Scenario 1 (extreme winter storm) results in the slick moving to the north, with no shoreline impact in Israel or Lebanon. A small amount (0.003% of the spill volume) is predicted to reach the shore in southern and western Cyprus.
- Scenario 2 (typical winter conditions) is predicted to result in the maximum linear extent of shoreline oiling (220 km), extending from Ashkelon to Beirut. Hotspots for shoreline deposition are Rosh Hanikra and southern Lebanon (typically 15 to 20 m^3/km, but locally as high as 50 m^3/km).

- In Scenarios 3 and 4, nearly all of the volume remaining after evaporation is predicted to be deposited on the shoreline by the end of the 30-day simulation. Scenario 4 (typical autumn conditions) had the shortest time period for a spill to reach landfall (12 days) and the greatest volumes reaching shore per length of coastline (up to 500 m3/km). In this scenario, 51.8% of the spill would be deposited along 110 km of coastline between Netanya and the Israel-Lebanon border. Local hotspots include Atlit, the southern coast of Haifa, parts of Haifa Bay, and the Akko coast, where deposition of up to 500 m^3/km may occur. Scenario 3 (typical summer conditions) had the second highest volume reaching shore per length of coastline (locally up to 200 m^3/km at Jieh, Lebanon).



Scenario 1: Extreme winter storm.

Scenario 2: Typical winter conditions.

Scenario 3: Typical summer conditions.

Scenario 4: Typical autumn conditions.

Figure 4-2. Total amounts of diesel fuel deposited on the coast at the end of 30 days after an instantaneous discharge at a Leviathan Field wellsite for four different scenarios representing various climatic conditions.

The potential area of influence based on all of the modeling scenarios is within a box bounded by the following coordinates: within a box bounded by the following coordinates: 31°30' to 35°45'N latitude, 32° to 35°30'E longitude. The actual area affected by a particular spill would be much smaller. For a fuel spill, assuming an initial spill volume of 8,415.6 m^3, with 45.6% evaporating in the first 2 days, the remaining volume would be 4,578.1 m^3. Assuming an average thickness between 1 µm and 0.04 µm (the latter being the threshold for a visible sheen on the sea surface), the area of the slick after the initial evaporation would be between 4,578 km^2 and 114,452 km^2.

4.2.3 Condensate Spill Modeling Results

The condensate spill scenario assumed a well loss of containment and subsequent release of condensate (API gravity of 30), resulting in the release of), continuing for a period of 30 days. The technical basis for the condensate spill scenario is provided in **Appendix J**. Spill fate was modeled for 30 days from the beginning of the spill.

Modeling of a condensate spill was conducted by using . The Leviathan-6 drill site was used as a release point. The following four time periods representative of various climatic conditions were used in the model:

- Scenario 1 – 9 December 2010 to 8 January 2011, a period that included an extreme winter storm;
- Scenario 2 – 26 January to 25 February 2008, typical winter conditions;
- Scenario 3 – 17 July to 16 August 2008, typical summer conditions with persistent northwesterly winds and swell; and
- Scenario 4 – 25 September to 25 October 2007, autumn conditions typical of the transition seasons and including at least one episode of strong easterly to northeasterly wind.

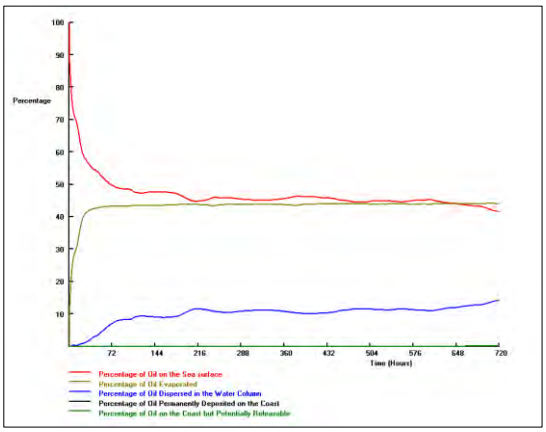
For simplicity, the condensate modeling essentially assumed that the daily spill volume ( ) would be released at the sea surface. In reality, a condensate spill from a well loss of containment at the seafloor would rise rapidly through the water column and could be affected by dissolution, dispersion, adsorption to suspended particulate matter, and dilution. Therefore, the actual volume reaching the sea surface could be less than .

The model includes a spill weathering component to estimate how much of the spilled volume would remain on the sea surface at various times following a spill. The weathering analysis does not take into account any spill response activities. CML's OSCP provides detailed information about the response capabilities and methods that CML would use to minimize the potential for significant impacts.

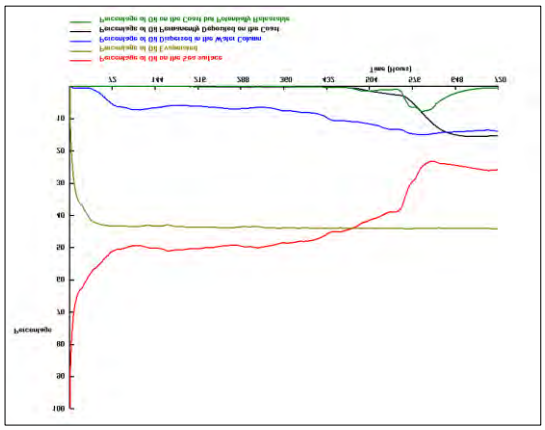
Table 4-5 and **Figure 4-3** summarize the modeling results for a condensate spill under the four scenarios. The model predicts that nearly 40% of the spill would evaporate in the first 24 hours. A spill is predicted to reach the shoreline after 7 days under Scenario 2, 13 days under Scenario 4, after 23 days under 3, or after 25 days under Scenario 1. At the end of 30 days, all four scenarios show 44% evaporation, from 25.8% to 41.5% oil remaining on the sea surface, and 11.6% to 14.2% dispersed in the water column. The percent of the spill deposited on the coastline ranges from 0.3% (Scenario 1) to 15.8% (Scenario 2), with impacts to the coastlines of Lebanon and Cyprus under Scenario 1, Israel, Lebanon, and southern Syria under Scenario 2, Lebanon and Syria under Scenario 3, and Egypt, Israel, and Lebanon under Scenario 4. The locations and magnitude of shoreline deposition are highly seasonally dependent. Total length of affected shoreline ranges from 54.2 to 388.5 km. Impact hotspots are Madfoun, Lebanon (up to 26.9 m^3/km); Sidon, Lebanon (up to 39.7 m^3/km); Latakiya, Syria (up to 68.3 m^3/km); and Haifa Bay (up to 149.6 m^3/km).

Table 4-5. Trajectory and weathering model results at the end of 30 days for a condensate spill under four environmental scenarios.

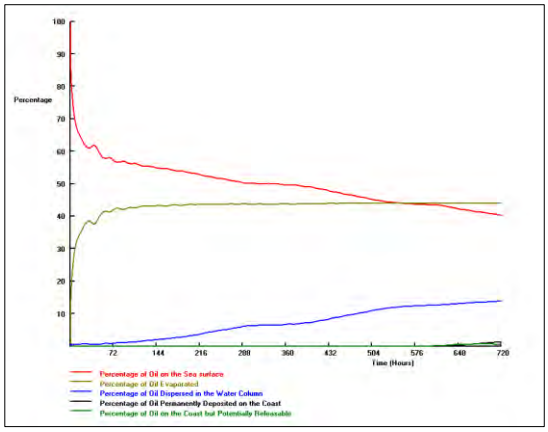
Scenario	Percent Evaporated at 30 days	Percent on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspots
1 extreme winter storm	44.1	41.5	14.2	0.3	25.75	54.2	Northern Lebanon and southwestern Cyprus	Near Madfoun, Lebanon (27 m^3/km) (169 bbl/km)
2 typical winter conditions	44	25.8	13.8	15.8	7.5	388	Gaza to southern Syria	Haifa to Jieh, mainly south of Jieh (> 16 m^3/km) (>100 bbl/km) Lebanon
3 typical summer conditions	44	40.2	14.0	1.8	23.0	103.8	Northern coast of Lebanon from Jieh north into Syria	North of Latakiya, Syria (> 16 m^3/km) (>100 bbl/km)
4 typical autumn conditions	44	30.6	11.6	13.4	13.2	320.8	El-Arish, Egypt to Jieh, Lebanon	Haifa Bay (up to 150 m^3/km) (up to 941 bbl/km)



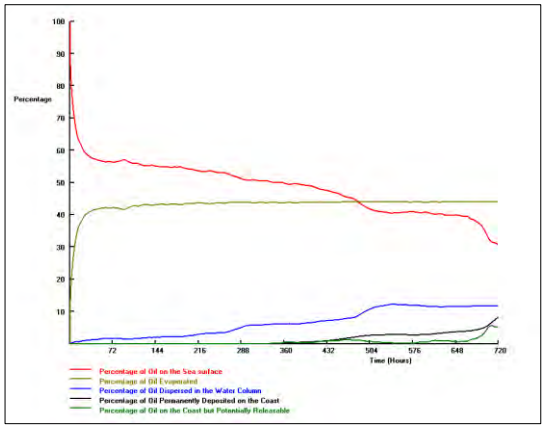
Scenario 1: Extreme winter storm.



Scenario 2: Typical winter conditions.



Scenario 3: Typical summer conditions.



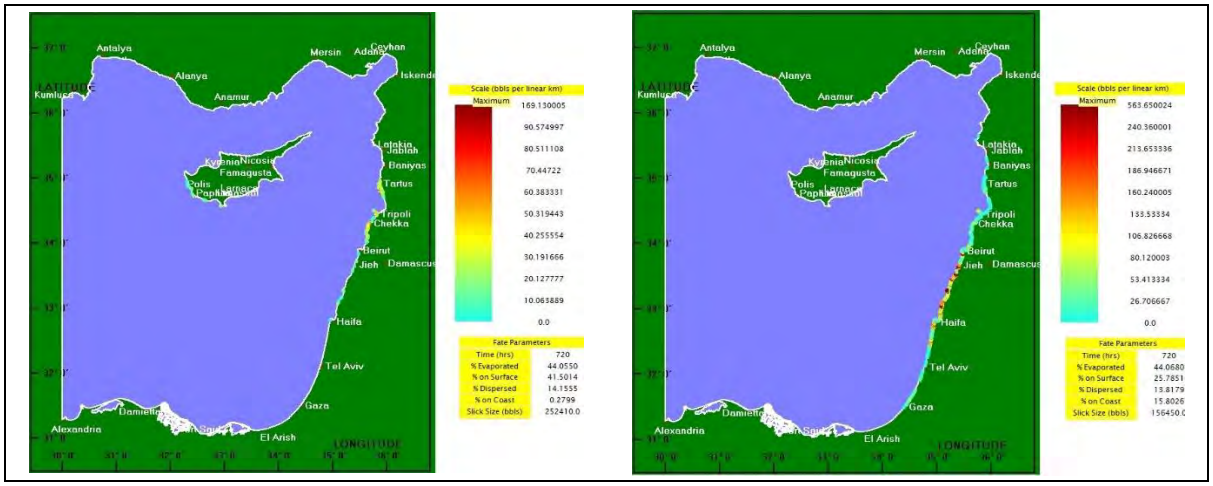
Scenario 4: Typical autumn conditions.



Figure 4-3. Spill fate parameters for a condensate spill at the Leviathan-4 drill site for four different scenarios representing various climatic conditions.

Figure 4-4 shows the extent and concentration of a condensate spill deposited on the coast for the four scenarios. Each scenario resulted in approximately 44% of the condensate being evaporated by the end of 30 days. In summary:

- Scenario 1 (extreme winter storm) produced the smallest coastal impact, with only 0.3% of the spill predicted to reach the shore and only 54.2 km of shoreline affected in northern Lebanon and southwestern Cyprus;
- Scenario 2 (typical winter conditions) had the shortest time period for a spill to reach landfall (7.5 days) and the maximum extent (linear extent) of shoreline oiling (388 km);
- Scenario 3 (typical summer conditions) had the second smallest percentage of the oil impacting the shoreline (1.8%) and impacted shorelines along the northern coast of Lebanon from Jieh north into Syria; and
- Scenario 4 (typical autumn conditions) had the second shortest time period for a spill to reach landfall (13.2 days), the second greatest length of shoreline affected (320.8 km), and the highest maximum oiling concentrations (up to 150 m^3/km).



Scenario 1: Extreme winter storm

Scenario 2: Typical winter conditions

Scenario 3: Typical summer conditions

Scenario 4: Typical autumn conditions

Figure 4-4. Total amounts of condensate deposited on the coast at the end of 30 days after a spill at the Leviathan-6 drill site for four different scenarios representing various climatic conditions.

Although localized hotspots were predicted to receive as much as 150 m^3/km of condensate, only 0.3 and 15.8% of the condensate is deposited on the coast and most shorelines were estimated to receive condensate concentrations of 3 m^3/km or less.

The potential area of influence under the four scenarios is within a box bounded by the following coordinates: 31° 00’ to 36° 00’ N latitude, and 30° 30’ to 36° 00’ E longitude. The actual area affected by a particular spill would be much smaller. Assuming a total spill volume of (i.e., times 30 days) with 37% evaporating in the first two days, the remaining volume would be 15,819 m^3. Assuming an average thickness between 1 µm and 0.04 µm, the area of the slick after the initial evaporation would be between 15,819 km^2 and 395,475 km^2.

4.2.4 Potential Impacts Associated with a Release of Hydrocarbons

4.2.4.1 Impacts on Air Quality

A fuel spill or condensate spill would affect air quality near the spill site by introducing VOCs through evaporation. Impacts would occur mainly during the first two days after the spill enters the environment. Approximately 46% of the fuel spill volume and 37% of the condensate spill volume are

predicted to evaporate, mostly within the first 24 to 48 hours (**Figures 4-1** and **4-3**). Because the fuel spill is a single, instantaneous event, most of the impacts on air quality due to evaporation would be limited to that period. For the condensate spill, impacts at the spill site would continue throughout the 30-day period as new condensate is released each day. It is estimated that a spill may travel approximately 20 km from the spill site during the first two days. Therefore, air quality impacts are likely to be limited to an arc within a 20-km radius of the spill site (with the arc depending on the direction of spill movement).

Little or no impact on coastal air quality would be expected due to the distance from shore and the early evaporation of the most volatile components. The earliest landfall is 12 days for the fuel spill and 7.5 days for the condensate spill.

4.2.4.2 Impacts on Water Quality

A fuel spill or condensate spill would affect water quality by increasing hydrocarbon concentrations due to dissolved components and small oil droplets. The water-soluble fractions of diesel fuel are dominated by two- and three-ringed PAHs, which are moderately volatile (National Research Council, 1983). Diesel fuel is readily and completely degraded by naturally occurring microbes (National Oceanic and Atmospheric Administration, 2023). Natural weathering processes are expected to eventually remove much of a fuel spill or condensate spill from the water column.

The maximum extent of water quality impacts has been estimated for both spill scenarios by assuming an average thickness between 1 µm and 0.04 µm after the initial evaporation. For a fuel spill, the area of the slick after the initial evaporation would be between 4,578 km^2 and 114,452 km^2. For the condensate spill, the area of the slick after the initial evaporation would be between 15,819 km^2 and 395,475 km^2.

Both diesel fuel and condensate are toxic to water column organisms including plankton and fishes. Based on safety data sheets (SDS) for these products, mortality may be expected at concentrations of approximately 1 to 10 mg/L and above. Hydrocarbon concentrations in the water column are not estimated by the model.

4.2.4.3 Impacts on Sediment Quality and Benthic Communities

A fuel spill would not affect sediment quality or benthic communities near the drill site because the spill is assumed to occur at the surface in a water depth of 1,540 to 1,800 m. A well loss of containment resulting in a condensate spill could affect sediments and benthic communities in the immediate vicinity of the drill site. BOEM (2012) estimates that a seafloor blowout may resuspend sediments within a 300-m radius. Benthic organisms within this radius could be killed or buried by resuspended sediment. The condensate is expected to rise through the water column and is unlikely to contact nearby sediments or benthic communities.

The modeling indicates that either a fuel spill or condensate spill could be carried into shallow water under certain meteorological and oceanographic conditions depending on the season, where it may contact shallow coastal sediments. Diesel fuel or condensate that reaches coastal sediment is likely to be highly weathered, with most of the volatile and toxic components either evaporated, dispersed, or dissolved. By the time the spill reaches the shoreline, the concentrations of toxic hydrocarbons that could come into contact with the sediment are likely to be below thresholds that could create sediment toxicity.

A spill that reaches the shallow subtidal sediments would cause increased hydrocarbon concentrations and may cause impacts on benthic communities due to coating and smothering of organisms as well as any residual toxicity.

4.2.4.4 Impacts on Marine Mammals

A fuel spill or condensate spill could affect marine mammals if they came into contact with an oil slick on the ocean surface. The area of the slick after the initial evaporation has been estimated as 4,578 to 114,452 km^2 for the fuel spill and 15,819 km^2 to 395,475 km^2 for the condensate spill. In the case of the diesel spill, most of the spill would evaporate or disperse within a few days. The condensate spill would also be evaporated and dispersed, but the duration of potential exposure would be longer because the spill is assumed to continue for 30 days. In the open ocean, although individual marine mammals may come into contact with a spill, population-level impacts are unlikely due to the low density of these animals in the offshore environment and the relatively brief duration of a spill event.

Hydrocarbons can affect marine mammals through various pathways: direct contact, inhalation of volatile components, ingestion (directly or indirectly through the consumption of fouled prey species), and (for mysticetes) impairment of feeding by fouling of baleen (Geraci and St. Aubin, 1990). Direct physical and physiological effects of exposure to diesel fuel could include skin irritation, inflammation, or necrosis; chemical burns of skin, eyes, and mucous membranes; inhalation of toxic fumes resulting in impaired pulmonary function; ingestion of oil directly or via oiled prey; and stress from the activities and noise of response vessels and aircrafts (Marine Mammal Commission, 2012).

Ingestion of the lighter hydrocarbon fractions found in diesel fuel or condensate can be toxic to marine mammals. Ingested hydrocarbons can remain within the gastrointestinal tract and be absorbed into the bloodstream and, thus, irritate and/or destroy epithelial cells in the stomach and intestines. Certain constituents such as PAHs include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms.

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 either the fuel spill or condensate spill scenario.

4.2.4.5 Impacts on Sea Turtles

A fuel spill or condensate spill could affect sea turtles if they came into contact with an oil slick on the ocean surface or along the shoreline during the nesting season. The area of the slick after the initial evaporation has been estimated at 4,578 to 114,452 km^2 for the fuel spill and 15,819 km^2 to 395,475 km^2 for the condensate spill. In the case of the diesel spill, most of the spill would be evaporated or dispersed within a few days. The condensate spill would also undergo evaporation and dispersal, but the duration of potential exposure would be longer because the spill is assumed to continue for 30 days.

In the open ocean, individual sea turtles may come into contact with a spill, but population-level impacts are unlikely due to the low density of these animals in the offshore environment and the relatively brief duration of a spill event. The main potential for impact would occur if a spill reached shorelines that are used as nesting habitat by sea turtles.

A fuel spill or condensate spill could affect sea turtles through various pathways: direct contact, inhalation of diesel fuel and its volatile components, ingestion of hydrocarbons (directly or indirectly through the consumption of fouled prey species) (Geraci and St. Aubin, 1987). Several aspects of sea turtle biology and behavior place them at risk, including lack of avoidance behavior, indiscriminate feeding in convergence zones, and inhalation of large volumes of air before dives (Milton et al., 2003). Studies have shown that direct exposure of sensitive tissues (e.g., eyes, nares, other mucous membranes) to volatile hydrocarbons may produce irritation and inflammation.

Hydrocarbons can adhere to turtle skin or shells. Turtles surfacing within or near a spill would be expected to inhale petroleum vapors. Ingested hydrocarbons, particularly the lighter fractions, can be toxic to sea turtles. Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters and are especially sensitive to released hydrocarbons.

Loggerhead and green turtles are known to nest along the shorelines of Israel, Lebanon, and Syria. 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 on CML's ESI Atlas and range from Rosh Hanikra to Nitsanim. The spill modeling predicts that none of these beaches would be contacted by a fuel spill or condensate spill under typical summer conditions (Scenario 3) (**Figures 4-2** and **4-4**) when nesting is occurring. In addition, sea turtle nesting beaches would be a high priority for protection in the event of a spill.

4.2.4.6 Impacts on Seabirds and Migratory Birds

A fuel or condensate spill could affect seabirds or migratory birds if they came into contact with an oil slick on the ocean surface. The maximum extent of potential impacts was estimated in **Section 4.2.3**. The potential area of influence based on all of the modeling is within a box bounded by the following coordinates: 31° 00' to 36° 00' N latitude, and 30° 30' to 36° 00' E longitude The area of the slick after the initial evaporation has been estimated at 4,578 to 114,452 km^2 for the fuel spill and 15,819 km^2 to 395,475 km^2 for the condensate spill. In the case of the diesel spill, most of the spill would be subjected to evaporation and dispersal within a few days. The condensate spill would also realize evaporation and dispersal, but the duration of potential exposure would be longer because the spill is assumed to continue for 30 days.

Seabirds or migratory birds in the eastern Mediterranean would have the potential to contact hydrocarbons from a spill. Direct contact of marine birds with hydrocarbons may result in the fouling or matting of feathers with subsequent limitation or loss of flight capability or insulating or water-repellent capabilities; irritation or inflammation of skin or sensitive tissues, such as eyes and other mucous membranes; or toxic effects from ingested diesel fuel or the inhalation of diesel and its volatile components (International Bird Rescue, 2014). In the open ocean, although individual marine birds may come into contact with a spill, population-level impacts are unlikely due to the low density of these animals in the offshore environment and the relatively brief duration of a spill event. The main potential for impact would occur if a spill reached shorelines that are used as bird foraging or breeding habitats.

Of the 15 Important Bird Areas (IBAs) designated in Israel, two include coastal habitats (BirdLife International, 2024c):

- Zevulun Valley IBA – an area of the coastal plain north of Haifa, largely developed or agricultural, with fishponds and some other small wetlands including the marsh at Ein Afeq (a nature reserve and Ramsar wetlands site), approximately 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 (8 km south of Haifa) and a large complex of fishponds at Ma'agan Mikhael and Ma'ayan Zvi, 25 km north of Netanya, as well as some small islands off Ma'agan Mikhael.

The spill modeling indicates that both IBAs could be contacted by a spill during the typical winter, typical summer, or typical autumn scenarios for a fuel spill or condensate spill.

A detailed analysis of sensitive areas and focal points along the Israeli shoreline was completed by Pareto Engineering Ltd. (2006) for the MoEP. In addition, CML's ESI Atlas identifies beaches, parks, and nature preserves (all of which may serve as bird habitat). These areas would be a high priority for protection in the event of a spill. CML will work with national and local agency personnel to provide labor and transportation to retrieve, clean, and rehabilitate birds and wildlife affected by an oil spill, as necessary.

4.2.4.7 Impacts on Fishes

A fuel spill or condensate spill could affect fishes if they came into contact with an oil slick on the ocean surface or hydrocarbons dissolved in the water column. The maximum area of the slick after the initial evaporation has been estimated at 114,452 km^2 for the diesel spill and 395,475 km^2 for the condensate spill. In the case of the diesel spill, most of the spill would undergo evaporation and dispersal within a few days. The condensate spill would also be subjected to evaporation and dispersal, but the duration of potential exposure would be longer because the spill is assumed to continue for 30 days.

Both diesel fuel and condensate are toxic to marine fishes. Based on SDSs for these products, mortality may be expected at concentrations of approximately 1 to 10 mg L^{-1} and above. Hydrocarbon concentrations in the water column are not estimated by the model. Most fishes inhabiting oceanic waters have planktonic eggs and larvae. While adult and juvenile fishes may actively avoid a large spill, planktonic fish eggs and larvae would be unable to avoid contact.

In the open ocean, individual fishes (as well as eggs and larvae) may come into contact with a spill, but population-level impacts are unlikely due to the relatively brief duration of a spill event.

4.2.4.8 Impacts on Fishing and Marine Aquaculture

A fuel spill or condensate spill in the Leviathan Field would be unlikely to affect fishing or marine aquaculture activities because of the distance from shore. There are no known fishing or marine farming areas in or near the Leviathan Field (see **Section 1.6.3**).

Fishing and marine farming areas (if present) along the Israeli coast could be affected in the event that a spill reached coastal waters or shorelines. Potential impacts could include direct impacts to fish or aquaculture species (e.g., toxicity or contamination) as well as temporary disruption or suspension of fishing or marine farming due to spill response activities.

4.2.4.9 Impacts on Culture and Heritage Sites

Potential culture and heritage sites in the Leviathan Field are discussed in **Section 1.9**. A fuel spill is not expected to affect archaeological sites on the seafloor (such as shipwrecks) because the spill is assumed to occur at the surface in a water depth of 1,590 to 1,653 m. A condensate spill from a seafloor well loss of containment is also unlikely to contact seafloor features because the condensate is expected to rise through the water column to the sea surface. A well loss of containment may physically disturb sediments within a radius of 300 m around a drill site (BOEM, 2012), but there are no known archaeological sites within this radius of the drill sites.

The spill modeling indicates that either a fuel spill or condensate spill could be carried into shallow water under certain meteorological and oceanographic conditions depending on the season, where it may contact shallow coastal sediments. There is the potential for culture and heritage sites along the coast to be contaminated or disturbed by spill response and cleanup activities.

A detailed analysis of sensitive areas and focal points along the Israeli shoreline, including archaeological sites, was completed by Pareto Engineering Ltd. (2006) for the MoEP. In addition, CML's ESI Atlas identifies archaeological sites along the Israel coast. Most of the sites are within the range of potential shoreline contacts for a fuel spill or condensate spill during the typical winter or autumn scenarios. These areas would be a high priority for protection in the event of a spill.

4.2.4.10 Impacts on Marine Transportation and Infrastructure

A fuel spill or condensate spill could temporarily disrupt vessel traffic because of oil spill response activities. The Leviathan Field is not located within a shipping lane as discussed in **Section 1.12.3**. The nearest shipping lanes are those approaching the port of Haifa. Numerous vessels pass through Israel's territorial waters, including those from the ports of Israel to destinations in southern Europe,

Cyprus, and North Africa, and routes between Alexandria and Port Said in Egypt to destinations in Lebanon and Syria. Depending on the trajectory of a spill and the level of response activities, some areas might be temporarily closed to vessel traffic.

A detailed analysis of sensitive areas and focal points along the Israeli shoreline, including transportation and infrastructure sites, was completed by Pareto Engineering Ltd. (2006) for the MoEP. In addition, CML's ESI Atlas identifies coastal infrastructure including ports, marinas, anchorages, power plants, and desalination plants along the Israel coast. The main port within the range of potential shoreline contacts is Haifa, and there are smaller ports at Acre, Tel Aviv, and Jaffa. These sites are within the range of potential shoreline contacts for a fuel spill or condensate spill during the typical winter, summer, or autumn scenarios. Ashdod is not within the range of shoreline impacts for a condensate spill, but the fuel spill is predicted to contact this area under typical winter conditions.

The deepwater coal loading pier at Orot Rabin Power Station is within the range of potential shoreline contacts for typical winter conditions and typical autumn conditions for both a fuel spill and condensate spill. The deepwater coal loading pier at Rutenberg Power Station is beyond the range of predicted shoreline contacts.

In accordance with CML's OSCP, coastal resources and infrastructure would be a high priority for protection in the event of a spill.

4.2.4.11 Impacts on Coastal Habitats and Infrastructure

Table 4-6 summarizes the occurrence of ESI shoreline types along the coast of Israel and the spill response considerations. Approximately 30% of the total shoreline length is fine-grained and beaches (ESI = 3) and this is the predominant type along 14 of 24 shoreline segments, especially south of Haifa. Coarse-grained sand beaches (ESI = 4) and mixed sand/gravel beaches (ESI = 5) account for approximately another 18%. Rip-rap and other man-made shoreline structures (ESI = 6B or 8) account for approximately 24% of the shoreline length and are predominant near Haifa, Tel Aviv, and Ashdod.

Table 4-7 provides further details concerning the coastal habitats and infrastructure along the coast of Israel. The shoreline is divided into 24 segments according to CML's ESI Atlas. The table also lists the amount of condensate predicted to contact each shoreline segment for a condensate spill in the Leviathan Field under each seasonal scenario. The amounts of condensate reaching each shoreline segment are based on a separate geospatial analysis of data from the condensate spill modeling discussed in **Section 4.2.3**. The following discussion focuses mainly on the condensate spill results as a worst case because the total spill volume is larger than the fuel spill and the range of coastal impacts is similar.

Of the four scenarios, three (winter storm, typical winter and typical autumn) are predicted to result in condensate contacting the shoreline of Israel. In the typical summer scenario, condensate is predicted to contact the Lebanese coast to the north of Jieh. The potential shoreline contacts in Israel during one or more seasons range from the Israel/Lebanon border to the Israel/Egypt border. Segments predicted to receive the greatest amounts of condensate (1,000 m^3/km or greater) range from the Acre south to Tirat Karmel (i.e., segments 4 through 6), including Haifa.

The shorelines potentially contacted by a condensate spill include a variety of natural habitats such as beaches as well as sensitive coastal areas including national parks, bathing and recreation areas, marine research centers, marine aquaculture facilities, and archaeological sites. Coastal infrastructure includes ports, marinas, anchorages, power plants, and desalination plants. The main port within the range of potential shoreline contacts is Haifa; shoreline contact is possible in three of the four scenarios. The smaller ports at Acre, Tel Aviv, and Jaffa are also within the range of potential shoreline contacts. Acre and Tel Aviv are within the range of shoreline contact for a condensate spill under typical winter and typical autumn conditions. Ashdod is within the range of shoreline impacts for a condensate spill under typical autumn conditions; a fuel spill may also contact this area under typical winter conditions.

In addition to cities such as Haifa and Tel Aviv, there are numerous coastal villages along the potentially affected shoreline. These areas serve coastal and marine-related tourism with lodging, restaurants, and other facilities. The main tourist attractions along the coast of Israel are bathing beaches, heritage sites, archaeological sites, nature reserves, and national parks. Tourism and recreation in the nearshore waters and on the coast of Israel are spread all along the coast from north to south. In nearshore waters, tourism is mainly based on marine sporting activities and recreation. Water sports include mainly diving, surfing, and sailing. Recreational activities and resources could be affected, resulting in temporary exclusion from these areas due to oil spill response and cleanup activities.

Table 4-6. Percentage occurrence of Environmental Sensitivity Index (ESI) shoreline types along the coast of Israel (from CML's ESI Atlas), and the associated response considerations (Adapted from: National Oceanic and Atmospheric Administration, 2010, 2014).

ESI Ranking	Description	Percent of Israel Coast	Impact and Response Considerations
1	Exposed rocky shores	7.52	The intertidal zone is steep (more than 30° slope), with very little width. Sediment accumulations are uncommon and usually ephemeral, because waves remove the debris that has slumped from the eroding cliffs. There is strong vertical zonation of intertidal biological communities. Species density and diversity vary greatly, but barnacles, snails, mussels, sea stars, limpets, sea anemones, shore crabs, polychaetes, and macroalgae are often very abundant. Oil reaching this shoreline type is held offshore by waves reflecting off the steep cliffs. Any oil that is deposited is rapidly removed from exposed faces. The most resistant oil would remain as a patchy band at or above the high-tide line. Impacts to intertidal communities are expected to be short-term in duration. An exception would be where heavy concentrations of a light refined product came ashore very quickly. Cleanup is usually not required. Access can be difficult and dangerous.
2	Exposed rocky platforms	11.41	The intertidal zone consists of a flat rock bench of highly variable width. The shoreline may be backed by a steep scarp or low bluff. There may be a beach of sand- to boulder-sized sediments at the base of the scarp. The platform surface is irregular and tidal pools are common. Small amounts of gravel can be found in the tidal pools and crevices in the platform. These habitats can support large populations of encrusting animals and plants, with rich tidal pool communities. Oil reaching this shoreline type will not adhere to the rock platform, but rather be transported across the platform and accumulate along the high-tide line. Oil can penetrate into beach sediments, if present. Persistence of oiled sediments is usually short-term, except in wave shadows or where the oil has penetrated sediments at the high-tide line. Cleanup is usually not required. Where the high-tide area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.
3	Fine- to medium-grained sand beaches	30.78	These beaches are generally flat and hard-packed. There can be heavy accumulations of wrack present. They are used by birds and turtles for nesting and feeding. Upper beach fauna are generally sparse, although amphipods can be abundant; lower beach fauna can be moderately abundant, but highly variable. For this shoreline type, light oil accumulations will be deposited as oily bands along the upper intertidal zone. Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach with the rising tide. Maximum penetration of oil into fine-grained sand is approximately 10 cm. Burial of oiled layers by clean sand within the first week after a spill typically will be less than 30 cm along the upper beach face. Organisms living in the beach sediment may be killed by smothering or lethal oil concentrations in the interstitial water. There may be declines in infauna, which can affect important shorebird foraging areas. These beaches are among the easiest shoreline types to clean. Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore. Activity through oiled and dune areas should be limited, to prevent oiling of clean areas. Manual cleanup, rather than road graders and front-end loaders, is usually advised to minimize the volume of sand removed from the shore and requiring disposal.
4	Coarse-grained sand beaches	8.49	Same as ESI 3.

Table 4-6. (Continued).

ESI Ranking	Description	Percent of Israel Coast	Impact and Response Considerations
5	Mixed sand and gravel beaches	9.96	Because of the mixed sediment sizes on these moderately sloping beaches, there may be zones of pure sand, pebbles, or cobbles. There can be large-scale changes in the sediment distribution patterns depending upon season, because of the transport of the sand fraction offshore during storms. Desiccation and sediment mobility on exposed beaches cause low densities of attached animals and plants. The presence of attached algae, mussels, and barnacles indicates beaches that are relatively sheltered, with the more stable substrate supporting a richer biota. During small spills, oil will be deposited along and above the high-tide swash. Large spills will spread across the entire intertidal area. Oil penetration into the beach sediments may be up to 50 cm; however, the sand fraction can be quite mobile, and oil behavior is much like on a sand beach if the sand fraction exceeds approximately 40%. Burial of oil may be deep at and above the high-tide line, where oil tends to persist, particularly where beaches are only intermittently exposed to waves. In sheltered pockets on the beach, pavements of asphalted sediments can form if oil accumulations are not removed, because most of the oil remains on the surface. Remove heavy accumulations of pooled oil from the upper beach face. All oiled debris should be removed; sediment removal should be limited as much as possible. Low-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents. High-pressure spraying should be avoided because of the potential for transporting contaminated finer sediments (sand) to the lower intertidal or subtidal zones. Mechanical reworking of oiled sediments from the high-tide zone to the middle intertidal zone can be effective in areas regularly exposed to wave activity. However, oiled sediments should not be relocated below the mid-tide zone. In-place tilling may be used to reach deeply buried oil layers in the mid-tide zone on exposed beaches.
6A	Gravel beaches	0.85	Gravel beaches can be steep, with multiple wave-built berms forming the upper beach. The degree of exposure to wave energy can be highly variable. Density of animals and plants in the upper intertidal zone is low on exposed beaches but can be high on sheltered gravel beaches and on the lower intertidal zone of all beaches. Stranded oil is likely to penetrate deeply into gravel beaches because of their high permeability. Rapid burial can occur at the high-tide and storm berms. Long-term persistence will be controlled by the depth of routine reworking by the waves. On exposed beaches, oil can be pushed over the high-tide berms, pooling and persisting above the normal influence of wave washing. Along sheltered portions of the shorelines, chronic sheening and the formation of asphalt pavements is likely where accumulations are heavy. Heavy accumulations of pooled oil should be removed quickly from the upper beach. All oiled debris should be removed. Sediment removal should be limited as much as possible. Low- to high-pressure flushing can be effective if all released oil is recovered with skimmers or sorbents. Mechanical reworking of oiled sediments from the high-tide line to the mid-beach face can be effective in areas regularly exposed to wave activity; the presence of multiple storm berms is evidence of wave activity. However, oiled sediments should not be relocated below the mid-tide zone. In-place tilling may be used to reach deeply buried oil layers along the mid-tide zone on exposed beaches.
6B	Rip-rap structures	10.12	Rip-rap is composed of cobble- to boulder-sized blocks of granite, limestone, or concrete. Rip-rap structures are used for shoreline protection and channel stabilization (jetties). Attached biota are sparse. Oil reaching this shoreline type adheres readily to the rough surfaces of the blocks. Deep penetration of oil between the blocks is likely. Uncleaned oil can cause chronic leaching until the oil solidifies. When the oil is fresh and liquid, high-pressure flushing and/or water flooding may be effective, making sure to recover all liberated oil. Heavy and weathered oils are more difficult to remove, requiring scrapping and/or hot water flushing. In extreme cases, it may be necessary to remove heavily oiled blocks and replace them.

Table 4-6. (Continued).

ESI Ranking	Description	Percent of Israel Coast	Impact and Response Considerations
7	Exposed tidal flats	3.40	Exposed tidal flats are broad intertidal areas composed primarily of sand and minor amounts of gravel or mud. The presence of sand indicates that tidal currents and waves are strong enough to mobilize the sediments. They are usually associated with another shoreline type on the landward side of the flat, though they can occur as separate shoals; they are commonly associated with tidal inlets. The sediments are water-saturated, with only the topographically higher ridges drying out during low tide. Biological use can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish. Oil does not usually adhere to the surface of exposed tidal flats but rather moves across the flat and accumulates at the high-tide line. Deposition of oil on the flat may occur on a falling tide if concentrations are heavy. Oil does not penetrate water-saturated sediments but may penetrate coarse-grained sand and coat gravel. Biological damage may be severe, primarily to infauna, thereby reducing food sources for birds and other predators. Currents and waves can be very effective in natural removal of the oil. Cleanup can be done only during low tide, thus there is a narrow window of opportunity. The use of heavy machinery should be restricted to prevent oil mixing into the sediments. Manual removal methods are preferred.
8	Sheltered rocky shores and sheltered man-made structures	13.79	These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities. Most structures are constructed of concrete, wood, or metal, and their composition, design, and condition are highly variable. Often there is no exposed beach at low tide, but a wide variety of habitats may be present. Attached animal and plant life can be moderate to high. Oil reaching this shoreline type will adhere readily to the rough surface, particularly along the high-tide line, forming a distinct oil band. The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface. Cleanup of seawalls is usually conducted for aesthetic reasons or to prevent leaching of oil. Low- to high-pressure flushing at ambient water temperatures is most effective when the oil is fresh. Hot water is needed for heavy or weathered oils.
9	Sheltered tidal flats	3.69	These habitats consist primarily of mud with minor amounts of sand and shell. They are usually present in calm-water habitats, sheltered from major wave activity, and frequently backed by marshes. The sediments are very soft and cannot support even light foot traffic in many areas. There can be large concentrations of bivalves, worms, and other invertebrates in the sediments. They are heavily used by birds for feeding. Oil does not usually adhere to the surface of sheltered tidal flats but rather moves across the flat and accumulates at the high-tide line. Deposition of oil on the flat may occur on a falling tide if concentrations are heavy. Oil will not penetrate the water-saturated sediments but could penetrate burrows and desiccation cracks or other crevices in muddy sediments. In areas of high suspended sediment concentrations, oil and sediments could mix, resulting in the deposition of contaminated sediments on the flats. Biological impacts may be severe. These are high priority areas for protection since cleanup options are limited. Cleanup of the flat surface is difficult because of the soft substrate; many methods may be restricted. Low-pressure flushing, vacuum, and deployment of sorbents from shallow-draft boats may be attempted.

Table 4-7. Coastal habitats and infrastructure along the Israel coast. The coastline is divided into 24 segments as indicated in CML's Environmental Sensitivity Index (ESI) Atlas. The table also lists amounts of condensate predicted to contact each shoreline segment under each seasonal scenario based on a geospatial analysis of data from the condensate spill modeling discussed in **Section 4.3.3**. Shading: ___ = shoreline contact predicted; ___ = no shoreline contact.

Coastal Segment No.	Condensate on Shoreline (m^3/km) after 30 days under each Spill Scenario				Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Comments
	1 Extreme Winter	2 Typical Winter	3 Typical Summer	4 Typical Autumn						
1	3	454	0	165	Israel-Lebanon Border to Gesher Haziv	Sandy and rocky	1: 1,214 m 2: 3,908 m 4: 3,551 m 5: 3,405 m 6A: 99 m 7: 97 m 8: 477 m 9: 2,504 m	Marine aquaculture (upland)	Betzet Stream Chziv Stream	Sandy beaches, swimming, fishing; Caverns (Rosh Haniqra); Betzet Beach; Achziv National Park; Achziv Beach; Offshore islands, including Achziv, Sgavion
2	0	511	0	452	Gesher Haziv to Shavei Zion	Sandy and rocky	1: 56 m 2: 1,900 m 4: 6,008 m 5: 5,201 m 6B: 1,811 m 7: 27 m 8: 354 m 9: 1,159 m	Marine anchorage Wastewater drainage pipe	Gaaton Stream Beit Haemek Stream	Achziv reef; Gali-Galil Beach; Sokolov Beach; Shavei Zion Beach; Archaeological site
3	0	472	0	153	Shavei Zion to Acre	Sandy and rocky	1: 1,989 m 2: 4,177 m 3: 1,963 m 4: 4,566 m 5: 2,779 m 6B: 933 m 7: 205 m 8: 650 m	Wastewater drainage pipe	Yasaf Stream Naaman Stream	Old Acre City Walls; Argaman Beach; Archaeological sites
4	0	337	0	1176	Acre to Kiryat Yam	Sandy	1: 142 m 3: 3,501 m 6B: 16 m	Marine anchorage Drain pipe	--	Zvulun Municipal Beach; Kan Municipal Beach; Confined Area
5	<1	306	0	2881	Kiryat Yam to Haifa	Sandy and rocky	1: 6,551 m 3: 3,837 m 6B: 7,112 m 8: 10,340 m 9: 2,241 m	Kishon Port and Marina Haifa Port (container, oil, chemical terminals) Fishermen anchorage	--	Kiryat Haim (North, Central, South) Municipal Beaches

Table 4-7. (Continued).

Coastal Segment No.	Condensate on Shoreline (m^3/km) after 30 days under each Spill Scenario				Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Comments
	1 Extreme Winter	2 Typical Winter	3 Typical Summer	4 Typical Autumn						
6	0	42	0	1042	Haifa to Tirat Karmel	Sandy and rocky	1: 643 m 2: 951 m 3: 3,707 m 4: 1,791 m 5: 2,336 m 6B: 3,568 m 8: 4,386 m	Haifa Port Marine aquaculture IOLR	--	Haifa Municipal Bathing Beach (including Bat Galim); Carmel Beach; Zamir Beach; Dado Beach
7	0	316	0	601	Tirat Karmel to Megadim	Sandy	3: 4,013 m 4: 3,323 m 5: 993 m 6A: 363 m 7: 47 m 9: 88 m	--	Oren Stream	Bathing beaches
8	0	233	0	474	Megadim to Habonim	Sandy	1: 4,381 m 2: 4,675 m 3: 3,917 m 4: 204 m 5: 958 m 6A: 28 m 7: 59 m 8: 198 m 9: 48 m	Marine aquaculture (upland)	Nahal Mearot Stream	Atlit Fortress; Neve Yam Beach; Habonim Beach; Archaeological sites
9	0	158	0	169	Habonim to Ma'ayan Tsvi	Rocky and sandy	1: 1,955 m 2: 5,227 m 3: 5,807 m 4: 730 m 5: 1,224 m 7: 284 m 9: 1,722 m	Anchorages	Dalia Stream	Archaeological sites; Nahsholim Beach; Dor (North, Central, South) Beaches; Dor-Habonim MPA and national park; Many inlets, bays, and abrasion platforms
10	0	268	0	155	Ma'ayan Tsvi to Or Akiva	Rocky and sandy	1: 245 m 2: 805 m 3: 6,547 m 4: 645 m 5: 2,204 m 6B: 501 m 7: 1,143 m 9: 579 m	Marine aquaculture (upland) Anchorages	--	Ma’agan Michael Beach; Jisr az-Zarqa Beach; Archaeological sites; Fishing

Table 4-7. (Continued).

Coastal Segment No.	Condensate on Shoreline (m^3/km) after 30 days under each Spill Scenario				Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Comments
	1 Extreme Winter	2 Typical Winter	3 Typical Summer	4 Typical Autumn						
11	0	305	0	122	Or Akiva to Hadera	Sandy and rocky	1: 457 m 2: 2,764 m 3: 5,135 m 4: 1,171 m 5: 1,894 m 6A: 158 m 6B: 2,389 m 7: 142 m 8: 1,900 m 9: 2,555 m	Anchorages Hadera-Orot Rabin Power Plant (offshore anchorage) Desalination plant/discharge pipeline Municipal wastewater discharge pipelines	Hadera Stream	Caesarea Beach; Sdot Yam Beach; Bathing beaches; Kfar Hayam Beach Resort; Giv' at Olga (North, Central, South) Beaches; Islands facing the beach
12	0	72	0	227	Hadera to Beit Herut	Sandy	1: 131 m 2: 2,783 m 3: 6,277 m 4: 357 m 5: 2,069 m 6A: 750 m 6B: 1,224 m 7: 492 m 8: 657 m 9: 88 m	--	Alexander Stream	Mikmoret (North, Central, South) Beaches; Beit Yanai Beach; Neurim Beach Resort; Alexander Stream National Park and Beit Yanai Beach Park; Long beaches under high calcareous sandstone cliffs
13	0	7	0	203	Beit Herut to Netanya	Sandy	1: 144 m 2: 108 m 3: 7,828 m 5: 2,400 m 6B: 1,020 m	Municipal wastewater discharge pipe and runoff drain	--	Neurim Beach; Kiryat Sanz Beach; Four Seasons Beach; Herzl Beach; Zvulun Beach; Argaman Beach; Long beach under calcareous sandstone cliffs; Two breakwaters in the city beach; Hotels
14	0	2	0	184	Netanya to Yakum	Sandy and rocky	2: 4,161 m 3: 5,718 m 4: 1,938 m 5: 1,641 m 7: 149 m	--	Poleg Stream	Poleg Stream National Park; Poleg Beach; Long beach under calcareous sandstone cliffs; The area between Poleg and Ga'ash is proposed as an MPA (extends to the end of the territorial waters)
15	0	<1	0	327	Yakum to Herzliya	Sandy	2: 4,330 m 3: 4,511 m 4: 2,138 m 5: 359 m 6A: 1,366 m 6B: 792 m	--	--	Ga'ash Beach; Nof-Yam (military); Apollonia National Park; Sidney Ali Beach; Sharon Beach; Acadia Beach; Zvulun Beach

Table 4-7. (Continued).

Coastal Segment No.	Condensate on Shoreline (m^3/km) after 30 days under each Spill Scenario				Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Comments
	1 Extreme Winter	2 Typical Winter	3 Typical Summer	4 Typical Autumn						
16	0	4	0	496	Herzliya to Tel Aviv	Sandy	1: 2,536 m 3: 3,660 m 4: 399 m 5: 1,947 m 6B: 2,680 m 7: 610 m 8: 5,957 m 9: 417 m	Marina Anchorages Municipal wastewater discharge pipelines	--	Herzelia Beach; Bathing beaches
17	0	0	0	650	Tel Aviv to Bat Yam	Sandy	1: 2,935 m 2: 430 m 3: 4,458 m 4: 104 m 6B: 6,509 m 7: 355 m 8: 3,230 m	Jaffa Port Promenades Municipal wastewater discharge pipelines	--	Multiple beaches (Sheraton, Hilton, Gordon, Frishman, Bograshov, Trumpeldor, Jerusalem, Geula, Dophinarium, Charles Klor. Givat Aliyah); Tel Aviv has 11 breakwaters; Abrasion platforms are evident in south Jaffa; Multiple beach hotels, resorts, seaside residences
18	0	2	0	503	Bat Yam to Gan Sorek	Sandy and rocky	1: 994 m 3: 3,317 m 5: 615 m 6B: 335 m	--	--	Multiple beaches (Jerusalem, Le'dugma, Riviera, Marina, Bat Yam, Rishon LeZion) Abrasion platforms are evident in Bat Yam and Rishon LeZion; Resorts, hotels, and seaside residence; Restricted military area (highly undisturbed area) Sea turtles nesting observed
19	0	31	0	573	Gan Sorek to Palmachim	Sandy	1: 67 m 2: 834 m 3: 2,027 m 4: 647 m 5: 889 m 7: 102 m	Municipal wastewater discharge pipelines	Soreq Stream	Palmachim Beach; Archaeological sites; Sea turtle nesting observed; Rubin Stream National Park; Palmachim Beach National Park
20	0	0	0	554	Palmachim to Ashdod	Rocky and sandy	6B: 3,474 m 8: 6,071 m 9: 157 m	Marine aquaculture Drain pipes	--	Beaches; Eshkol Power Station
21	0	0	0	470	Ashdod to Nitsan	Sandy and rocky	3: 5,490 m 5: 541 m 6B: 3,714 m 7: 215 m 8: 6,907 m 9: 158 m	Ashdod Port Anchorage Desalination plant and discharge pipe Coal harbor Municipal and industrial wastewater discharge pipelines and runoff drain	Lakhish Stream	Mey Ami Beach; Lido Municipal Beach; Oranim Municipal Beach; Kshatot Municipal Beach; 11th Beach; Archaeological site; Sea turtle nesting observed; Areas in industrial regions are reinforced with concrete; Fish cages 11 km offshore

Table 4-7. (Continued).

Coastal Segment No.	Condensate on Shoreline (m^3/km) after 30 days under each Spill Scenario				Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Comments
	1 Extreme Winter	2 Typical Winter	3 Typical Summer	4 Typical Autumn						
22	0	40	0	338	Nitsan to Ashkelon	Sandy	3: 8,626 m	--	Evtach Stream	Nizanim Beach; Long sandy beach backed by sand dunes; Nizanim Sand Dunes National Park/Nizanim Sands Protected Area
23	0	74	0	376	Ashkelon to Zikim	Sandy	3: 5,446 m 5: 905 m 6B: 3,908 m 8: 3,656 m 9: 235 m	Natural gas receiving terminal Crude oil port, coal harbor Anchorage IEC power station Desalination plant and discharge pipe Marina	--	Bar Cochva Beach; Anchorages; Shimshon Beach; Pipeline landfall
24	0	74	0	620	Zikim to Israel-Palestinian Territory Border	Sandy	3: 4,237 m	--	Shikma Stream	Zikim Beach

ESI Shoreline Classifications: 1 – Exposed cliffs and rock walls; 2 – Exposed abrasion platforms; 3 – Fine- to medium-grained sand beaches; 4 – Coarse-grained sand to mixed sediment beaches; 5 – Irregular rock platforms or diverse formation beaches; 6A – Gravel or pebble beaches; 6B – Embankments and breakwaters; 7 – High-drainage estuaries or beaches with high biodiversity; 8 – Marinas, harbors, anchorages, or protected beaches; 9– Highly sensitive coastal or other areas.

4.2.5 Mitigation Measures

Mitigation for accidental spills includes both spill prevention and response measures. CML will use safe drilling practices during its activities in the Leviathan Field to reduce the likelihood of an accidental spill. Best industry practice will be used during all drilling phases (e.g., setting of BOP; cementing of concrete between bore and protective pipe). Detailed BOP specifications are provided in **Section 3.2.4**. The detailed casing design and testing are described in **Section 3.2.6**. In addition, once the drillship to be used has been identified, CML and the drillship's owner will engage in a comprehensive inspection and testing of the drillship's subsea BOP system to ensure compliance with the U.S. BSEE regulations. The inspection and testing will be witnessed and certified by a third-party surveyor. CML has committed to operating in Israel per BSEE regulations, unless superseded by MoEP regulations.

A detailed analysis of sensitive areas and focal points along the Israeli shoreline was completed by Pareto Engineering Ltd. (2006) for the MoEP. In addition, CML's ESI Atlas identifies coastal habitats, infrastructure, and sensitive areas that would be a high priority for protection in the event of a spill. Some of these have been cited in the preceding impact discussions, including sea turtle nesting beaches, coastal bird habitats, fishing and marine farming areas, archaeological sites, and coastal infrastructure sites. In the event of a spill reaching the coast, the response would take into account the predominant habitat types and the response and cleanup strategies that are most effective and appropriate for those areas. CML's OSCP provides detailed information about the response capabilities and methods that CML would use to minimize the potential for significant impacts.

4.2.6 Impact Significance

Impact significance for accidental spills is summarized in **Table 4-8**. The likelihood of a large fuel spill or a worst-case condensate spill from a well loss of containment is rated as unlikely (2), taking into account CML's well control, blowout prevention, and other spill prevention measures. The consequences range from minor (2) to medium (3) depending on the resource, with a condensate spill considered to have greater consequences because of the extended time period (30 days) and the general greater volumes of oil reaching the shoreline. The residual risk is rated as Low to Moderate.

Table 4-8. Summary of potential impacts from accidental pollution events.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Accidental spills: Fuel spill from the drillship (8,415.6 m^3)	Air quality	Elevated volatile organic compound (VOC) concentrations due to evaporation of volatile hydrocarbons (mostly in first 24 to 48 hours)	• Spill prevention measures • Drillship Shipboard Oil Pollution Emergency Plan • Oil Spill Contingency Plan	2	2	4 Low
	Water quality	Sheen or slick on water surface; elevated hydrocarbon concentrations in water column		2	2	4 Low
	Marine mammals	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items		2	2	4 Low
	Sea turtles	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items		2	2	4 Low
	Seabirds and migratory birds	Potential impacts due to inhalation, ingestion, direct contact with eyes or feathers, or ingestion of fouled prey items		2	3	6 Mod
	Fishes	Potential impacts due to direct contact with oil or ingestion of fouled prey items		2	2	4 Low
	Fishing Activities and Marine Farming	Potential disruption of fishing due to response activities; potential contamination of fishing areas or marine farming areas if a spill reached shoreline		2	2	4 Low
	Culture and Heritage Sites	Potential contamination of coastal heritage sites (if spill reached shoreline)		2	2	4 Low
	Marine Transportation and Infrastructure	Potential disruption or rerouting of ship traffic due to response activities		2	2	4 Low
	Coastal Habitats and Infrastructure	Potential contamination of beaches, shorelines, parks, preserves, marinas, ports, etc.		2	3	6 Mod

Table 4-8. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Accidental spills: Condensate spill from a well loss of containment (/day for 30 days)	Air quality	Elevated VOC concentrations due to evaporation of volatile hydrocarbons (mostly first 24 to 48 hours)	• Blowout preventer and well control methods • Oil Spill Contingency Plan	2	2	4 Low
	Water quality	Sheen or slick on water surface; elevated hydrocarbon concentrations in water column		2	2	4 Low
	Sediment quality	Physical impact to sediments within 300 m of well loss of containment site; sediment contamination unlikely		2	2	4 Low
	Benthic communities	Physical impact to benthic organisms within 300 m of well loss of containment site; benthic community impacts due to sediment contamination are unlikely		2	2	4 Low
	Marine mammals	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items		2	3	6 Mod
	Sea turtles	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items		2	3	6 Mod
	Seabirds and migratory birds	Potential impacts due to inhalation, ingestion, direct contact with feathers, or ingestion of fouled prey items		2	3	6 Mod
	Fishes	Potential impacts due to direct contact with oil or ingestion of fouled prey items		2	3	6 Mod
	Fishing Activities and Marine Farming	Potential disruption of fishing due to response activities; potential contamination of fishing areas or marine farming areas if a spill reached shoreline		2	2-3	4-6 Mod
	Culture and Heritage Sites	Potential contamination of coastal heritage sites (if spill reached shoreline)		2	2	4 Low
	Marine Transportation and Infrastructure	Potential disruption or rerouting of ship traffic due to response activities		2	2	4 Low
	Coastal Habitats and Infrastructure	Potential contamination of beaches, parks, shorelines, preserves, marinas, ports, etc.		2	3	6 Mod

4.3 LIGHT DISTURBANCES

Light sources on the offshore drillship, installation vessel, and support vessels include navigational lighting; helicopter flight deck lights, and safety and performance lighting (for work areas) (Golder Associates et al., 2007).

All vessels maintain exterior lighting for navigational and aviation safety. The total time for drilling and completing all of the three wells in the Leviathan Expansion Project is estimated to be 366 days (see **Section 3.2.3**). The drilling program will be supported by three MMC 87 Class platform supply vessels operating out of the port of Haifa (see **Section 3.2.2.1**). Each supply vessel is expected to make four one-way trips per week during drilling and completion. Additional vessels will be on-site for infrastructure installation operations (see **Table 3-5**), including a pipeline installation vessel, a supply/standby vessel, MPCV, LCV, and crew change vessel.

Resources potentially affected by artificial lighting include marine mammals, sea turtles, seabirds and migratory birds, and pelagic fishes. The effects of artificial lighting on marine mammals is unknown, although it is unlikely that marine mammals are directly affected as they are not known to use lighting cues (in air) in their foraging, reproduction, or other activities (Stanton and Cowart, 2024). Salmon and Wyneken (1987) noted that light cues are important for the dispersal of hatchlings, further noting that there is likely to be a distance offshore where the cue is either not available or not used.

There is a growing empirical basis demonstrating that offshore dispersal for marine turtle hatchlings is compromised by light pollution originating from land-based or marine structures (Marangoni et al., 2022), although the potential to affect hatchlings near the Leviathan Expansion activities (120 km offshore) is considered extremely limited.

4.3.1 Potential Impacts

4.3.1.1 Impacts on Sea Turtles

Adult sea turtles spend most of their time submerged (Renaud and Carpenter, 1994; Polovina et al., 2003) and are therefore unlikely to be exposed to artificial lighting from the drillship and supply vessels. Some sea turtles may be attracted to offshore structures (Rosman et al., 1987; Lohoefener et al., 1990), but it is unknown whether artificial lighting plays any role in this attraction.

Sea turtle hatchlings use lighting cues for navigation, and artificial lighting can disrupt their nocturnal orientation (Witherington, 1997; Tuxbury and Salmon, 2005). It has been suggested that sea turtle hatchlings could be attracted to brightly lighted offshore structures, including drillship and platforms, where they may be subject to increased predation by birds and fishes (U.S. National Marine Fisheries Service [NMFS], 2007). However, when offshore, hatchlings may rely less on light cues than when they are emerging on the beach (Salmon and Wyneken, 1990). Once hatchlings swim away from the nesting beach, they inhabit mats of flotsam (Carr and Meylan, 1980; Bolten and Witherington, 2003) and their ability to swim toward a drillship or other offshore structures would be very limited. Due to the distance of the Leviathan Field from nesting beaches (greater than 120 km from the nearest shoreline), it is unlikely that large numbers of hatchling turtles would be affected. In the Gulf of Mexico, where thousands of offshore structures are present, drillship and platform lighting has been evaluated as unlikely to appreciably reduce the reproduction, numbers, or distribution of sea turtles (NMFS, 2007). Any exposure of sea turtles to light emitted from the drillship or supply vessels would be relatively short term in nature (i.e., several months) and typical of normal maritime activities in the Mediterranean.

4.3.1.2 Impacts on Sea Birds and Migratory Birds

Seabirds can be attracted to offshore structures because of both the lights and the structure itself (Wolfson et al., 1979; Tasker et al., 1986; Baird, 1990; Wiese et al., 2001), as well as to the increased

concentrations of fishes around the structure (Baird, 1990; Montevecchi et al., 1999). Seabirds use mostly optical cues for migrating between breeding and wintering areas; navigation aids include internal maps, sunlight and sunrise/sunset cues, starlight and celestial navigation, topography, and an internal magnetic compass (Greer et al., 2010). Birds migrating through an environment that is otherwise flat and very dark at night find offshore platforms an attractive visual cue. It should be noted that visibility is important in itself, to prevent collisions.

The presence of offshore structures can have both positive and negative impacts on birds (Baird, 1990; Montevecchi et al., 1999; Fraser et al., 2006). Some birds may be attracted to offshore structures because of the lights, as well as the fish populations that aggregate around these structures. Particularly sensitive species would be petrels and other procellariforms that forage on vertically migrating bioluminescent prey. Birds may use offshore structures for resting, feeding, or as temporary shelter from inclement weather (Russell, 2005). However, birds migrating over water at night have been known to strike offshore structures, resulting in death or injury (Wiese et al., 2001; Russell, 2005; OSPAR Commission, 2012).

A study in the North Sea indicated that offshore platform lighting can cause circling behavior in some birds, especially on cloudy nights; apparently the birds' geomagnetic compasses are upset by the red part of the spectrum from the lights currently in use (Van de Laar, 2007; Poot et al., 2008). The numbers varied greatly, from none at all to tens of thousands of birds per night per platform, with an apparent effect radius of up to 5 km. A study in the Gulf of Mexico also noted the phenomenon (Russell, 2005). The overall consequences of circling behavior are unknown, but the impact is unlikely to be significant based on the limited scope and duration of drilling and completion activities.

While the bulk of the bird migration over Israel occurs inland, the edge of the migration routes passes over the nearshore portions of the eastern Mediterranean Sea. The radius of the bird monitoring radar located in Latrun, Israel, reaches to approximately 30 km off the shoreline and regularly detects activity up to its margin (Dinevich and Leshem, 2010). The bird migration period extends from March to the end of May and from August to the end of November. Because of the distance between the Leviathan Field and the nearest shoreline (approximately 120 km), it is expected that the drillship and other Leviathan Expansion Project vessels will not be visible to migrating birds that routinely migrate along or near the coast. Consequently, lighting is unlikely to have significant impact on seabird or migratory bird populations.

4.3.1.3 Impacts on Fishes

Offshore structures typically attract epipelagic fishes such as tunas, dolphins, billfishes, and jacks (e.g., Holland et al., 1990; Higashi, 1994). Offshore vessels, as floating structures in the deepwater environment, essentially act as fish aggregating devices (FADs), especially for large pelagic species. Day/night variations in fish populations around platforms suggest that lighting may be part of the attraction (Wilson et al., 2006). Offshore structures also provide shelter and food in the form of attached fouling biota (Gallaway and Lewbel, 1982).

Positive fish associations with offshore drillships and platforms are well documented (Gallaway and Lewbel, 1982; Wilson et al., 2003, 2006; Peabody and Wilson, 2006). The FAD effect could possibly enhance the feeding of epipelagic predators by attracting and concentrating smaller fishes. Because the drillship is a temporary structure and will be moving between drill sites, any impacts on fish populations are likely to be insignificant.

4.3.2 Mitigation Measures

Navigational lighting onboard both the drillship and installation vessels will meet International Convention for Safety of Life at Sea (SOLAS) requirements as per IMO Resolution MSC.253(83) or equivalent requirements. No mitigation is proposed for this type of lighting, as the requirements are essential for navigational safety.

Helicopter flight decks use perimeter lighting in accordance with international standards such as International Civil Aviation Organization Annex 14, Volume II (Heliports) or API Recommended Procedure 2L (Recommended Practice for Planning, Designing, and Constructing Heliports for Fixed Offshore Platforms). No mitigation is proposed for this type of lighting, as the requirements are essential for aviation safety.

To the extent practicable without compromising safety or work performance, safety and performance lighting in open deck areas will be shielded (i.e., oriented downward) to minimize excess light emissions into the environment.

4.3.3 Impact Significance

Impact significance for light hazards is summarized in **Table 4-9**. The consequence of potential impacts to sea turtles, seabirds and migratory birds, and pelagic fishes is rated as insignificant (1). The likelihood of impacts on sea turtles and birds are rated as possible (3). Although the attraction of pelagic fishes is almost certain, the likelihood of any adverse impacts on them is also rated possible (3). The residual risk is assessed as Low in all cases.

Table 4-9. Summary of potential impacts from light hazards.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Artificial lighting on drillship, installation vessel, and supply vessels	Sea turtles	Possible attraction of hatchlings resulting in exposure to discharges and predation	To the extent practicable without compromising safety or work performance, lighting in open deck areas will be shielded (i.e., oriented downward) to minimize excess light emissions into the environment.	3	1	3 Low
	Seabirds and migratory birds	Possible attraction and/or disorientation including circling behavior and collisions with drillship structure	Same as above	3	1	3 Low
	Pelagic fishes	Attraction to lights resulting in exposure to discharges and noise	Same as above	3	1	3 Low

4.4 NOISE

Sources of underwater noise during the drilling, completion, and installation program include the drillship, installation vessel, supply vessels, and helicopters. The source characteristics are summarized in **Section 3.3**. Resources potentially affected by underwater noise include marine mammals, sea turtles, and fishes.

To evaluate potential impacts of noise, it is necessary to distinguish between different types of sound sources because different criteria have been developed for them (NMFS, 2024; Popper et al., 2014). Transient sounds are short-lived and can be impulsive or non-impulsive. Impulsive sounds (such as those made by explosions, seismic airguns, and pile driving) are typically abrupt, of brief duration,

and may contain a wide range of frequencies. Near their source, such sounds often have a rapid rise time, quickly reaching a maximum value, followed by a period of decay. Continuous sounds can be tonal (consisting of one or more frequencies, with or without harmonics), or broadband (containing a wide range of frequencies) and can change in amplitude with time. All the sound sources considered in this analysis are considered continuous, broadband sources for the purpose of impact analysis. As noted by Richardson et al. (1995), the distinction between continuous and transient sources is not absolute; although noise from drillship, installation vessel, supply vessels, and helicopters is continuous, it could be considered transient insofar as a stationary receiver is concerned.

4.4.1 Source Characterization

Drillship. Drilling rigs and semisubmersible drillships produce primarily continuous, broadband sound, with strong tonal components at low frequencies (Richardson et al., 1995). Sound from Leviathan Field drilling activities was referenced by Genesis using measurements from a drillship (Miles et al., 1987). This is a conservative assumption because a drilling rig is likely to be louder than a semisubmersible drillship (e.g., Richardson et al., 1995). The drilling rig noise was estimated to generate a peak SPL of 177 dB re 1 µPa (see **Section 3.3.1**). The drillship will be a noise source in the Leviathan Field during the entire period of drilling and completion activities. The total time for drilling and completing all of the wells is estimated to be 366 days (see **Section 3.2.4**).

Supply Vessels and Installation Vessel. The drilling program will be supported by three MMC 87 Class platform supply vessels. The installation program is expected to be supported by a pipeline installation vessel, supply/ standby vessel, MPCV, LCV, and a crew change vessel. All drilling support vessels are expected to operate out of the port of Haifa (see **Section 3.2.3**), the subsea installation and support vessels will likely operate out of Cyprus. Broadband source levels are expected to be in the range of 170 to 180 dB re 1 µPa at 1 m (Richardson et al., 1995). Most of the energy is in frequencies below 100 to 200 Hz, and propeller cavitation is usually the dominant noise source. Although support vessels and the installation vessel are considered continuous sound sources, an individual animal's exposure to the sound would likely be occasional and transient as the vessels move between the shore base and the project area.

Helicopter. A Sikorsky S-76C++ helicopter will make an average of 10.5 round-trips per week between Haifa and the project area during the drilling program and a total of about 30 round-trips during subsea infrastructure installation. Penetration of aircraft noise into the water is greatest directly below the aircraft; at angles greater than 13° from the vertical, much of the sound is reflected and does not penetrate into the water. The duration of underwater sound from passing aircraft is much briefer in water than air; for example, a helicopter passing at an altitude of 152 m (500 ft) that is audible in air for 4 minutes may be detectable underwater for only 38 seconds at 3 m (10 ft) depth and for 11 seconds at 18 m (59 ft) depth (Richardson et al., 1995). Realistically, an individual animal's exposure to the sound from the helicopter would likely be occasional and transient as the helicopter moves between the shore base and the drillship.

4.4.2 Impacts on Marine Mammals

The impacts of underwater noise on marine mammals have been studied and reviewed extensively (Richardson et al., 1995; National Research Council, 2003, 2005; Southall et al., 2007, 2016, 2021; Ellison et al., 2012). However, there are some key limitations: 1) most impacts are not readily predictable, except for the potential for injury or auditory trauma from high-energy sources; and 2) the biological significance of lesser impacts such as behavioral responses is difficult to assess.

Richardson et al. (1995) defined four zones of potential noise effects on marine mammals. In order of increasing severity, they are 1) audibility; 2) responsiveness (behavioral effects); 3) masking; and 4) hearing loss, discomfort, or injury (physical effects). The levels of sound produced during drilling and completion activities are sufficient to be audible to marine mammals, to produce behavioral

responses, and possibly to contribute to masking effects; however, the source levels are much lower than those known to cause hearing loss or injury as discussed in the following subsections.

4.4.2.1 Potential Impacts: Injury Including Auditory Trauma

Source levels for a drillship were estimated as a peak SPL of 177 dB re 1 µPa, and source levels for installation/supply vessels are expected to be in the range of 170 to 180 dB_{rms} re 1 µPa (see **Section 3.3.1**). For comparison, the NMFS has historically used a received level of 180 dB_{rms} re 1 µPa as a minimum threshold for potential auditory impacts. The 180 dB criterion is very simplistic and was developed prior to the more sophisticated assessments of auditory sensitivity and impacts. The source levels for the drillship, installation, and supply vessels are at or below this threshold, indicating that an animal would have to be 1 m or less from the source to be exposed to potentially injurious sound levels. More recently, the NMFS (2024) has published criteria for permanent threshold shift (PTS) and temporary threshold shift (TTS). Dual criteria were proposed based on peak SPL and cumulative sound exposure level (**Table 4-10**). The sound exposure level criteria are too complex to be used here, but the peak SPL criteria can be evaluated. Specifically, source levels are well below the peak SPL criteria for PTS or TTS onset, indicating that neither of these impacts would be an issue for the drillship or supply vessels.

Table 4-10. Criteria for permanent threshold shift (PTS) and temporary threshold shift (TTS) onset for cetaceans in response to non-impulse sounds (From: National Marine Fisheries Service, 2024).

Hearing Group (and Functional Hearing Range)	Examples in the Levantine Basin (see **Section 1.6.2**)	PTS Onset Threshold for Non-Impulse Sources[a]	TTS Onset Threshold for Non-Impulse Sources[a]
Low-frequency cetaceans (7 Hz–36 kHz)	Fin whale Minke whale Humpback whale	197	177
High-frequency cetaceans (150 Hz–160 kHz)	Sperm whale Short-beaked common dolphin Risso's dolphin Striped dolphin Rough-toothed dolphin Common bottlenose dolphin Cuvier's beaked whale False killer whale Killer whale Indo-Pacific humpback dolphin	201	181
Very High-frequency cetaceans (275 Hz–165 kHz)	Dwarf sperm whale[b] Harbor porpoise[b]	181	161
Phocid Pinnipeds in water (40 Hz–90 kHz)	Mediterranean monk seal[b]	195	175

[a] Values are cumulative sound exposure levels over 24 hours in units of dB re 1 µPa2s.
[b] Indicates vagrant species whose presence is in the Levantine Basin is not confirmed (see Section 1.6.2).

4.4.2.2 Potential Impacts: Behavioral Responses

Low-frequency noise from vessels can be detected by marine mammals (Richardson et al., 1995). Mysticetes (baleen whales such as the fin and minke whale) are more likely to detect low-frequency sounds than most odontocetes (toothed whales and dolphins), which have their best hearing in high frequencies.

The NMFS SPL criterion of 120 dB re 1 µPa is applied for marine mammal behavioral responses to continuous noise. This is based on the lowest received levels at which responses have been observed. Based on the estimated source levels, marine mammals within approximately 1,000 m of the drillship or supply vessels/installation vessel may be exposed to sound levels sufficient to elicit behavioral responses (**Table 4-11**). Although the NMFS criterion does not distinguish between mysticetes and odontocetes, it applies most appropriately to mysticetes such as the fin whale and minke whale, which are low-frequency specialists. Because most odontocetes have their best hearing in mid- or high frequencies, they would have to be closer to the source to be affected.

Table 4-11. Sound sources associated with the Leviathan Expansion Project and calculated distances to the current U.S. National Marine Fisheries Service criterion for behavioral response to continuous sources.

Sound Source	Source Levels (dB re 1 µPa 1 m)	Criterion for Behavioral Response (dB re 1 µPa)	Calculated Distance to Threshold (m)[a]
Drillship	177	120	708
Supply vessels / Installation vessel	170–180	120	316–1,000

[a] Distance calculated assuming spherical spreading (i.e., transmission loss = 20 log r).

The NMFS 120-dB threshold is very simplistic. There has been considerable research about the levels of received sound that can cause behavioral responses in marine mammals, as well as the biological significance of those responses (Richardson et al., 1995; National Research Council, 2005; Southall et al., 2007; Ellison et al., 2012). There is evidence that many factors other than received sound level, including the activity state of animals exposed to different sounds, the nature and novelty of a sound, and spatial relations between sound source and receiving animals (i.e., the exposure context) strongly affect the probability of a behavioral response (Ellison et al., 2012).

In conclusion, underwater noise from the drillship and supply vessels/installation vessel may elicit behavioral responses in marine mammals in the immediate vicinity of these sound sources. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area.

4.4.2.3 Potential Impacts: Masking

Masking refers to obscuring sounds of interest by interfering sounds, general of similar frequencies (Richardson et al., 1995). Payne and Webb (1971) first raised the possibility that noise from anthropogenic sources might affect marine mammal communication. Acoustic masking from shipping noise and other anthropogenic sources is increasingly being considered as a threat to marine mammals, particularly those most able to detect low-frequency sounds such as mysticetes (Clark et al., 2009; Castellote et al., 2010).

Noise from ships is ubiquitous in the world's oceans and is the dominant source of underwater noise at frequencies below 300 Hz in many areas (Wenz, 1962; Ross, 1976; Hildebrand, 2009; McKenna et al., 2012). On the scale of ocean basins, shipping noise is increasing as the level of ship traffic increases (McDonald et al., 2006).

Although vessel noise can be considered a point source, distant shipping noise (where no single ship dominates the spectrum) is the broader concern (Clark et al., 2009). Distant shipping primarily consists of frequencies below 100 Hz, since sound attenuation increases exponentially with increasing frequency (Southall and Scholik-Schlomer, 2008).

As individual sound sources, the drillship, and supply vessels/installation vessel are not likely to result in significant auditory masking effects. However, the underwater noise would be an incremental contribution to the overall noise from shipping in the region.

4.4.3 Impacts on Sea Turtles

Three sea turtle species are known to occur in the Levantine Basin: the green turtle, leatherback turtle, and loggerhead turtle (see **Section 1.7.2.2**). Turtles are low-frequency hearing specialists with their best hearing at frequencies less than 1 kHz (Ridgway et al., 1969; Lavender et al., 2012; Martin et al., 2012).

Sound exposure criteria for marine mammals historically 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 during drilling and completion activities are sufficient to be audible to sea turtles and to produce behavioral responses; however, the source levels are much lower than those known to cause auditory impacts such as TTS or PTS. 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) 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 characterized as low, moderate, or high based on proximity to the source, as summarized in **Table 4-12**.

Table 4-12. Relative risk of auditory impacts on sea turtles exposed to shipping noise and other continuous sound sources (From: Popper et al., 2014).

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

Sea turtles more than a few hundred meters from the drillship and supply vessels are probably at low risk for 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).

In conclusion, sea turtles near the drillship and supply vessels/installation vessel may be exposed to sound levels sufficient to elicit behavioral responses and potentially to create auditory interference by masking. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area.

4.4.4 Impacts on Fishes

Sound plays a major role in the lives of all fishes (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 fishes communicate with sounds and use sounds in a wide range of behaviors including, but not limited to, mating and territorial interactions (Zelick et al., 1999). Most fishes cannot hear sounds above approximately 3 to 4 kHz, and the majority of species are only able to detect frequencies of 1 kHz or below. Broad discussions of interactions of anthropogenic sounds and fishes can be found in Popper and Hastings (2009a,b) and Popper and Hawkins (2012).

Popper et al. (2014) proposed preliminary sound exposure guidelines for fishes exposed to shipping and continuous noise sources. There is no direct evidence of mortality or potential mortal injury to fishes 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 fishes that have a swim bladder used in hearing. Also, the risk of impacts was qualitatively characterized as low, moderate, or high based on proximity to the source, as summarized in **Table 4-13**.

Table 4-13. Relative risk of auditory impacts on fishes exposed to shipping noise and other continuous sound sources (From: Popper et al., 2014).

Type of Impact	Proximity to Source			Threshold
	Near (tens of meters)	Intermediate (hundreds of meters)	Far (thousands of meters)	
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 (fishes with a swim bladder involved in hearing)
Temporary threshold shift (TTS)	Moderate	Low	Low	158 dB_{rms} for 12 hours (fishes with a swim bladder involved in hearing)
Masking	High	High	Moderate-High	None specified
Behavioral response	Moderate-High	Moderate	Low	None specified

Based on the exposure guidelines, fishes that remain for extended periods (e.g., 12 to 48 hours or more) in the immediate vicinity of the drillship may be at risk for recoverable tissue injury, TTS, auditory masking effects, and behavioral responses. At distances beyond a few hundred meters, fishes are probably at low risk for any impacts other than auditory masking. Impacts are unlikely to occur near supply vessels because the exposure of individual fishes would be so brief.

In conclusion, fishes that remain for extended periods near the drillship and/or support and installation vessels may be exposed to sound levels sufficient to elicit behavioral responses, to create auditory interference by masking, and to cause recoverable auditory impacts (TTS). Due to the limited spatial extent and recoverable nature of impacts, these are unlikely to be significant on a population level.

4.4.5 Mitigation Measures

There are no planned mitigation measures to reduce underwater noise. Drillship and support vessels/installation vessel engines will be operated and maintained in accordance with manufacturers' specifications to avoid excessive noise and emissions.

No critical habitats for marine mammals, sea turtles, or fishes have been identified within the Leviathan Field. No seasonal periods of peak abundance or activity have been identified in the Application Area that would warrant scheduling constraints. The sea turtle nesting season 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. However, scheduling activities to avoid this time period is 1) not warranted due to the distance from shore (greater than 120 km); and 2) not practical given the duration of planned activities (the total time for drilling and completing all of the wells is estimated to be 366 days).

4.4.6 Impact Significance

Impact significance for noise is summarized in **Table 4-14**. The consequence of potential impacts to marine mammals, sea turtles, and fishes are rated as insignificant (1) and the likelihood of impacts is rated as possible (3). The residual risk is assessed as Low.

Table 4-14. Summary of potential impacts from underwater noise.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Noise from drillship, installation vessel, supply vessels, and helicopters	Marine mammals	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
	Sea turtles	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
	Fishes	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low

4.5 NATURAL VALUES AND ECOLOGY

4.5.1 Impacts on Seafloor Disturbance

4.5.1.1 Impacts on Sediment Quality and Benthic Communities

Because a DP drillship or DP semisubmersible will be used, there will be no anchoring. DP drillships disturb only a very small area of the seafloor around the wellbore where the bottom template and wellbore are located; the area has been estimated to be 2,500 m^2 or less (BOEM, 2012). Benthic organisms in the immediate vicinity of the wellbore will be crushed or buried. As discussed in **Section 1.7.1**, only soft bottom benthic communities are present at and near the drill sites, and the types of communities are broadly similar throughout the Leviathan Field (and presumably ubiquitous in similar water depths in the region). Due to the small areal extent, impacts on sediment quality and benthic communities from drilling and completion activities are evaluated as negligible.

As described in **Section 4.1.2**, approximately 6,018 m^2 of seafloor will be disturbed during installation of subsea infrastructure. An additional 3,771 m^2 of seafloor will be disturbed or affected by WBM deposition. Total seafloor area affected is estimated to be 9,789 m^2. Benthic organisms in the footprint and immediate vicinity of the drill sites and installed infrastructure will be crushed or buried. As discussed in **Section 1.7.1**, only soft bottom benthic communities are present at and near the drill sites and along the routes of the subsea infrastructure, and the types of communities are broadly similar throughout the Leviathan Field (and presumably ubiquitous in similar water depths in the region). There are no known unique or sensitive benthic communities in the area of impact. Impacts on sediment quality and benthic communities from seafloor infrastructure installation activities are evaluated as negligible.

4.5.1.2 Impacts on Water Quality

During drilling and completion operations, the seafloor at each well location will be disturbed. Physical disturbance will result from drilling and wellhead emplacement, and installation of flowlines,

umbilicals, and other seafloor infrastructure. Local water quality will be affected by these installation operations.

The seafloor will also be disturbed via deposition of WBM near the wellbore. The total area affected via drilling and completion activities per well, including drilling muds and cuttings deposition, is summarized in **Appendix K**. Additional discussion of muds and cuttings deposition is presented in **Section 4.5.2**. Impacts to water quality will occur in the immediate vicinity of drilling and completion operations, installation of infrastructure, and within the deposition field for discharges of muds and cuttings.

4.5.1.3 Mitigation Measures

No mitigation measures are recommended for seafloor disturbance due to unavoidable nature of the impact. CML will conduct a post-drilling survey at each drill site to ensure that the seafloor is clear of equipment and debris from drilling and completion activities. No rehabilitation or restoration of benthic habitats is recommended due to the low level of residual impact. The affected areas will eventually recover through larval settlement and migration of benthic organisms from adjacent areas.

4.5.1.4 Impact Significance

Impact significance for seafloor disturbance is summarized in **Table 4-15**. The consequence of potential impacts to sediment quality, benthic communities, and water quality is insignificant (1) due to the small area affected around each drill site/installation location and the temporary period of water quality degradation. In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drillship (i.e., it is referring to the likelihood of impacts occurring beyond the mixing zone). The impacts are rated as possible (3) and the residual risk is assessed as Low.

Table 4-15. Summary of potential impacts from seafloor disturbance.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Seafloor disturbance	Sediment quality	Physical disruption and resuspension of sediments	None	3	1	3 Low
	Benthic communities	Localized burial and crushing of individual organisms; areal extent 2,500 m^2 or less per drill site and from seafloor infrastructure installation	None	3	1	3 Low
	Water quality	Mobilization of local sediments, potential mobilization of sediment-bound contaminants, deposition of muds and cuttings	None	3	1	3 Low

In evaluating likelihood for sediment quality and benthic impacts, a 100-m mixing zone was assumed around the drillship (i.e., it refers to the likelihood of impacts occurring beyond this radius).

4.5.2 Impacts of Drilling Discharges

4.5.2.1 Discharge Characteristics

Drilling discharge quantities and components have been summarized in **Section 3.6.2**. CML plans to drill the new Leviathan Field wells using a combination of WBM and MOBM. The first two initial well intervals (before the marine riser is set) are expected to be drilled using WBM and the cuttings, as well as excess cement, would be released at the seafloor. Once the marine riser is set allowing mud

and cuttings to be returned to the drillship, the remaining well intervals would be drilled with MOBM. Cuttings from MOBM well intervals will be shipped to shore and not discharged to the sea.

Pre-commissioning discharges will also be released from subsea infrastructure, as detailed in **Section 3.6.1.7**.

4.5.2.2 Modeling of Drilling Discharges Fate

Drilling discharges were modeled by Applied Science Associates (ASA; now part of TetraTech) using the Leviathan-9 drill site as a representative location (**Appendix K**) for the 2016 Leviathan Field EIA (CSA, 2016). Those results remain relevant for discharges that will occur during drilling of the Leviathan Expansion Project wells. The modeling was conducted using the model and the input data included the proposed well intervals and discharge quantities, site-specific current data from the Leviathan Field, and particle size data from CML for MOBM well cuttings treated in a thermomechanical cuttings cleaner (TCC) unit. It should be noted that since the modeling was conducted, CML no longer plans to discharge treated MOBM well cuttings and all MOBM well cuttings will be shipped to shore (see **Section 2.3.1**). Therefore, the actual muds and cuttings discharge areal extent and thickness will likely be substantially less than modeled, with muds and cutting discharges occurring exclusively at the seafloor and centered around the wellbore. Two seasonal scenarios were modeled: winter (December to February), and summer (July to September). Drilling discharges from seafloor release of WBM in the initial well intervals will largely be limited to within tens of meters of each drill site in thicknesses >6.3 mm. Detailed methods and results are presented in **Appendix K**.

Modeling results are summarized in **Figures 4-5** and **4-6**. The areal extent of thickness contours is summarized in **Tables 4-16** and **4-17**.

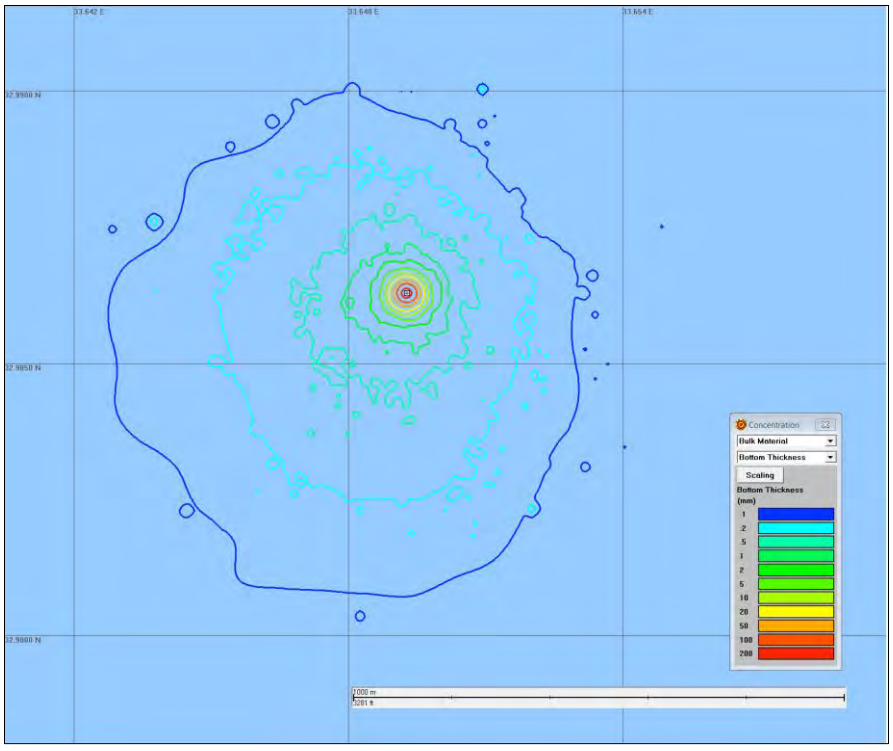


Figure 4-5. Cumulative deposition thickness for drilling discharges from the Leviathan-9 drill site for the winter (December to February) scenario.

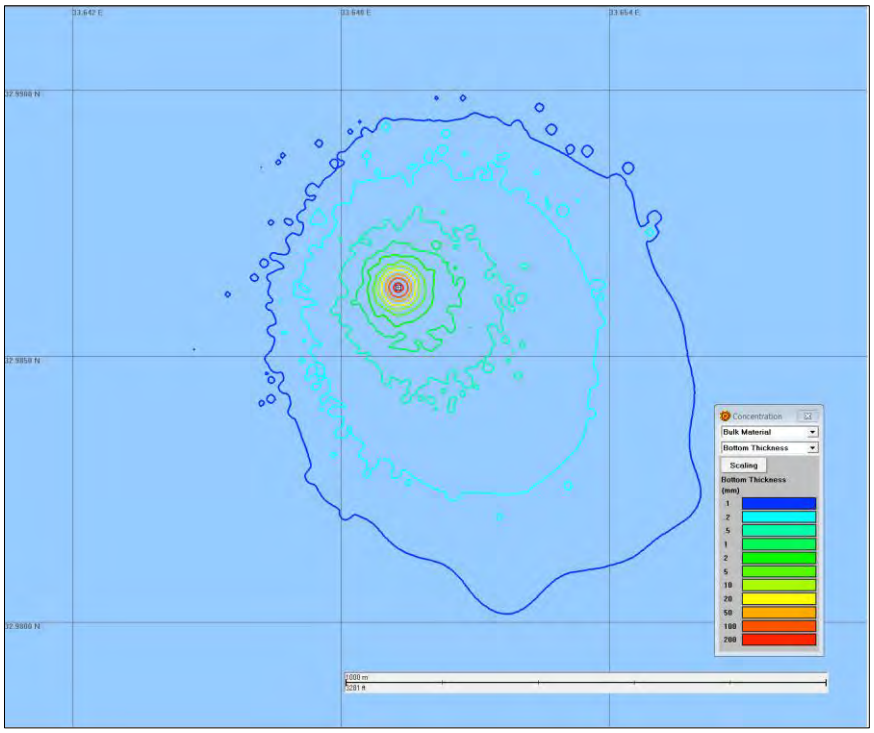


Figure 4-6. Cumulative deposition thickness for drilling discharges from the Leviathan-9 drill site for the summer (July to September) scenario.

Table 4-16. Areal extent of seafloor deposition of drilling discharges for two seasonal scenarios at the Leviathan-9 drill site. Burial thresholds (6.3 mm is the burial thickness affecting 5% of benthic species; 54 mm is the median burial thickness affecting 50% of benthic species) from Smit et al. (2008) are in bold.

Table 4-17. Maximum extent of thickness contours resulting from drilling discharges for two seasonal scenarios at the Leviathan-9 drill site. Burial thresholds (6.3 mm is the burial thickness affecting 5% of benthic species; 54 mm is the median burial thickness affecting 50% of benthic species) from Smit et al. (2008) are in bold.

The key findings of the modeling can be summarized as follows:

4.5.2.3 Potential Impacts on Water Quality and Fishes

During the two initial well intervals, releases of WBM and cuttings at the seafloor will produce turbidity in near-bottom waters. The turbidity plume will be carried away from the well by near-bottom currents and may be detectable within tens to hundreds of meters of the wellbore. As resuspended sediments settle to the seafloor, the water clarity will return to background conditions within minutes to a few hours after discharges cease. The duration of these two well intervals is brief (approximately 6.5 days total per well).

No MOBM is planned to be discharged to the sea. The cuttings from the production hole section using MOBM will be shipped to shore. In conclusion, cuttings discharges from the drillship will produce intermittent turbidity in the water column but are expected to have little or no impact on plankton or fish due to fact that no MOBM (or cuttings drilled using MOBM) will be discharged to the sea.

4.5.2.4 Potential Impacts on Sediment Quality and Benthic Communities

During the two initial well intervals, releases of WBM and cuttings at the seafloor will create a mound with a diameter of several meters to tens of meters around the wellbore. Also, during setting of the casing, cement slurry will be pumped into the well to bond the casing to the walls of the hole. Excess cement slurry will emerge from the hole and accumulate on the seafloor, typically within 10 to 15 m around the wellbore (Shinn et al., 1993). Cement slurry components include cement mix and some of the same chemicals used in WBM (Boehm et al., 2001). These releases will alter the

sediment quality near the well location. Sediments will eventually return to baseline conditions due to normal sediment movement, remixing of sediments by benthic organisms, and sediment deposition from the water column.

The main benthic impacts during the initial two well intervals will be the burial and smothering of benthic organisms within several meters to tens of meters around the wellbore. WBM can also cause oxygen depletion in near-surface sediments (Trannum et al., 2006; Schaanning et al., 2008a,b). Soft bottom sediments disturbed by cuttings, drilling mud, and cement slurry will eventually be recolonized through larval settlement and migration from adjacent areas. The deposition of muds and cuttings particles can prompt tube building and burrowing activity of indigenous fauna in response to this short-term disturbance of the sediment surface (Trannum et al., 2010).

MOBM-wetted drill cuttings will be collected on the drillship and sent to either an onshore recycling facility or to a landfill capable of handling hazardous wastes. No MOBM or MOBM-wetted cuttings will be discharged to the sea. The cuttings discharge modeling predicts that deposition of discharged cuttings (WBM-wetted only) will occur in all directions around the drill site, but primarily toward the southeast (**Figures 4-5** and **4-6**). Due to the water depth, the drilling discharges are predicted to produce a thin layer on the seafloor, with most of the deposition occurring within a few hundred meters of the discharge point. Thicknesses of 1 mm or greater are predicted to occur within 136 to 149 m from the discharge point. Thicknesses are predicted to be 0.1 mm or less at distances greater than 676 to 775 m from the discharge point (**Table 4-17**).

Benthic community effects of drilling discharges have been reviewed extensively (National Research Council, 1983; Neff, 1987, 2005, 2010; Bakke et al., 2013). Due to the low toxicity of most drilling fluids, the main mechanism of impact to benthic communities is increased sedimentation, resulting in burial or smothering. Most benthic fauna live in the upper few centimeters of offshore, fine-grained sediments, with benthic communities composed of varying feeding guilds – filter feeders, surface deposit feeders, subsurface deposit feeders, and carnivores. Deposit feeders, in particular, are recognized for their ability to process/ingest or move sediment during tube building and feeding (i.e., bioturbation). The maximum depth of bioturbation is in the range of 4 to 5 cm for most infauna, although larger infaunal burrowers are known to extend 20 or more cm into the sediment. Infaunal feeding guilds are important in determining impacts from sediment deposition (i.e., filter feeding species are highly susceptible to increased sedimentation compared to deposit feeders).

The potential impacts of cuttings deposition can be summarized based on a monitoring study conducted in the deepwater Gulf of Mexico (Continental Shelf Associates, Inc., 2006). Areas of cuttings deposition within approximately 500 m of drill sites were associated with elevated organic carbon concentrations and anoxic conditions. Affected areas had patchy zones of disturbed benthic communities, including microbial mats, areas lacking visible benthic macroinfauna, zones dominated by pioneering stage assemblages, and areas where surface-dwelling species were selectively lost. Infaunal and meiofaunal densities generally were higher near drilling, although some faunal groups were less abundant near drill sites. Some stations near drilling had lower diversity, lower evenness, and lower richness indices compared with stations farther away from drilling. Some stations affected by drilling were dominated by high abundances of one or a few deposit-feeding species, including known pollution indicators.

A thickness of 6.3 mm has been proposed by Smit et al. (2008) as a PNEC threshold for benthic species that are sensitive to sediment deposition. The model predicts that deposition having a thickness of 6.3 mm or more would affect approximately 0.008 km^2 around each drill site under either scenario and would extend approximately 54 to 55 m from the discharge point. The total area receiving this thickness of deposition from the three new wells from the Leviathan Expansion Project would be 0.024 km^2, or approximately 0.005% of the seafloor area in the Leviathan Field blocks (500 km^2).

A thickness of 54 mm has also been proposed as a "median" impact threshold for burial of soft-bottom benthic organisms (Smit et al., 2008). The model predicts that deposition having a thickness of 54 mm or more would affect approximately 0.002 km^2 around each drill site under either scenario and would extend approximately 27 m from the discharge point. The total area receiving this thickness of deposition from the three new wells from the Leviathan Expansion Project would be 0.006 km^2, or approximately 0.001% of the seafloor area in the Leviathan Field blocks (500 km^2).

The three new proposed wells (Lev-10, Lev-11, and Lev-23) are all more than 100 m from each other and therefore there should be no potential for cumulative deposition of muds and cuttings.

The benthic communities around all of the proposed drill sites are expected to consist of soft bottom organisms. Soft bottom areas buried by cuttings will eventually be recolonized through larval settlement and migration from adjacent areas. Recovery may require several years (Neff et al., 2000; Continental Shelf Associates, Inc., 2004, 2006) and is dependent on the nature of the indigenous fauna, their tolerance to burial, life history characteristics (e.g., spawning and settlement characteristics), and their relative abundance in the deposition areas.

4.5.2.5 Mitigation Measures

The following mitigation measures are included in CML's plan:

- Cuttings from MOBM well intervals will be collected on the drillship and not discharged to the sea.
- A background monitoring survey has been conducted and confirms that there are no deepwater coral communities or other hard bottom communities near the proposed drill sites (**Appendix C**).
- Simulation modeling has been conducted to evaluate the potential deposition of drill muds and cuttings on the seafloor around the drill sites (**Appendix K**). The modeling confirms that a relatively small area of seafloor around each drill site will receive deposits sufficiently thick to cause burial or smothering of benthic organisms.

4.5.2.6 Impact Significance

The significance of impacts from drilling discharges is summarized in **Table 4-18**. The consequence of potential impacts is insignificant (1) for water quality and fishes, and minor (2) for sediment quality and benthic communities. In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drillship (i.e., it refers to the likelihood of impacts occurring beyond this radius). Likelihood is rated almost certain (5) for water quality and fishes, and likely (4) for sediment quality and benthic communities. The residual risk is rated as Moderate in all cases.

Table 4-18. Summary of potential impacts of drilling discharges on nature and ecology.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Drilling discharges	Water quality; fishes	Turbidity within a few tens of meters to a few kilometers discharge locations	• Selection of low-toxicity MOBM • No discharge of MOBM or MOBM-wetted cuttings • Preferably, all additives to the WBM/Brine will be PLONOR or Gold-rated according to OSPAR guidelines; barite will have a low metals concentration and will comply with the discharge-to-sea permit thresholds for mercury and cadmium; WBM and brine will be tested in accordance with Discharge to Sea Permit requirements • Drilling mud samples will be taken for every drilling section in compliance with Discharge to Sea Permit requirements, including the periodic toxicity testing of drilling muds during drilling • Surface waters in the vicinity of the drillship shall be visually monitored for oil sheen on a daily basis	5	1	5 Mod
	Sediment quality	Deposition of cuttings particles on the seafloor, causing changes in grain size and mineralogy	• No discharge of MOBM or MOBM-wetted cuttings	4	2	8 Mod
	Benthic communities	Localized burial and smothering of benthic organisms. Burial impacts are most likely within 65 m of drill sites. Anoxia and other benthic impacts may occur due to changes in sediment grain size.	• Background monitoring survey conducted to verify there are no deepwater sensitive habitats	4	2	8 Mod

In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drillship (i.e., it refers to the likelihood of impacts occurring beyond this radius).
MOBM = mineral oil-based mud.

4.5.3 Impacts of Routine Discharges

Routine discharges from the drillship (exclusive of drilling muds and cuttings), installation vessel, and various support vessels will include sanitary waste, grey water, organic (food) waste, cooling water, desalination brine, and deck drainage (see **Section 3.6.3**). All discharges will comply with the appropriate requirements of MARPOL Annex I (oil pollution prevention), Annex IV (sewage pollution prevention), and Annex V (garbage pollution prevention) as well as the applicable Discharge to Sea Permit. Specific treatment processes are detailed in **Section 3.6.3** for individual waste streams.

It is acknowledged that vessels may attract motile fishes and invertebrates (e.g., see discussion in **Section 4.3.1.3**) either as FADs or due to lighting effects. As a result, select marine fauna may be present around the drillship, installation vessel, and/or support vessels in higher abundance than normal. This increase in local fish or invertebrate abundance increases the potential for exposure to routine discharges.

4.5.3.1 Impacts on Water Quality and Fishes

Sanitary and grey water as well as organic food waste from the drillship and support vessels may affect concentrations of suspended solids, nutrients, and chlorine as well as generating biochemical oxygen demand. Sanitary waste will pass through an IMO-approved sewage treatment plant prior to discharge. Grey water will be discharged without treatment while food waste will be macerated to pass through a 25-mm mesh in accordance with MARPOL requirements. Cleaning agents used on the drillship that end up in discharged grey water will be compatible with usage in the marine environment. Apart from the presence and concentrations of pollutants which may be present in grey water discharges (e.g., cleaning agents), mixing and dilution are the most significant variables affecting any potential impacts to local marine resources. These discharges are expected to be diluted rapidly in the open sea, and the risk for adverse effects from grey water discharges is expected to be low (BOEM, 2012; Ytreberg et al., 2020). Impacts to water quality would likely be undetectable beyond 100 m from the source and impacts on fishes or other water column organisms are unlikely due to the intermittent and transient nature of the water quality impacts.

Cooling water and desalination brine are discharges that do not contain added chemicals or contaminants other than the potential for anti-corrosives or anti-scaling agents. The discharges may have localized impacts on water temperature and salinity near the discharge point. It is expected that these discharges would be rapidly diluted and impacts to water quality would likely be undetectable beyond 100 m from the source. Impacts on fishes or other water column organisms are unlikely due to the intermittent and transient nature of water quality impacts.

Deck drainage consists mainly of runoff (rainwater) that falls on the drillship decks. Drainage from machinery areas will pass through an oil-water separator prior to discharge or be retained on board to be disposed of onshore. It is expected that deck drainage would be diluted rapidly in the open ocean and will produce no sheen on the water surface. No impacts on fishes or other water column organisms are expected.

Ballast water discharges can result in the introduction of alien invasive species (AIS) (IMO, 2004; IPIECA and International Association of Oil & Gas Producers [OGP], 2024). The introductions can occur when vessels are moved from another geographic location. AIS introduced in ballast water can have a variety of environmental and economic impacts, such as competing with or preying upon native species, decreasing biodiversity, fouling fishing nets, and clogging water systems (Lovell and Stone, 2005; IPIECA and OGP, 2024). CML will operate in accordance with the guidelines developed by IPIECA and OGP (2024), which recommend specific measures to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. The drillship will have a Ballast Water Management Plan and will be equipped with an IMO-approved ballast water management system to minimize the potential for introducing AIS. The water depth, soft

bottom substrate, and distance from shore of the Leviathan Field are factors that make it unlikely for AIS from ballast water to become established in the region. Some AIS require hard bottom substrate and will not become established in a soft bottom environment. Due to the distance from shore, any species associated with the drillship are unlikely to reach Israeli coastal waters.

4.5.3.2 Impacts on Marine Mammals and Sea Turtles

Routine discharges from the drillship, installation vessel, or support vessels associated with activities in the Leviathan Field and along transit corridors to shore include sanitary and domestic wastes, food waste, deck drainage, cooling water, etc. During the drilling of each well, drilling muds and cuttings will be discharged only at the seafloor, and only for the initial sections of each well; no on-site discharge of MOBM will occur. Within the open ocean environment of the Leviathan Field, discharged fluids will rapidly disperse and dilute in local currents. Therefore, it is not likely that marine mammals or sea turtles will encounter discharged materials in concentrations that would cause significant impacts.

4.5.3.3 Mitigation Measures

The drillship, installation vessel, and supply vessels will comply with MARPOL Annex I (oil pollution prevention), Annex IV (sewage pollution prevention), and Annex V (garbage pollution prevention). Individual waste streams are detailed in **Section 3.6.3** and summarized briefly here:

- Sanitary waste will pass through an IMO-approved sewage treatment plant prior to discharge.
- Grey water will be discharged without treatment.
- Food waste will be macerated to pass through a 25-mm mesh in accordance with MARPOL Annex V requirements, commingled with the grey water and discharged overboard more than 12 nmi from shore.
- Cooling water, desalination brine, and deck drainage from non-hazardous areas will be discharged without treatment. Drainage from hazardous areas will be collected and sent to shore for proper disposal.
- Bilge water and deck drainage from machinery areas will pass through an oil-water separator prior to discharge (in accordance with MARPOL Annex I requirements) or be retained on board to be disposed of onshore.
- CML will operate in accordance with the MoE guidelines for operating vessels in Israel in respect to AIS, which conform with the IPIECA guidelines and IMO Resolution MEPC.207(62). All operating project vessels will provide the following documentation for AIS clearance to minimize the risk of introducing AIS: Declaration letter with working areas in the past 5 years, Ballast Water Management Plan and international Ballast Water Management Certificate, International Anti-fouling System certificate and haul cleaning reports.

4.5.3.4 Impact Significance

Potential impacts of other discharges are summarized in **Table 4-19**. The consequence of potential impacts is insignificant (1). In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drillship, installation vessel, and support vessels (i.e., it refers to the likelihood of impacts occurring beyond this radius). The likelihood is rated as possible (3) and the residual risk for water quality, fishes, and benthic communities is assessed as Low.

Table 4-19. Summary of potential impacts of other discharges on nature and ecology.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Other discharges (sanitary and grey water, food waste, cooling water, desalination brine, deck drainage)	Water quality; fishes; marine mammals; sea turtles	Localized, transient impacts on water quality within a few meters to a few hundred meters of drillship or other vessels	• Sanitary waste will pass through an IMO-approved sewage treatment plant prior to discharge • Food waste will be macerated to pass through a 25 mm mesh in accordance with MARPOL Annex V requirements, commingled with the grey water and discharged overboard more than 12 nmi from shore • Drainage from hazardous areas will be collected and sent to shore for proper disposal • Bilge water and deck drainage from machinery areas will pass through an oil-water separator prior to discharge (in accordance with MARPOL Annex I requirements) or be retained on board to be disposed of onshore • All operating project vessels will provide the following documentation for AIS clearance to minimize the risk of introducing AIS: Declaration letter with working areas in the past 5 years, Ballast Water Management Plan and international Ballast Water Management Certificate, International Anti-fouling System certificate and haul cleaning reports	3	1	3 Low

Table 4-19. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Other discharges (ballast water)	Fishes; benthic communities	Potential introduction of AIS in ballast water	• CML will operate in accordance with guidelines developed by IPIECA 436 and IMO Resolution MEPC.207(62) to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. Vessels will have a Ballast Water Management Plan and be equipped with an IMO-approved ballast water management system	3	1	3 Low

AIS = alien invasive species; IMO = International Maritime Organization; MARPOL = International Convention for the Prevention of Pollution from Ships. In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drillship (i.e., it refers to the likelihood of impacts occurring beyond this radius).

4.5.4 Impacts of Vessel Traffic

Vessel traffic during the drilling program will include routine supply vessel trips between the shore base in Haifa and the project area. The drilling program will be supported by three MMC 87 Class platform supply vessels as explained in **Section 3.2.2.1**. Each supply vessel is expected to make four one-way trips per week during drilling and completion. Supply vessels may disturb marine mammals or turtles, and there is a small possibility of a vessel striking a marine mammal or sea turtle. Additional vessel trips will occur during the subsea installation operations, including those from the pipeline installation vessel, supply/standby vessels, the MPCV, LCV, and crew change vessel. It is likely that the subsea installation vessel will operate out of Cyprus.

The movements of the drillship and installation and support vessels, including initial mobilization, movements between drill sites, and demobilization at the end of the program, could also disturb marine mammals or sea turtles. However, these vessels are expected to pose little risk of vessel strikes because of their slow speed. A DP drillship would mobilize to the Leviathan Field under its own power. A DP semisubmersible would be towed to the site by anchor handling towing supply (AHTS) vessels. Any noise-related disturbance would be similar to existing vessel traffic in the region.

4.5.4.1 Impacts on Marine Mammals

Many marine mammal species are vulnerable to collisions with moving vessels (ship strikes) (Laist et al., 2001; Douglas et al., 2008; Pace, 2011). Most reports of collisions involve large whales; most dolphins are agile swimmers, but vessel strikes have been reported for them as well (van Waerebeek et al., 2007). Of the 11 marine mammal species known to have been hit by vessels in the eastern Mediterranean Sea, fin whales are struck most frequently, and sperm whales are hit commonly (Laist et al., 2001). Although all sizes and types of vessels can collide with whales, most lethal or severe injuries are caused by ships 80 m or longer and traveling 14 knots or faster (Laist et al., 2001).

Vessel strikes are among the threats affecting the population status of both humpback and sperm whales (NMFS, 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 tugboats. There were also instances in which sperm whales approached vessels too closely and were injured by propellers (NMFS, 2010).

4.5.4.2 Impacts on Sea Turtles

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 during the drilling program is similar to that associated with existing vessel traffic in the region. Studies indicate that sea turtles are at the sea 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).

The likelihood of a supply vessel striking a sea turtle is low. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area.

4.5.4.3 Mitigation Measures

No mitigation measures are recommended for vessel traffic. Support vessel operators are expected to follow all applicable maritime navigation rules and would normally follow the most direct route (weather conditions permitting) between the drill sites and the shore base. Support vessels are expected to use existing routes into port including well-traveled shipping lanes. Vessel operators normally maintain a watch for obstructions during transit and will not deliberately approach a whale or turtle.

4.5.4.4 Impact Significance

Potential impacts of support vessel traffic on marine mammals and sea turtles are summarized in **Table 4-20**. The likelihood of the aspect is rated possible (3); although the vessel trips are certain to occur, proximity sufficient to cause impacts is less likely. The consequence of potential impacts in most cases will be insignificant (1) on a population level. The residual risk is rated as Low.

Table 4-20. Summary of potential impacts of support vessel traffic.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Support vessel traffic	Marine mammals, sea turtles	Short-term behavioral disturbance; potential for a vessel to strike a marine mammal or sea turtle	• None recommended	3	1	3 Low

4.5.5 Impacts of Helicopter Traffic

Helicopter support will be provided by a Sikorsky S-76C++ operated from Haifa Airport as explained in **Section 3.2.2.1**. The helicopter will make an estimated 10.5 trips per week between Haifa and the project area during drilling. A Sikorsky S-76C++ helicopter is expected to make a total of 30 round-trips between Haifa and the project area during installation activities.

Corporate policies for helicopter companies typically require a minimum altitude of 210 m during transit to and from a drillship and a minimum altitude of approximately 150 m while traveling between drillships or platforms (BOEM, 2012). In addition, helicopters are expected to follow Federal Aviation Administration (2004) Advisory Circular 91-36D or similar guidelines, which recommend a minimum altitude of 610 m when flying over noise-sensitive areas such as parks, preserves, and wildlife areas.

4.5.5.1 Impacts on Marine Mammals and Sea Turtles

Helicopter traffic 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. The duration of underwater sound from passing aircraft is much briefer in water than air; for example, a helicopter passing at an altitude of 152 m (500 ft) that is audible in air for 4 minutes may be detectable underwater for only 38 seconds at 3 m (10 ft) depth and for 11 seconds at 18 m (59 ft) depth (Richardson et al., 1995). Realistically, an individual animal's exposure to the sound from the helicopter would likely be occasional and transient as the helicopter moves between the shore base and the project area.

The most likely impacts on marine mammals and sea turtles from helicopter flights would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area.

4.5.5.2 Impacts on Seabirds and Migratory Birds

Seabirds and migratory birds can be disturbed by helicopters, and there is a small possibility of a helicopter striking a bird. The most likely impacts would be short-term behavioral changes such as course changes or disruption of activities. Potential impacts on dense bird populations would be reduced by maintaining recommended minimum altitudes when flying over coastal habitats such as parks, wildlife refuges, and wilderness areas.

4.5.5.3 Mitigation Measures

Helicopters are expected to maintain company-recommended minimum altitudes when flying over the open ocean and sensitive habitats such as parks and preserves. This will minimize the potential for disturbing bird colonies along the coast. No additional mitigation measures are recommended.

4.5.5.4 Impact Significance

Potential impacts of helicopter traffic on marine mammals, sea turtles, and seabirds and migratory birds are summarized in **Table 4-21**. The likelihood of the aspect is rated possible (3); although helicopter trips are certain to occur, proximity sufficient to cause impacts is less likely. The consequence of potential impacts in most cases will be insignificant (1) at a population level. The residual risk is rated as Low.

Table 4-21. Summary of potential impacts of helicopter traffic.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Helicopter traffic	Marine mammals; sea turtles; seabirds and migratory birds	Short-term behavioral disturbance of marine mammals, sea turtles, or birds; potential for a helicopter to strike a bird	• Maintain recommended minimum altitudes when flying over sensitive coastal habitats such as parks and preserves	3	1	3 Low

4.5.6 Impacts of Marine Debris

CML's waste management procedures are discussed in **Section 3.8**. All wastes will be handled and disposed according to MARPOL requirements and permit requirements. However, there is the potential for solid waste to be accidentally lost overboard, resulting in marine debris in the water or on the seafloor (BOEM, 2012). The risk of solid waste being lost overboard will be minimized through the drillship operator's and the subsea installation contractor's Garbage Management Plan as required by MARPOL Annex V and the additional waste management requirements set by CML. Potential impacts of marine debris are discussed in the following subsections, and additional impact considerations for wastes are analyzed in **Section 4.8**.

4.5.6.1 Impacts on Water Quality, Sediment Quality, and Benthic Communities

Debris accidentally lost overboard could have impacts on water and sediment quality and benthic communities (National Research Council, 2008; BOEM, 2012). Heavy items such as welding rods, buckets, pieces of pipe, etc. may have a minor, localized impact on sediment quality beneath the drillship location by creating small areas of hard substrate on the soft bottom seafloor (Shinn et al., 1993; Gallaway et al., 2008). Lighter pieces of debris may float on the sea surface and adversely affect water quality and marine biota (National Research Council, 2008; NOAA, 2024). The potential impacts on water quality from marine debris are expected to be similar to those from the existing shipping and fishing industries.

4.5.6.2 Impacts on Marine Mammals and Sea Turtles

Materials accidentally lost overboard during offshore oil and gas operations could entangle marine fauna or cause injury through the ingestion of the debris (Laist, 1996). Marine debris is among the threats affecting the population status of both humpback and sperm whales (NMFS, 1991, 2010). Ingestion of or entanglement with accidentally discarded trash and debris can kill or injure sea turtles (Laist, 1996; Lutcavage et al., 1997). 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 their preferred food: jellyfish. Ingestion of plastic and Styrofoam can result in drowning, lacerations, digestive disorders or blockage, and reduced mobility. The types of impacts on marine mammals and sea turtles from drilling-related marine trash and debris would be similar to those from existing shipping and fishing industries.

4.5.6.3 Impacts on Fishes

During Leviathan Expansion Project activities, debris such as welding rods, buckets, pipe segments, and other materials may accidentally fall overboard. Dense, solid waste objects will fall to the seafloor where they will be colonized by epibiota and possibly small fishes. Seafloor debris could leach chemicals into the surrounding water potentially affecting local benthic organisms, including demersal fish species.

4.5.6.4 Impacts on Seabirds and Migratory Birds

Marine trash and debris could injure or kill birds that ingest 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 types of impacts on marine birds from drilling-related marine trash and debris would be similar to those from the existing shipping and fishing industries.

4.5.6.5 Mitigation Measures

The risk of solid waste being lost overboard will be minimized through the drillship operator's Garbage Management Plan as required by MARPOL Annex V and the additional waste management requirements set by CML. CML will conduct a post-drilling ROV survey/inspection at each drill site to ensure that the seafloor is clear of equipment and debris from drilling and completion activities.

4.5.6.6 Impact Significance

Potential impacts of marine debris on marine mammals, sea turtles, and seabirds and migratory birds are summarized in **Table 4-22**. Existing waste management practices are expected to be effective and the release of marine debris into the environment is rated as unlikely (2) to possible (3). The consequence of potential impacts in most cases will be insignificant (1). The residual risk is rated as Low.

Table 4-22. Summary of potential impacts of marine debris.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Marine debris	Water quality; sediment quality; benthic communities	Potential accumulation of metal debris on the seafloor, with growth of fouling biota	• Drillship operator's and subsea installation contractor's Garbage Management Plan and the additional requirements set by CML will minimize the potential for accidental loss of items overboard • Post-drilling ROV survey to ensure the seafloor is clear of equipment and debris	2-3	1	2-3 Low
	Marine mammals; sea turtles; seabirds; migratory birds; fishes	Potential entanglement, ingestion; leaching of residual chemicals due to accidental loss of debris	• Drillship operator's Garbage Management Plan and the additional requirements set by CML will minimize the potential for accidental loss of items overboard	2-3	1	2-3 Low

4.6 CULTURE AND HERITAGE SITES

As explained in **Section 1.9**, CML contracted GEMS to conduct an archaeological assessment in the Leviathan Field prior to preparation of the 2016 Leviathan Field EIA (CSA, 2016). GEMS used a high-resolution sub-bottom profiler, side-scan sonar, and multibeam bathymetry and backscatter data collected by an autonomous underwater vehicle (AUV) for their archaeological assessment (Geoscience Earth & Marine Services, 2014). The survey encompassed 795 km^2 of seafloor. Data were collected on 193 primary lines and 18 tie-lines. GEMS reviewed the side-scan sonar data to delineate potential submerged cultural resources with dimensions greater than 5 m long and 2 m wide, and a length to width ratio of at least 2.5 to 1. GEMS established these mapping parameters to eliminate a potentially large number of smaller dimension contacts without significance scattered throughout the Leviathan Field.

CML will implement the recommended avoidance zones to avoid damaging archaeological resources as instructed by United States Department of the Interior – Bureau of Ocean Energy Management - Gulf of Mexico Region NTL No. 2005-G07, as reissued 25 June 2020.

Archaeological assessments were also conducted by at the three proposed drill sites and along subsea infrastructure corridors included in the Leviathan Expansion Project. Key findings included the following:

4.6.1 Impacts of Seafloor Disturbance

All potential impacts of seafloor-disturbing activities are expected to be avoided.

4.6.2 Impacts of Drilling Discharges

No significant impacts are expected from drilling discharges.

4.6.3 Impacts of Accidental Spills

Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a well loss of containment (see **Section 4.2**). Neither is likely to affect archaeological resources on the seafloor such as shipwrecks. A spill reaching the coastline could contaminate cultural and heritage sites or cause disturbance during spill response and cleanup activities.

A fuel spill would not affect archaeological sites on the seafloor because the scenario assumes a spill from the drillship at the sea surface. Spilled fuel will float and disperse at the sea surface and will not contact wreck sites on the seafloor.

A condensate spill from a well loss of containment could result in physical disturbance around the drill site. BOEM (2012) estimated that a seafloor blowout could physically disturb a radius of approximately 300 m around a drill site. A condensate spill is expected to rise through the water column and would not be likely to contact archaeological sites on the seafloor. No impacts are expected on archaeological sites in the Leviathan Field.

As discussed in **Section 4.2**, spill fate modeling indicates that a fuel or condensate spill could be carried into shallow water under certain meteorological and oceanographic conditions depending on the season, where it may contact shallow coastal sediments. There is the potential for cultural and heritage sites along the coast to be contaminated or disturbed by spill response and cleanup activities.

A detailed analysis of sensitive areas and focal points along the Israeli shoreline, including archaeological sites, was completed by Pareto Engineering Ltd. (2006) for MoEP. In addition, CML's ESI Atlas identifies archaeological sites along the Israel coast. Most of the sites are within the range of potential shoreline contacts for a fuel or condensate spill during the typical winter, summer, or autumn scenarios. The areas would be a high priority for protection in the event of a spill. Therefore, it is expected that significant impacts would be avoided.

4.6.4 Mitigation Measures

The following mitigation measures are proposed to prevent and reduce harm to cultural and heritage sites:

- An archaeological assessment was conducted by GEMS as discussed in Section 1.9 before the issuance of the 2016 Leviathan Field EIA (CSA, 2016). CML will implement a 305-m avoidance zone for sonar contacts identified by GEMS as potential wreck sites, and a 31-m avoidance zone for other contacts that may represent associated debris. No seafloor-disturbing activities will be conducted within these avoidance zones.

- Archaeological assessments of the three proposed drill sites and associated infrastructure corridors were conducted by Xodus, as outlined above.
- During routine operations, should any object be determined to likely represent an antiquity, Israel's Antiquities Authority will be notified.
- Archaeological sites would be a high priority for protection in the event of a spill reaching the coast. A detailed analysis of sensitive areas and focal points along the Israeli shoreline, including archaeological sites, was completed by Pareto Engineering Ltd. (2006) for the MoEP. In addition, CML's ESI Atlas identifies coastal archaeological sites. The response to a specific spill would take into account the potential impacts on these areas in developing and implementing a response strategy.

4.6.5 Impact Significance

Impact significance for culture and heritage sites is summarized in **Table 4-23**. The likelihood is rated as unlikely (2) because all impacts are expected to be avoided through standard practices, procedures and safeguards. The consequence of impacts is rated as minor (2) for seafloor disturbance, drilling discharges, and accidental spills. Residual risk is assessed as Low.

Table 4-23. Summary of potential impacts on culture and heritage sites.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Seafloor disturbance	Culture and heritage sites	Possible physical damage to wreck sites from drilling and/or subsea infrastructure installation	• 305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts ( )	2	2	4 Low
Drilling discharges	Culture and heritage sites	Possible burial or contamination of wreck sites	• 305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts (	2	2	4 Low
Accidental spills	Culture and heritage sites	Possible contamination; indirect effects of physical damage during cleanup activities (if a spill reached the coastal zone)	• 305-m avoidance zone for potential wreck sites; 31-m avoidance zone for other sonar contacts ( ) • Oil spill response would prioritize protection of archaeological sites if a spill reached the shoreline	2	2	4 Low

4.7 AIR QUALITY

Two aspects of CML's proposed activities were identified that could potentially affect air quality (**Table 4-1**): air emissions and accidental spills.

4.7.1 Impacts of Air Emissions

4.7.1.1 Routine Project Emissions

Sources of air pollutant emissions during the project include engines onboard the drillship, installation vessel, support vessels, and helicopters. Engines on these vessels will produce emissions including CO, NO_x, SO_x, VOCs, and PM, as well as GHGs such as CO_2, CH_4, and N_2O. Aircraft emissions will include NO_x, hydrocarbons, CO, and PM.

In **Section 3.4**, emissions were estimated using a worksheet developed by BOEM (2020), using vessel specifications as provided by CML. Helicopter calculations were based on published emissions estimates for a Sikorsky S-76C++ helicopter (Rindlisbacher and Chabbey, 2015). **Table 4-24** summarizes the estimated total emissions for drillship and support vessels during drilling and completion of the three wells that are part of the Leviathan Expansion Project.

Table 4-24. Total estimated air pollutant emissions from one drillship and three supply vessels during drilling and completion of the three proposed wells.

Activity	Total Duration (days)	Total Estimated Emissions (metric tonnes)									
		CO	NO_x	SO_x	VOCs	PM2.5	PM10	CO_2	CH_4	N_2O	GHGs
Drilling	246	91.1	581.1	0.4	16.7	14.2	14.6	39,727	0.2	1.8	39,729
Well Completion	120	44.5	283.5	0.2	8.2	6.9	7.1	19,379	0.1	0.9	19,380
	105	46.37	295.61	0.18	8.50	7.22	7.44	20,210	0.12	0.89	20,211
	105	42.14	268.65	0.16	7.72	6.56	6.77	18,367	0.11	0.81	18,368
	105	42.91	273.58	0.17	7.87	6.68	6.89	18,704	0.11	0.83	18,705
Total		267.02	1,702.44	1.11	48.99	41.56	42.8	116,387	0.64	5.23	116,393

Drilling will require 246 days for all three wells (24 hours per day); completion will require a total of 120 days (24 hours per day). Each supply vessel was assumed to operate for 16 hours/day for 105 days (2 round-trips per week; 17 weeks per well). Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet; drillship ( ) emissions were calculated using actual fuel usage data (i.e., 60 m^3 per day); support vessel emissions were calculated using maximum horsepower ratings, adjusted to 75% maximum load. CO_2, CH_4, and N_2O emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + CH_4 + N_2O.
CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; N_2O = dinitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

Table 4-25 summarizes the estimated total emissions from installation activities (i.e., subsea infrastructure) that are part of the Leviathan Expansion Project. Helicopter emissions for both drilling and installation activities are less than 3 metric tonnes for each of the pollutants estimated (see **Section 3.4.2.3**) and are omitted from the tables.

Table 4-25. Total estimated air pollutant emissions from subsea infrastructure installation activities during the Leviathan Expansion Project.

Vessel Type	Total Estimated Emissions (metric tonnes)									
	CO	NO_x	SO_x	VOCs	PM2.5	PM10	CO_2	CH_4	N_2O	GHGs
Pipeline Installation	20.30	129.46	0.08	3.72	3.16	3.26	8,850	0.05	0.39	8,851
Supply / Standby Vessel	22.99	146.59	0.09	4.21	3.58	3.69	10,022	0.06	0.44	10,023
Multi-Purpose Construction Vessel	21.25	135.48	0.08	3.90	3.31	3.41	9,262	0.05	0.41	9,263
Light Construction Vessel with ROV	2.51	15.98	0.01	0.46	0.39	0.40	1,092	0.01	0.05	1,093
Crew Change Vessel	5.67	36.13	0.02	1.04	0.88	0.91	2,470	0.01	0.11	2,470
Total	72.72	463.63	0.28	13.33	11.32	11.67	31,697	0.19	1.40	31,699

Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2020) air emissions worksheet and actual fuel usage data from previous campaigns for each vessel. Operating days were based on projected number of vessel days (see **Section 3.4**). CO_2, CH_4, and N_2O emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + CH_4 + N_2O.
CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; N_2O = dinitrogen oxide; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

Air pollutant emissions from engines on the drillship and from installation vessels will produce localized, transient impacts on air quality. The total time for drilling and completing all the wells is estimated to be 366 days. The time required for the subsea installation campaign varies, depending upon the specific vessel being used: pipeline installation vessel, 43 days; supply/standby vessel, 211 days; multi-purpose construction vessel, 117 days; light construction vessel with ROV, 23 days; and crew change vessel, 156 days (see **Section 3.2.3**). Although emissions will be occurring over a long period, the project-specific emission rates represent a small percentage of the emissions from shipping in the Mediterranean. Due to the distance of the project area from shore (greater than 120 km), no impacts on coastal air quality are expected.

4.7.1.2 Impacts of Accidental Spills

Spill scenarios are described in **Section 4.2**. Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a well loss of containment. The fuel spill scenario assumed an instantaneous release of 8,415.6 m^3 from the drillship. The condensate spill scenario assumed a well loss of containment resulting in the release of continuing for a period of 30 days.

A fuel spill or condensate spill would affect air quality near the spill site by introducing VOCs through evaporation. Impacts would occur mainly during the first two days after the spill enters the environment. Approximately 45% of the fuel spill volume and 44% of the condensate spill volume are predicted to evaporate, mostly within the first 24 to 48 hours. Because the fuel spill is a single, instantaneous event, the impacts would be limited to that period. For the condensate spill, impacts at the spill site would continue throughout the 30-day period as new condensate is released each day. It is estimated that a spill may travel approximately 20 km from the spill site during the first two days, the period of time in which a significant portion of the fuel or condensate will evaporate. Therefore, air quality impacts are likely to be limited to an arc within a 20-km radius of the spill site (with the arc depending on the direction of spill movement).

Little or no impact on coastal air quality would be expected due to the distance from shore and the early evaporation of the most volatile components. The earliest landfall is expected to be 12 days for a fuel spill and 7.5 days for a condensate spill.

4.7.2 Mitigation Measures

CML proposes the following measures to reduce impacts from air pollutant emissions:

- All drillship, installation vessel, and support vessel engines, generators, and other emission sources will be operated and maintained in accordance with manufacturers' recommendations to avoid excessive emissions.
- The drillship, installation vessel, and supply vessels will comply with applicable MARPOL Annex VI regulations including the use of low sulfur fuels and meeting the applicable NOx emission limits under Regulation 13 of Annex VI (Note: Israel has not ratified Annex VI). The fuel oil supplied to the drillship and installation vessel will meet the requirements of Regulations 14 and 18 of Annex VI of MARPOL 73/78.
- Use of low sulfur fuel oil to reduce SOx emissions.
- Fugitive emissions will be minimized to the extent practicable by using leak resistant equipment and reducing the number of tanks and other potential emissions sources.
- To date, no H_2S has been recorded within the immediate vicinity and the low thermal gradient in the area is not suggestive of H_2S.

4.7.3 Impact Significance

Impact significance for air quality is summarized in **Table 4-26**. For routine air emissions from the drillship, installation vessel, support vessels, and helicopters, the consequence of impacts is rated as insignificant (1). The likelihood of impacts from these routine emissions is rated possible (3) and the

residual risk is rated as Low. For accidental spills, the likelihood is rated unlikely (2) and the consequence is minor (2) for air quality, with a residual risk of Low.

Table 4-26. Summary of potential impacts on air quality.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Air emissions (drillship)	Air quality	Localized, transient elevations in air pollutant concentrations near drillship; greenhouse gas emissions	• Routine maintenance and inspection of engines and generators • Compliance with MARPOL Annex VI regulations including the use of low sulfur fuel and meeting the NOx emission limits under Regulation 13 of Annex VI	3	1	3 Low
Air emissions (installation vessel, support vessels and helicopters)	Air quality	Localized, transient elevations in air pollutant concentrations along installation and transportation routes; greenhouse gas emissions	• Routine maintenance and inspection of engines and generators • Compliance with MARPOL Annex VI regulations including the use of low sulfur fuel and meeting the NOx emission limits under Regulation 13 of Annex VI	3	1	3 Low
Air emissions (flaring/ production testing)	Air quality	Localized, transient elevations in air pollutant concentrations near drillship; greenhouse gas emissions	• Use of high-efficiency burner to minimize air pollutants from incomplete combustion	3	1	3 Low
Accidental spills: Fuel spill from the drillship (8,415.6 m^3)	Air quality	Elevated volatile organic compound (VOC) concentrations due to evaporation of volatile hydrocarbons (mostly first 24 to 48 hours)	• Spill prevention measures • Drillship Shipboard Oil Pollution Emergency Plan • Oil Spill Contingency Plan	2	2	4 Low
Accidental spills: Condensate spill from a well loss of containment (for 30 days)	Air quality	Elevated VOC concentrations due to evaporation of volatile hydrocarbons (mostly first 24 to 48 hours)	• Blowout preventer and well control methods • Oil Spill Contingency Plan	2	2	4 Low

In evaluating likelihood for air quality impacts, a 100-m mixing zone was assumed around the drillship (i.e., it is referring to the likelihood of impacts occurring beyond this radius).

4.7.4 Emissions from Expected Malfunctions

The Leviathan Expansion Project will be located far from any population or shipping lanes, and any malfunctions from project equipment are not expected to result in impacts to any environmental or social receptors.

4.8 WASTE

Waste management for the well drilling and completion and subsea infrastructure installation and commissioning program is described in **Section 3.8**. All wastes will be handled and disposed according to MARPOL requirements and permit requirements (e.g., Discharge to Sea Permit). Under MARPOL Annex V (Resolution MEPC.201[62]), all fixed or floating platforms are required to carry a garbage management plan and maintain a Garbage Record Book.

Wastes that cannot be discharged overboard under MARPOL requirements will be shipped to authorized waste recycle or disposal sites onshore in accordance with the regulations. Waste storage areas will be designated on the drillship, installation vessel, and support vessels in areas isolated from other operations. Waste containers will be stored in these areas prior to processing or shipment to the contract waste management vendor. All waste materials will be stored properly in containers that are non-leaking and compatible with the waste being stored. All containers will have their lids, rings, covers, bungs, and other means of closure properly installed at all times except when waste is being added or removed.

No significant environmental impacts are expected from waste disposal. The waste will be transported to shore in supply vessels during their routine trips and will not generate additional air emissions, discharges, or other impacts. Solid waste disposal requirements for the drilling and completion and subsea infrastructure installation and commissioning program are expected to be negligible relative to the available services and recycle or landfill capacity in Israel.

4.9 HAZARDOUS MATERIALS

4.9.1 Risk Mitigation

Drilling and completion activities will include the use of hazardous materials including MOBM and drilling mud additives. The subsea infrastructure installation and commissioning activities will also utilize hazardous materials, primarily in association with pre-commissioning activities. The chemicals and quantities to be used (i.e., for drilling and completion per well; for subsea infrastructure and commissioning operations) are summarized in **Section 3.5**. All hazardous materials will be handled in accordance with their SDS-specified guidelines (**Appendix G**), as integrated into the hazardous materials handling guidelines established for the drillship, installation vessel, and support vessels.

Each specific chemical or product for which an SDS has been provided identifies information pertinent to chemical composition, brand name, CAS number (chemical abstract system number) and/or UN number, and storage requirements. Handling of hazardous materials will also comply with the project-specific Toxin Permit requirements. All personnel must receive hazard communication information and training before handling, using, or otherwise being exposed to hazardous chemicals. Hazardous chemicals may only be handled or used after reviewing the SDS and label information and only if the container is properly labeled with chemical hazard information.

Hazardous waste streams will be segregated by type and will not be mixed together or managed in the same container with non-hazardous wastes. Hazardous waste storage areas will be designated on the drillship, installation vessel, and support vessels in areas isolated from other operations. Waste containers will be stored in these areas prior to processing or shipment to the contract waste management vendor. Separate storage locations or sufficient space/barriers will be provided to enable the segregation of incompatible chemicals. All waste materials will be stored properly in properly labeled containers that are non-leaking and compatible with the waste being stored. All containers will have their lids, rings, covers, bungs, and other means of closure properly installed at all times except when waste is being added or removed. Hazardous chemical containers and storage areas will be maintained in clean condition with no residues or spilled materials on the container, floor, or surrounding area.

No significant environmental impacts are expected from the management of hazardous materials. Hazardous waste will be segregated from non-hazardous waste and transported to shore in supply vessels during their routine trips and will not generate additional air emissions, discharges, or other impacts. Disposal requirements for hazardous materials are expected to be negligible relative to the available services and waste management capacity in Israel.

4.9.2 Discovery of Hazardous Materials During Drilling

Based on prior drilling experience in the Leviathan Field, there is a limited potential for encountering hazardous materials during drilling (e.g., H_2S). In the event that H_2S is encountered, the main objective is to shut in and secure the well to prevent any escape to the atmosphere. Operations will only be resumed when necessary safety equipment has been installed on the drillship. H_2S scavenger will be available on the drillship and the mud treated to prevent any H_2S gas from reaching the surface. The mud logging personnel will install and maintain H_2S detection equipment at strategic locations on the drillship. The Control Room Operator and supervisory personnel will be alerted should the presence of H_2S be detected. The drillship contractor has procedures for responding to an H_2S alarm on the drillship, including instructions to crew members in the event of an alarm.

4.9.3 Emergency Measures

CML's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including those involving hazardous materials. CML will also require the drillship 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. In the event of an accident or emergency, the designated person in charge, the drillship contractor's offshore installation manager, is in overall command. The drillship contractor's Emergency Response Plan and procedures must be applied to manage drill site emergency situations to ensure safe evacuation, escape, and rescue of drilling and support personnel. The maintenance and safe operation of evacuation and escape equipment is the responsibility of the drillship contractor. CML and the drillship contractor will coordinate their incident management processes in the event of an emergency that requires onshore emergency response coordination via remove incident management teams.

4.10 EARTHQUAKE PREPAREDNESS

CML has considered seismic risk (including potential earthquakes) in developing the proposed Leviathan Expansion Project. The design and engineering of the wells consider any identified seismic risk as well as seafloor and shallow geohazards.

Regional seismicity is discussed in **Section 1.4.3**. Earthquakes in the vicinity of the Leviathan Field are relatively rare. There have been no strong (magnitude 5.4 or greater) regional earthquakes recorded since 1983 within 200 km of the Leviathan Field.

4.10.1 Responding to Early Earthquake and Tsunami Warnings

CML's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including earthquakes. CML will also require the drillship contractor(s) to have an Emergency Response Plan in place to deal specifically with the actions to be taken in the event of earthquake or tsunami warnings.

4.10.2 Means to Prevent Damage

The Geologic Survey of Israel (2023) did not identify any geohazards in the vicinity of the Leviathan Field that would be a geological risk to drilling or infrastructure installation and dynamic changes to seafloor stability are not expected. The design and engineering of the wells consider any identified seismic risk and have been designed to prevent damage in case a seismic event occurs.

4.10.3 Emergency Procedures for Earthquake Incidents

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. In the event of an accident or emergency, the designated person in charge, the drillship contractor's offshore installation manager, is in overall command. The drillship contractor's Emergency Response Plan and procedures must be applied to manage drill site emergency situations to ensure safe evacuation, escape, and rescue of drilling and support personnel. The maintenance and safe operation of evacuation and escape equipment is the responsibility of the drillship contractor. CML and the drillship contractor will coordinate their incident management processes in the event of an emergency that requires onshore emergency response coordination via remove incident management teams.

No environmental impacts from earthquakes are expected during the Leviathan Field drilling and completion program. The response to any spills resulting from an earthquake or other emergency would be in accordance with CML's OSCP. The potential impacts of accidental events including a fuel spill and condensate spill from a well loss of containment are evaluated in **Section 4.2**.

4.11 FISHING AND MARINE AQUACULTURE

No fishing areas are known within the Application Area due to water depth and distance from shore (see **Section 1.6.3**). No mariculture or fish farming operations are known to exist near the Leviathan Field. Due to the water depth and the distance from coastal fishing and marine farming areas, no impacts are expected from routine drilling and completion and subsea installation activities.

Three aspects of CML's proposed activities were identified that could potentially affect fishing activities and marine farming: physical presence and exclusion zone, support vessel traffic, and accidental spills.

4.11.1 Impacts on Fishing Activity

4.11.1.1 Impacts of Physical Presence and Exclusion Zone

All vessels (including fishing boats) will be excluded from a 500-m radius exclusion zone around the drillship and installation vessel for safety reasons. Support vessels will monitor this exclusion zone and help minimize the potential for other vessels to enter this area. Because the drill sites and subsea infrastructure corridors are not in a known fishing area, it is unlikely that any fishing vessels would be affected by this exclusion.

4.11.1.2 Impacts of Support Vessel Traffic

The drilling program will be supported by three MMC 87 Class platform supply vessels operating out of the port of Haifa; specifications of example vessels are provided in **Appendix G**. Each supply vessel is expected to make four one-way trips per week. The vessels will normally follow the most direct route between the shore base and the drillship, weather permitting. Shipping lanes extend westward from Haifa in the direction of the Leviathan Field, and it is expected that most of the supply vessel route would be in or near these existing shipping lanes where there is already vessel traffic. Therefore, no interactions with fishing vessels or gear are expected during these trips.

The subsea installation program will require multiple trips between the Leviathan Field and the subsea installation constructor's shore base which will likely be located in Limassol, Cyprus. The estimated vessel activity levels, duration, frequency, and total trips are presented in **Table 4-27**, by installation activity.

Table 4-27. Estimated installation vessel days and supply vessel trips to and from Cyprus for the subsea installation during the Leviathan Expansion Project.

Vessel Type	Activity Duration (days)	Activity	Frequency	Total Trips
Pipeline Installation Vessel	60	1	1 trip for pipeline campaign	1
Supply / Standby Vessel	240	All	~2 trips per week	70
Multi-Purpose Construction Vessel	180	2,3,4,5,6	1 trip for umbilical campaign 2 trips for subsea campaign 2 trips for pre-comm campaign	5
Light Construction Vessel with ROV	30	7	1 trip for pre-lay, pre-commissioning	1
Crew Change Vessel	240	All	~2 trips per week	70
			Total	147

Activity 1: Flowline and PLET Installation.
Activity 2: Jumper Installation.
Activity 3: Umbilical Installation.
Activity 4: Flying Leads Installation.
Activity 5: Flowline Testing and Pre-Commissioning.
Activity 6: Umbilical and Flying Leads Testing and Pre-Commissioning.
Activity 7: Pre-Lay Activities.

4.11.1.3 Impacts of Accidental Spills

Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a well loss of containment (see **Section 4.2.1**). Both have the potential to affect fishing activities if a spill reached coastal areas. The impacts could result from 1) exposure of fishery species to fuel oil or condensate; and/or 2) response activities including vessel traffic and areas temporarily closed to fishing during cleanup.

A fuel spill or condensate spill in the Leviathan Field would be unlikely to affect fishing or marine farming activities because of the distance from shore. There are no known fishing or marine farming areas in or near the Leviathan Field.

Fishing and marine farming areas along the Israeli coast could be affected in the event that a spill reached coastal waters or shorelines. Potential impacts could include direct impacts to fish or aquaculture species (e.g., toxicity or contamination) as well as temporary disruption or suspension of fishing or marine farming due to spill response activities.

Israeli shorelines potentially contacted by a spill range from Israel's northern border south to Gaza, with the most extensive impacts during typical winter conditions for either a fuel spill or condensate spill. Most fish farming takes place in secure bays to avoid damage to the cages. Fish farms in secure bays are not expected to be contacted by a spill.

4.11.1.4 Mitigation Measures

Prior to commencing the Leviathan Expansion Project drilling and completion and subsea infrastructure installation programs, CML will issue a Notice to Mariners to inform fishing vessels and other vessel operators of planned vessel movements and the buffer zone around the drillship and installation vessel.

Fishing and marine farming areas would be a high priority for protection in the event of a spill. A detailed analysis of sensitive areas and focal points along the Israeli shoreline, including

archaeological sites, was completed by Pareto Engineering Ltd. (2006) for the MoEP. CML's ESI Atlas also identifies sensitive marine areas including fishing and marine farming areas. The OSCP includes notification procedures. The response to a specific spill would take into account the potential impacts on these areas in developing and implementing a response strategy.

4.11.1.5 Impact Significance

Impact significance for fishing and marine aquaculture is summarized in **Table 4-28**. Impacts on fishing activities due to the physical presence of the drillship and the exclusion zone are considered possible (3) and the consequence is rated insignificant (1), with a residual risk of Low.

Similarly, impacts on fishing activities due to the physical presence of the installation vessel and its exclusion zone are considered possible (3) and the consequence is rated insignificant (1), with a residual risk of Low.

Support vessel traffic is certain to occur, but the likelihood of proximity sufficient to cause impacts is lower and is rated as possible (3). The consequence of impacts on fishing activities is insignificant (1) and the residual risk rated as Low.

The fuel spill and condensate spill are unlikely events (2) with potential consequences rated as minor (2) for a fuel spill and minor to medium (2 to 3) for a condensate spill. The residual risk ranges from Low to Moderate.

Table 4-28. Summary of potential impacts on fishing and marine aquaculture.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Physical presence and exclusion zone (drilling and completion)	Fishing activities	Exclusion of fishing vessels from 500-m buffer zone around drillship	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
Physical presence and exclusion zone (subsea installation)	Fishing activities	Exclusion of fishing vessels from 500-m buffer zone around installation vessel	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
Support vessel traffic	Fishing activities	Potential interactions with fishing vessels or gear during routine vessel traffic between shore base (Haifa) and the project area	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
Accidental spill (fuel)	Fishing activities; marine farming	Possible contamination of fish and shellfish resources; interruption of fishing activities due to response and cleanup activities	• Oil Spill Contingency Plan includes notification procedures; spill response would prioritize sensitive areas including fishing and marine farming areas	2	2	4 Low
Accidental spill (condensate from a well loss of containment)	Fishing activities; marine farming	Possible contamination of fish and shellfish resources; interruption of fishing activities due to response and cleanup activities	• Oil Spill Contingency Plan includes notification procedures; spill response would prioritize sensitive areas including fishing and marine farming areas	2	2-3	4-6 Mod

4.11.2 Means to Prevent Overfishing around Fish Aggregating Marine Structures

No fishing areas are known within the Application Area due to water depth and distance from shore and any fish aggregating effect that project vessels may have on commercial fish species would not result in overfishing. No deepwater trawling is known to occur in the vicinity of the Leviathan Field.

4.12 SAFETY AND PROTECTION

Consistent with international industry practice, CML will establish a 500-m radius exclusion zone around the drillship, which will be kept clear of all unauthorized vessels. A continuous bridge watch on the drilling unit will be maintained to ensure compliance with the exclusion zone. A standby vessel (e.g., a supply vessel) supporting the drilling and completion activities will keep watch also and will be used to enforce the exclusion zone, intervening if any vessel makes a close approach.

Similarly, during subsea infrastructure installation, a 500-m radius exclusion zone around the pipelay vessel will be kept clear of all unauthorized vessels.

The resources potentially affected by the exclusion zone are marine transportation system and infrastructure.

4.13 MONITORING AND CONTROL PROGRAM

Monitoring procedures are an integral element of CML'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 CML's Environment, Health, and Safety (EHS) procedures. The following discussion is divided into three categories: environmental monitoring, discharge monitoring, and other performance monitoring.

4.13.1 Environmental Monitoring

Prior to previous drilling in the Leviathan Field, CML conducted a Background Monitoring Survey of the marine environment as required by the Ministry Guidelines. The survey report is provided in **Appendix C**.

CML will conduct a post-drilling environmental monitoring survey around the proposed wells in the Leviathan Field. The post-drilling survey will include sampling of seawater, sediments, and infauna. Reporting of results will include comparison of baseline and post-drilling survey results.

The following additional environmental monitoring is planned:

- CML will visually monitor waters in the vicinity of the drillship for oil sheen on a daily basis. If an oil sheen is observed, the source will be identified and steps taken to reduce, minimize, or eliminate (if possible) the discharge if the source is a drillship or support vessel.
- CML will conduct post-drilling surveys to ensure that the seafloor around each drill site is clear of equipment and debris.
- Leviathan Field monitoring will occur on a five year basis that will assess the environmental condition around the production wells.

4.13.2 Discharge Monitoring

Discharge monitoring includes the following elements:

- Monitoring of drilling discharges will be conducted as part of daily monitoring activities on the drillship. This includes the testing of drilling muds and associated chemicals, and periodic toxicity testing of drilling muds during drilling in accordance with Discharge to Sea Permit requirements.

- WBM will be sampled during the first two drilling sections. The WBM will also be subject to a toxicity test that will be conducted by a certified lab.
- Barite will be tested for metals including mercury and cadmium before and during project activities.
- The drillship's routine discharges will be sampled on a daily or monthly basis, depending on the system.
- CML will conduct a performance assessment at least once during the drilling of each well to confirm compliance with the discharge monitoring and reporting requirements on the drillship. These include barite certificates, SDSs for all chemicals listed in the Chemical Use Plan, and the chemicals inventory, among others.
- Documentation of all discharges and related monitoring activities will be conducted as part of daily monitoring activities on the drillship(s) and installation vessel, and per the Offshore Discharge Program that will be prepared.

4.13.3 Other Performance Monitoring

Performance assessments will be conducted to address requirements identified under the Environmental Approval and Exploration Authorization and to review the implementation of the EHS management plans required per the Environmental Approval. Other performance monitoring activities include the following:

- CML will conduct a performance assessment immediately prior to initiating the drilling and completion program to determine the status of the EHS processes and resources in place.
- CML will conduct performance assessments to the drillship to confirm that spill response resources are in place, trained personnel are available on-site, and third-party contractors are familiar with spill prevention and response procedures, including notification requirements. The assessment will be reviewed and updated annually.
- CML will conduct a performance assessment to confirm that a Notice to Mariners was issued and support vessels were instructed to monitor and enforce the exclusion zone.
- Waste management will be evaluated during a performance assessment on the drillship at least once during the drilling program. Waste tracking documentation and related monitoring activities will be conducted per the Waste Management Program that will be prepared.
- Fuel use will be monitored and estimated air pollutant emissions will be calculated upon the termination of drilling activities.
- Marine Environment Background Monitoring Plan (previously completed).

4.14 DECOMMISSIONING OPERATIONS

At the end of the production life of the Leviathan Expansion Project wells, CML will initiate decommissioning of wells and subsea infrastructure. Prior to decommissioning, CML will conduct an environmental impact assessment to determine the most environmentally friendly method of decommissioning and will obtain approval from appropriate Ministry authorities. A comparative assessment and net environmental benefit analysis may also be performed to further characterize and quantify various decommissioning options (e.g., full removal, partial removal, abandonment in place). Existing regulatory requirements at the time of decommissioning will provide the primary framework for decommissioning options to be considered.

Sources of potential impact resulting from future decommissioning are similar to those identified for drilling and subsea infrastructure emplacement, including vessel or infrastructure discharges, physical presence, exclusion zones, vessel movement, air emissions, vessel sound emissions, light emissions, solid waste, helicopter traffic/sound emissions, and seafloor disturbance. These sources of impact potentially affect a suite of environmental resources, including physical/chemical, biological, and environmental/social attributes. Decommissioning operations are expected to be temporary and short term in nature, producing limited, localized impacts. The decommissioning assessment, to be

conducted prior to decommissioning, will fully outline decommissioning options and expected impacts from each.

Several key sources of impact associated with decommissioning are outlined below.

4.14.1 Discharges

During the plugging and abandonment of each well, there is the potential for small discharges of cement, MEG, and brine to escape from the wellhead and be distributed onto the seafloor. These discharges, heavier than seawater, may affect sediment quality and benthic communities in relatively close proximity to the wellhead. Deposition of these materials may result in localized changes in the texture and physical/chemical properties of the sediments, or may affect local soft bottom infauna. The effects to sediment quality and benthic communities due to these possible discharges are not readily quantifiable due to the uncertainty concerning discharge material composition, volumes, and depositional patterns.

4.14.2 Seafloor Disturbance

The Leviathan Field wells will be permanently abandoned prior to removal of the wellheads, along with removal of any connecting infrastructure (e.g., jumpers, flowlines, etc.). Multiple attempts at wellhead removal may be warranted. One attempt to remove wellheads and associated structures from the seabed during decommissioning means using the vessel crane once to pull up a wellhead after it had been cut. A second attempt to remove wellheads and associated structures would be running the cutting tools again, if required, and attempting to again pull the structure up with the vessel crane. A light well intervention vessel may deploy an ROV-supported wellhead retrieval package to cut and recover the wellheads for onshore disposal. The cut to remove the wellheads will be below the seabed (nominally 0.5 to 1.5 m below the sediment surface).

The wellheads will be cut from the inside. At present, there is no plan for dredging around the wellhead to minimize seabed disturbance. Subsea infrastructure will be flushed and possibly pigged to remove residual hydrocarbons, then cut and lifted to surface for transport to shore and disposal or recycling.

The wellheads may be cut with an abrasive cutter utilizing high pressure water and abrasive sorted grit particles. The abrasive grit will be discharged at the cut point, below seabed; the grit will be expected to either settle on top of the shallowest abandonment plug inside the well, or below seabed level after passing through the conductor pipe.

At a minimum, the physical dimensions of seafloor disturbance caused by removal of the wellhead system is approximately 0.7 m^2. If all three of the Leviathan Expansion Project wells are decommissioned, total seafloor disturbance from decommissioning, including removal of the wellhead system, is approximately 2 m^2. Similarly, removal of subsea infrastructure will disturb sediments immediately beneath and adjacent to flowlines, umbilicals, etc. This disturbance will result in increased turbidity near each wellhead and subsea infrastructure removal operation, with potential for mobilization of sediment-bound chemicals in the water column near the seafloor.

4.14.3 Waste Management

The intentional release of solid waste into the marine environment is prohibited under MARPOL and national regulation. Solid waste will not intentionally be discarded in the Leviathan Field or along transit corridors to shore. However, accidental loss of debris from project vessels may occasionally occur.

It is possible that debris may accidentally fall overboard during decommissioning activities in the Leviathan Field. Buoyant debris and solid waste will be transported by surface currents, while heavier, non-buoyant solid waste will sink to the seafloor. Buoyant debris may or may not undergo degradation (e.g., wood, cardboard, and paper will degrade over time; plastics will degrade more slowly according to their composition). Degradation by-products may affect local water quality, including potentially leaching chemicals that may cause localized changes in water quality.

4.15 MARINE TRANSPORTATION SYSTEMS AND INFRASTRCUTURE

4.15.1 Impacts of Project-Specific Vessel Traffic

Support vessel operations for the Leviathan Expansion Project drilling and completions campaign will be conducted primarily from the shore base in Haifa, although shore base activities in Cyprus or Greece are also being considered; the subsea installation campaign will likely operate from a shore base in Limassol, Cyprus. Based on recent statistics, Haifa Port handled 11,702,000 tons of cargo and 736,138 twenty-foot equivalent units (TEUs) in 2023 (Haifa Port, 2024). By comparison, the port of Limassol handled almost 1 million tonnes of cargo, approximately 200,000 cruise passengers, 67,529 TEUs, and 22,244 vehicles in 2022 (DP World, 2023). Leviathan Expansion Project vessels will contribute a small incremental increase to vessel traffic at Haifa Port or the port of Limassol. It is not expected that the increase in vessel traffic from the Leviathan Expansion Project will significantly interfere with routine operations at either port. Impacts on marine transportation and infrastructure due to support vessel traffic are considered unlikely (2) and the consequence is rated insignificant (1), with a residual risk of Low (**Table 4-29**).

Table 4-29. Summary of potential impacts of support vessel traffic on marine transportation systems and infrastructure.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Support vessel traffic	Marine transportation system and infrastructure	Project vessel movement and interaction with other marine traffic, including port traffic	Provide Notice to Mariners in advance of proposed activities	2	1	2 Low

4.16 IMPACTS ON MARINE TRANSPORTATION SYSTEM AND INFRASTRUCTURE

The Leviathan Field is not within any shipping lane. However, shipping lanes extend westward from Haifa in the direction of the Leviathan Field. Therefore, it is possible that shipping traffic may pass through the area enroute to or from various Mediterranean ports, but impacts are expected to be negligible.

4.16.1 Impact Significance

Impact significance for safety and protection is summarized in **Table 4-30**. Impacts on marine transportation and infrastructure due to the physical presence of the drillship and installation vessel and exclusion zone are considered unlikely (2) and the consequence is rated insignificant (1), with a residual risk of Low.

Table 4-30. Summary of potential impacts of safety and protection zones.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Safety and protection zones	Marine transportation system and infrastructure	Exclusion of vessels from 500-m buffer zone around drillship and installation vessel	• Provide Notice to Mariners in advance of proposed activities • Use standard navigation markings	2	1	2 Low

4.16.2 Mitigation Measures

CML proposes the following measures regarding safety and protection zones, consistent with international industry practice:

- CML will establish a 500-m radius exclusion zone around the drillship and installation vessel, which will be kept clear of all unauthorized vessels. A continuous bridge watch will be maintained to ensure compliance with the exclusion zone.
- Navigational markings onboard both the drillship, installation vessel, and supply vessels will meet SOLAS requirements as per IMO Resolution MSC.253(83) or equivalent requirements.
- Prior to commencing the Leviathan Expansion Project drilling and completion program, CML will consult with Haifa port authorities and provide Notice to Mariners to inform the public of planned vessel movements and the exclusion zone around the drillship and installation vessel.
- CML will require support vessel operators to follow all applicable maritime navigation rules and will advise the operators to follow the most direct route (weather conditions permitting) between the drill sites and the shore base.

Chapter 5: Proposal for Application Provisions

5.1 GENERAL

CSA (2016) provides a general description of application provisions in Section 5.1 of the 2016 document. Key findings are outlined below.

Key Findings:
- This section outlines CML environmental management practices, followed by a review of the mitigation and abatement actions to be implemented and followed to protect the environment during the Leviathan Expansion Project drilling and completion and subsea infrastructure installation activities.

5.1.1 Chevron Mediterranean Limited Environmental Health & Safety Management

CSA (2016) provides a description of Health and Safety Management in Section 5.1.1 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Environmental, Health and Safety (EHS) management is implemented through a hierarchy of policies, plans, and procedures that cascade from the corporate level to the business units and their individual operations.

Proposed Project:
- CML will comply with existing EHS policies, plans, and procedures, and will implement its Operational Excellence Management System (OEMS) which includes Operational Excellence (OE) standards, processes and procedures.
- Chevron's OEMS is a comprehensive approach to systematically manage workforce safety and health, process safety, reliability and integrity, environment, efficiency, security, and stakeholder risks in order to meet our OE objectives.
- The OEMS is implemented across offshore operations and is applied to third-party contractors involved in drilling and other support activities. This ensures that all levels of operations are performed in a consistent manner such that safety and environmental protection are consistently achieved. The integration of Chevron's OEMS into contractor operations is implemented through Bridging Documents that identify common processes and approaches to address any differences in procedures between CML and the contractor as well as any site-specific hazards of the Leviathan Expansion Project activities. CML will conduct an extensive comparison and review of vessel plans, processes, and procedures relative to Chevron's OEMS to ensure that the contractor's plans are acceptable for use as the primary system during the Leviathan Field drilling and completion activities.

5.1.2 Environmental Policy

CSA (2016) describes Environmental Policy in Section 5.1.2 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- As part of OEMS, CML implements several key OE processes under Environment focus area that focus on development of energy resources in a responsible manner and working diligently to reduce risks to the environment and human health. CML is committed to ensuring compliance with applicable EHS legislation, implementing best practice standards where laws do not exist, and mitigating risk while protecting the environment and the communities where the company operates.

Proposed Project:

- The Leviathan Expansion Project activities will be conducted in alignment with the Discharge to Sea Permit and Toxin Permit requirements.
- CML will comply with its existing Operations Excellence Management System (OEMS), including compliance with existing EHS policies, plans, and procedures, and pending implementation of its OEMS.

5.1.3 Summary of Potential Impacts and Mitigation Measures

Table 5-1 outlines the impacts identified in association with the routine activities to be conducted under the proposed Leviathan Expansion Project and the viable mitigation measures noted for each to reduce or eliminate impact, culminating in a determination of residual risk.

Table 5-1. Summary of potential impacts, mitigation measures, likelihood, consequence, and residual risk from routine activities associated with the Leviathan Expansion Project.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Artificial lighting on drillship, installation vessel, and supply vessels	Sea turtles	Possible attraction of hatchlings resulting in exposure to discharges and predation	To the extent practicable without compromising safety or work performance, lighting in open deck areas will be shielded (i.e., oriented downward) to minimize excess light emissions into the environment.	3	1	3 Low
	Seabirds and migratory birds	Possible attraction and/or disorientation including circling behavior and collisions with drillship structure	Same as above	3	1	3 Low
	Pelagic fishes	Attraction to lights resulting in exposure to discharges and noise	Same as above	3	1	3 Low
Noise from drillship, installation vessel, supply vessels, and helicopters	Marine mammals	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
	Sea turtles	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
	Fishes	Behavioral responses such as avoidance; potential for auditory masking	None	3	1	3 Low
Seafloor disturbance	Sediment quality	Physical disruption and suspension of sediments	None	3	1	3 Low
	Benthic communities	Localized burial and crushing of individual organisms; areal extent 2,500 m^2 or less per drill site and from seafloor infrastructure installation	None	3	1	3 Low
	Water quality	Mobilization of local sediments, potential mobilization of sediment-bound contaminants, deposition of muds and cuttings	None	3	1	3 Low

Table 5-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Drilling discharges	Water quality; fishes	Turbidity within a few tens of meters to a few kilometers from discharge locations	Selection of low-toxicity MOBM No discharge of MOBM or MOBM-wetted cuttings. All MOBM-wetted cuttings will be captured and shipped onshore for disposal and all MOBM will be contained within a "closed system". Once the BOP and riser are installed there is a continuous conduit from the wellbore and the rig and fluid displacements will be performed prior to any planned disconnects. All additives to the WBM/Brine will be PLONOR or Gold-rated according to OSPAR guidelines; barite will have a low metals concentration and will comply with the discharge-to-sea permit thresholds for mercury and cadmium; WBM and brine will be tested in accordance with Discharge to Sea Permit requirements Drilling mud samples will be taken for every drilling section in compliance with Discharge to Sea Permit requirements, including the periodic toxicity testing of drilling muds during drilling Surface waters in the vicinity of the drillship shall be visually monitored for oil sheen on a daily basis	5	1	5 Mod

Table 5-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Drilling discharges (cont'd)	Sediment quality	Deposition of cuttings particles on the seafloor, causing changes in grain size and mineralogy	No discharge of MOBM or MOBM-wetted cuttings	4	2	8 Mod
	Benthic communities	Localized burial and smothering of benthic organisms. Burial impacts are most likely within 65 m of drill sites. Anoxia and other benthic impacts may occur due to changes in sediment grain size.	Background monitoring survey conducted to verify there are no deepwater coral or other hard bottom communities present	4	2	8 Mod
Drillship, installation vessel, support vessel routine discharges (sanitary and grey water, food waste, cooling water, desalination brine, deck drainage)	Water quality; fishes; marine mammals; sea turtles	Localized, transient impacts on water quality within a few meters to a few hundred meters of drillship, installation vessel, or other vessels	Compliance with MARPOL requirements Drillship discharges and other project vessel (including the installation vessel) discharges will be in compliance with the Discharge to Sea Permit	3	1	3 Low
Flowline pre-commissioning fluid discharges (including preservation fluids)	Water quality; fishes; benthic communities	Localized, transient impacts on water quality within a few meters to a few hundred meters of the discharge; potential exposure to fishes and benthic communities when discharged at depth	All pre-commissioning and preservation fluids will be Gold-rated under the Offshore Chemical Notification Scheme	4	2	8 Mod

Table 5-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Other discharges (sanitary and grey water, food waste, cooling water, desalination brine, deck drainage)	Water quality; fishes; marine mammals; sea turtles	Localized, transient impacts on water quality within a few meters to a few hundred meters of drillship or other vessels	Sanitary waste will pass through an IMO approved sewage treatment plant prior to discharge Food waste will be macerated to pass through a 25 mm mesh in accordance with MARPOL Annex V requirements, commingled with the grey water and discharged overboard more than 12 nmi from shore Drainage from hazardous areas will be collected and sent to shore for proper disposal Bilge water and deck drainage from machinery areas will pass through an oil-water separator prior to discharge (in accordance with MARPOL Annex I requirements) or be retained on board to be disposed of onshore	3	1	3 Low
Other discharges (ballast water)	Fishes; benthic communities	Potential introduction of AIS in ballast water	All operating project vessels will provide the following documentation for AIS clearance to minimize the risk of introducing AIS: Declaration letter with working areas in the past 5 years, Ballast Water Management Plan and international Ballast Water Management Certificate, International Anti-fouling System certificate and haul cleaning reports	3	1	3 Low
Support vessel traffic	Marine mammals, sea turtles	Short-term behavioral disturbance; potential for a vessel to strike a marine mammal or sea turtle	None recommended	3	1	3 Low

Table 5-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Helicopter traffic	Marine mammals; sea turtles; seabirds and migratory birds	Short-term behavioral disturbance of marine mammals, sea turtles, or birds; potential for a helicopter to strike a bird	Maintain recommended minimum altitudes when flying over sensitive coastal habitats such as parks and preserves	3	1	3 Low
Marine debris	Water quality; sediment quality; benthic communities	Potential accumulation of metal debris on the seafloor, with growth of fouling biota	Drillship and vessel operator's Garbage Management Plan and the additional requirements set by CML will minimize the potential for accidental loss of items overboard Post-drilling and post-installation ROV surveys to ensure the seafloor is clear of equipment and debris	2-3	1	2-3 Low
	Marine mammals; sea turtles; seabirds; migratory birds; fishes	Potential entanglement, ingestion; leaching of residual chemicals due to accidental loss of debris	Drillship and vessel operator's Garbage Management Plan and the additional requirements set by CML will minimize the potential for accidental loss of items overboard	2-3	1	2-3 Low
Seafloor disturbance	Culture and heritage sites	Possible physical damage to wreck sites	305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts (	2	2	4 Low
Drilling discharges	Culture and heritage sites	Possible burial or contamination of wreck sites	305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts (	2	2	4 Low
Air emissions (drillship)	Air quality	Localized, transient elevations in air pollutant concentrations near drillship; greenhouse gas emissions	Routine maintenance and inspection of engines and generators Compliance with MARPOL Annex VI regulations including the use of low sulfur fuel and meeting the NOx emission limits under Regulation 13 of Annex VI	3	1	3 Low

Table 5-1. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Air emissions (installation vessel, support vessels and helicopters)	Air quality	Localized, transient elevations in air pollutant concentrations along installation and transportation routes; greenhouse gas emissions	Routine maintenance and inspection of engines and generators Compliance with MARPOL Annex VI regulations including the use of low sulfur fuel and meeting the NOx emission limits under Regulation 13 of Annex VI	3	1	3 Low

5.2 KEY DEVELOPMENT PLANS

A series of key plans have been developed, or are in the process of being developed, for the Leviathan Expansion Project. Key plans include the following:

- Leviathan Development Plan: outlines the scope of drilling and completion and subsea infrastructure installation, as well as operation, of three new wells and associated infrastructure.
- Ballast Water Management Plan: outlines the procedures to be following to manage ballast water, including provisions to eliminate the potential for the introduction of AIS. CML will operate in accordance with guidelines developed by IPIECA 436 and IMO Resolution MEPC.207(62) to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. Applicable project vessels will have a Ballast Water Management Plan and be equipped with an IMO approved ballast water management system.
- Marine Environment Background Monitoring Plan: CML will continue to conduct monitoring in the Leviathan Field, including the area encompassed by the Leviathan Expansion Project, per the 2020 Plan (MVI, 2021b).
- Chemical Use Plan: This plan will summarize procedures and requirements for offshore chemical use and storage, all of which will be according to MARPOL Convention Annex II requirements.
- Oil Spill Contingency Plan (OSCP): The project-specific OSCP will include response procedures for all credible spill scenarios, as outlined previously. CML's OSCP shall outline Tier II and III equipment and resource requirements. CML will maintain appropriate oil spill response and clean-up equipment and supplies to quickly and efficiently address spill incidents. The OSCP will contain schedules for the regular maintenance and inspection of equipment, and will include those high risk spill points (e.g., bunkering hoses, storage tank valves, etc.). Offshore chemical use and storage will be according to MARPOL Convention Annex II requirements. Absorbent material will be available onboard all vessels to cleanup any deck spills or leaks, with suitable storage and disposal procedures for waste oil. Procedures will be put in place for bunker transfer and other bulk storage transfers to minimize the risk of a spillage.
- Emergency Response Plan (ERP): The ERP deal specifically with the actions to be taken in the event of emergencies; for both drilling and completion and installation of subsea infrastructure, CML will coordinate with the drillship and installation vessel contractors, aligning their incident management processes to ensure a coherent response in the event of an emergency. Emergency response capabilities for both personnel and equipment shall be tested regularly via drills and exercises to familiarize personnel with the emergency response procedures.
- Garbage Management Plan/Garbage Record Book: Per requirements outlined in MARPOL Annex V (Resolution MEPC.201[62]), all fixed or floating platforms are required to carry a garbage management plan and maintain a Garbage Record Book. CML will ensure that both the drillship and installation vessel contractors have current management plans and record books which meet these requirements.
- Drillship Shipboard Oil Pollution Emergency Plan (SOPEP): CML will ensure that the drillship vessel contractor has a current SOPEP, prepared in compliance with Resolution MEPC.54(32), as amended by resolution MEPC.86(44), as well as Resolution MEPC.85(44), as amended by resolution MEPC.137(53).
- Installation Vessel Shipboard Oil Pollution Emergency Plan: Similar to the bullet above, CML will ensure that the installation vessel contractor has a current SOPEP, prepared in compliance with Resolution MEPC.54(32), as amended by resolution MEPC.86(44), as well as Resolution MEPC.85(44), as amended by resolution MEPC.137(53).
- Environmental Management and Monitoring Plan: The EMMP will summarize resource-specific impacts and associated mitigation measures, and will identify those parties responsible for monitoring mitigation effectiveness and reporting. Following an adaptive management approach, CML will continue to mitigate or will modify mitigation measures to further enhance resource protection.

5.3 PLANS RELEVANT TO DEVELOPMENT AND PRODUCTION

The following section outlines the guidelines and plans that will be conducted under the Leviathan Expansion Project during the various phases of drilling and completion, subsea infrastructure installation, and operation.

5.3.1 Drilling and Production Test Performance

CSA (2016) describes Drilling and Production Test Performance in Section 5.2.1 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- CML will take a risk assessment approach that analyzes safety and environmental hazards and establish procedures, work practices, training programs, and equipment requirements, including monitoring and maintenance rules. Risk assessment and mitigation measures will be extended to requirements for its contractors and subcontractors who provide services and material for the drilling program.
- Drilling operations will be conducted in compliance with a series of operational procedures and instructions, including prescribed drilling procedures, well control procedures, and work instructions.
- Drilling operations will be conducted using industry best practice. The installation, maintenance and testing of the blowout preventer (BOP) will follow prescribed safety protocols.
- Drilling operations will comply with the drillship well control standards, including adherence to safe drilling practices. All drill string sections will be properly cemented to assure well integrity. At the completion of drilling, the well will be properly abandoned per current industry best practice and with adherence to the drillship well control standards.
- Training employees and contractors to be cognizant of company and industry practices to prevent major incidents.

Proposed Project:

- CML will comply with its existing drilling performance requirements and will seek alignment with its selected drillship contractor.

5.4 TRACKING AND MONITORING

CSA (2016) discussed Monitoring Systems in Section 5.2.5 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- Current monitoring at current meter moorings in the Leviathan Field.

Proposed Project:

- Field sampling program that established the baseline for water and sediment quality and infaunal communities. A Pre-Drilling ROV survey will be conducted to establish a baseline of the seafloor surroundings around each drill site.
- A Post-Drilling ROV survey will be conducted to ensure that the seafloor around each drill site is clear of equipment and debris.

5.5 MISSING INFORMATION AND DATA GAPS TO SUPPORT IMPACT ANALYSES

During preparation of this EIA Addendum for the Leviathan Expansion Project, no significant data gaps or missing information was identified.

5.6 REQUIRED PLANS

5.6.1 Plans for Field Development and Production

See **Sections 5.2** (Leviathan Development Plan) and **5.3.1** (Drilling and Production Test Performance).

5.6.2 Handling and Treatment of Hazardous Materials

CSA (2016) describes Handling of Hazardous Materials in Section 5.2.2 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- Hazardous materials storage areas will be designated on the drillship in areas isolated from other operations. Those storage areas will be maintained in clean condition with no residues or spilled materials on the container, floor, or surrounding area.
- Hazardous waste streams will be segregated by type according to their SDS and will not be mixed or managed in the same container with non-hazardous wastes.
- Separate storage locations or sufficient space/barriers will be provided to enable the segregation of incompatible chemicals.
- All hazardous and non-hazardous waste materials will be stored properly in containers that are non-leaking and compatible with the waste being stored. All containers will have their lids, rings, covers, bungs, and other means of closure properly installed at all times except when waste is being added or removed.
- Hazardous wastes will be handled in compliance with requirements of the Toxin Permit, as well as Israel specific hazardous waste handling guidelines (e.g., for onshore disposal of MOBM), and guidelines as detailed in the drillship environmental management procedures.
- Firefighting Equipment will be available on board.

Proposed Project:

- Hazardous materials will be handled in accordance with the terms and conditions of the Toxin permit received from the Ministry of Environmental Protection and in accordance with the policy of the drillship contractor. Emergency response management to incidents such as hazardous materials is detailed in a Bridging Document between CML and the drillship contractor. The purpose of the Bridging Document is to document agreements and clarify expectations regarding the division and implementation of CML's Operational Excellence Management System (OEMS) requirements with the drillship contractor's Safety Management System (SMS). The Drillship is responsible for the response to all emergency incidents on the vessel, including those involving hazardous materials. Any spill or release overboard shall be managed by CML Emergency Response Plan, as further described in Section 4.9.3.
- MOBM, additives, chemicals, and their quantities will be selected prior to commencement of the project and presented in the applicable permit applications.
- MOBM cuttings throughout the drilling will be transferred to a supply vessel and into skip and ship tanks to be taken to land for disposal.

5.6.3 Reduction and Prevention of Harm to Seafloor, Seawater and the Coastline including Marine Ecology, Cultural and Heritage Sites, Fishing, and Marine Farming

CSA (2016) describes Prevention of Harm to the Seafloor, Seawater, and Coastline in Section 5.2.3 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- All discharges to the sea will be according to the Discharge to Sea Permit requirements.
- The operator will maintain his solids control equipment (e.g. shakers, centrifuges, screens, etc.) in acceptable operating condition, and will ensure that routine maintenance and testing is conducted.
- Drilling will be done using a combination of WBM and MOBM. The first initial well intervals (before the marine riser is set) would be drilled using seawater and a water-based mud. Once the marine riser is set, allowing mud and cuttings to be returned to the drillship, the remaining well intervals would be drilled with MOBM.
- CML will implement a 305 m radius avoidance zone for any contacts with potential wreck sites and will operate according to conditions set by the Israel Antiquity Authority (IAA).
- CML will operate in accordance with guidelines developed by OGP/IPIECA (IPIECA and International Association of Oil & Gas Producers, 2024) and IMO Resolution MEPC.207(62) to increase awareness of Alien Invasive Species (AIS) risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle.
- The risk of solid waste being lost overboard (where it could pose a potential harm to the seafloor or to the coastline) will be minimized through CML waste management procedures and the drillship operator's Garbage Management Plan as required by MARPOL Annex V and Israeli regulation.
- Due to the distance from shore, CML does not expect any significant impacts on fishing or marine farming.
- Prior to commencing the Leviathan Field drilling and completion program, CML will issue a Notice to Mariners to inform fishing vessels and other vessel operators of planned vessel movements and the buffer zone around the drillship.
- Due to the distance from shore, CML does not expect any impacts on coastal habitats, infrastructure, or resources.
- In the event of a spill the response would consider the fishing and marine farming areas, as well as give high priority for protection, response and cleanup strategies regarding predominant habitat types in case the spill reaches the coast.

Proposed Project:

- CML will conduct a post-drilling survey following completion of the newly drilled wells.

5.6.4 Preservation of Fauna and Flora, Including Pelagic Species

CSA (2016) describes Preservation of Fauna and Flora, Including Pelagic Species, in Section 5.2.3 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- The risk of solid waste being lost overboard (where it could pose a risk of entanglement or ingestion by marine fauna), will be minimized through CML waste management procedures and the drillship operator's Garbage Management Plan as required by MARPOL Annex V and Israel Regulation.

- 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 light emissions into the environment and potential harm to birds and pelagic species, when feasible and when vessel navigational safety is not compromised.
- Support vessel operators are expected to follow all applicable maritime navigation rules and would normally follow the most direct route (weather conditions permitting) between the drill sites and the shore base. This will reduce the chance of a vessel striking a marine mammal or sea turtle.

Proposed Project:
- Low toxicity drilling fluids shall be used for the MOBM system.

5.6.5 Monitoring – Data Collection

CSA (2016) describes Data Collection in Section 5.2.5 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Monitoring program shall be prepared and conducted following completion of drilling and completion operations at all three drill sites. This Post-Drilling Monitoring survey shall include sampling of seawater, sediments, and infauna. Reporting of results will include comparison of Pre-Drilling and/or marine background survey and Post-Drilling Survey results.
- Surface waters in the vicinity of the drillship shall be visually monitored for oil sheen on a daily basis.
- Discharges shall be monitored according to Discharge to Sea Permit requirements.
- Drilling mud samples will be taken for every drilling section in compliance with Discharge to Sea Permit requirements, including the periodic toxicity testing of drilling muds during drilling.

Proposed Project:
- Monitoring of the Leviathan Field will occur every five years over the field's production life using the 2020 Leviathan Field Monitoring Survey (**Appendix M**) design. Use of this previously approved design will result in findings that are directly comparable to both the 2014 Leviathan Field Characterization Survey and future 5-year field-wide monitoring efforts.
- Post-drill monitoring of individual wellsites typically includes sediment sampling for metals and particle size in strata located various distances from the wellsite, as well as videographic transects to visually document the state of the seafloor surrounding the wellsite.

5.6.6 Provisions for Monitoring Systems

As part of the EMMP, monitoring of various mitigation measures will be conducted. The EMMP will summarize resource-specific impacts and associated mitigation measures, and will identify those parties responsible for monitoring mitigation effectiveness and reporting. Following an adaptive management approach, CML will continue to mitigate or will modify mitigation measures to further enhance resource protection. Also see **Section 5.4**.

5.6.7 Preventing/Reducing Light Hazards

CSA (2016) describes Preventing/Reducing Light Hazards in Section 5.2.6 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- 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 both the drillship, installation vessel, and supply vessels will meet SOLAS requirements as per IMO Resolution MSC.253(83) or equivalent requirements.
- Helicopter flight decks shall use perimeter lighting in accordance with international standards (e.g., Basic Aviation Risk Standard, Offshore Helicopter Operations, Safety Performance Requirements issued by the Flight Safety Foundation [2016]).

5.6.8 Reducing Air Contaminant Emissions

CSA (2016) describes Reducing Air Contaminant Emissions in Section 5.2.7 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- All drillship, installation vessel, and support vessel engines, generators, and other emission sources will be operated and maintained in accordance with manufacturers' recommendations to avoid excessive emissions.
- The drillship, installation vessel, and supply vessels will comply with applicable MARPOL Annex VI regulations.

5.6.9 Measures for Preventing or Reducing Noise

CSA (2016) describes Measures for Preventing or Reducing Noise in Section 5.2.8 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Drillship, installation vessel, and support vessel engines will be operated and maintained in accordance with manufacturers' specifications to avoid excessive noise.

5.6.10 Drilling Mud and Cuttings and Other Discharges

CSA (2016) describes Drilling Mud and Cuttings and Other Discharges (see Section 5.2.9 of the 2016 document). New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Drilling will be done using a combination of WBM and MOBM. The first two initial well intervals (before the marine riser is set) would be drilled using a water-based mud. Once the marine riser is set, allowing mud and cuttings to be returned to the drillship, the remaining well intervals would be drilled with MOBM.

Proposed Project:
- Currently, CML anticipates the selection of a base MOBM fluid similar to for the mud system (**Appendix E**).
- Drilling operations will be subject to the Discharge to Sea Permit limits, the latter of which will define conditions, discharge monitoring, sampling analysis methods, frequencies, limits and reporting.
- The equipment on board the drillship, including slops oil in water separators, will comply with the requirements of the International Convention for the Prevention of Pollution from Ships 1973, as amended by the Protocol of 1978 (MARPOL 73/78).

5.6.11 Waste Treatment and Removal

CSA (2016) describes Waste Treatment and Removal in Section 5.2.12 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- All wastes shall be handled and disposed according to MARPOL regulations and permit requirements.
- All waste materials shall be stored properly in containers that are non-leaking and compatible with the waste being stored. All containers will have their lids, rings, covers, bungs, and other means of closure properly installed at all times except when waste is being added or removed.
- Waste containers will be stored in these areas prior to processing or shipment to the contract waste handling vendor.

Proposed Project:
- Waste management will comply with conditions set in the Toxin Permit and in the Discharge to Sea Permits provided by the Ministry of Environmental Protection.

5.6.12 Safety and Protection Zones (Exclusion Zones)

CSA (2016) describes Safety and Protection Zones, or exclusion zones (see Section 5.2.11 of the 2016 document). Genesis (2016) discusses establishment of an exclusion zone around pipelay operations (see Section 4.8). New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:
- Navigational markings onboard the drillship, installation vessel, and supply vessels will meet SOLAS requirements as per IMO Resolution MSC.253(83) or equivalent requirements.
- Prior to commencing the Leviathan Field drilling and completion program and the subsea infrastructure installation operations, CML will consult with Ministry of Transportation and provide Notice to Mariners to inform the public of planned vessel movements and the exclusion zone around the drillship and installation vessel.

Proposed Project:
- CML will establish a 500 m radius exclusion zone around the drillship and installation vessel, which will be kept clear of all unauthorized vessels. A continuous bridge watch will be maintained to ensure compliance with the exclusion zone.

5.6.13 Emergency Procedures

CSA (2016) describes Emergency Procedures (see Section 5.2.13 of the 2016 document). Genesis (2016) describes emergency procedures in Section 4.7.3 of the 2016 document.

Key Findings:
- CML will develop a new Oil Spill Contingency Plan (OSCP) to reflect Leviathan drilling and subsea infrastructure installation activities. The plan will be submitted to MoEP.
- Accidental spills shall be reported to the relevant authorities.
- CML's OSCP outlines Tier II and III equipment and resource requirements. CML will maintain appropriate oil spill response and cleanup equipment and supplies to efficiently address spill incidents.
- CML requires the drillship and installation vessel contractor(s) to have Emergency Response Plans to deal specifically with the actions to be taken in the event of emergencies.
- CML and the vessel contractors (i.e., drillship, installation vessel) will coordinate their incident management processes in the event of an emergency that requires emergency response coordination via incident management teams.

- Emergency response capabilities of equipment and personnel shall be tested through regular drills and exercises and drills to familiarize personnel with the emergency response procedures.
- Equipment stockpiles onshore and aboard supply vessels shall be checked routinely.
- CML conducts oil spill dispersion modeling to determine likely trajectories and resources at risk.

Proposed Project:
- Information in the CSA (2016) document is sufficient for assessment purposes.

5.6.14 Geological and Seismic Risks

CSA (2016) describes Geological and Seismic Risks (see Section 5.2.14 of the 2016 document). Genesis (2016) addresses geological and seismic risks in Section 5.2.9 of the 2016 document.

Key Findings:
- Geological, seismic, and sedimentological aspects of the project area and region were discussed in Section 1.4. As noted, 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.
- The proponent's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including earthquakes. The proponent will also require the drillship 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. In the event of an accident or emergency, the designated person in charge, the drillship contractor's offshore installation manager, is in overall command. The drillship contractor's Emergency Response Plan and procedures must be applied to manage drill site emergency situations to ensure safe evacuation, escape, and rescue of drilling and support personnel. The maintenance and safe operation of evacuation and escape equipment is the responsibility of the drillship contractor. The proponent and the drillship contractor will coordinate their incident management processes in the event of an emergency that requires onshore emergency response coordination via remove incident management teams.
- No environmental impacts from earthquakes were expected during the Leviathan Field drilling and completion program. The response to any spills resulting from an earthquake or other emergency would be in accordance with the proponent's OSCP. The potential impacts of accidental events including a fuel spill and condensate spill from a well loss of containment were evaluated in **Section 4.2**.

Proposed Project:
- Information in the CSA (2016) document is sufficient for assessment purposes.

5.6.15 Protection and Maintenance of Pipelines

Due to water depths of the Leviathan Field and the absence of seafloor-based activities (e.g., deepwater trawling), no protective measures have been identified for protection of linear infrastructure. CML will conduct routine inspection and maintenance (e.g., pigging) operations on subsea linear infrastructure per industry good practice.

5.6.16 Decommissioning and Abandonment

No plan currently existing for the decommissioning and abandonment of wells or subsea infrastructure associated with the Leviathan Expansion Project. As the Leviathan Field nears the end of its productive life, and prior to decommissioning, CML will conduct an environmental impact assessment to determine the most environmentally friendly method of decommissioning and will obtain approval from appropriate Ministry authorities. A comparative assessment and net environmental benefit analysis may also be performed to further characterize and quantify various decommissioning options (e.g., full removal, partial removal, abandonment in place). Existing regulatory requirements at the time of decommissioning will provide the primary framework for decommissioning options to be considered.

5.6.17 Periodical Reporting and Incident Notification Procedures

CSA (2016) describes Periodical Reporting and Incident Notification Procedures (see Section 5.2.15 of the 2016 document). Genesis (2016) addresses this topic in Section 5.2.12 of the 2016 document. New information for the proposed Leviathan Expansion Project is mentioned under the proposed project.

Key Findings:

- Periodical reporting shall be done according to the specific requirements laid out in the Discharge to Sea Permit and Toxin Permit conditions.
- Incident notification shall be done according to CML's incident notification procedure.

5.7 CHANGES IN DEVELOPMENT PLAN

CSA (2016) addresses Changes in Development Planning (see Section 5.2.16 of the 2016 document).

Key Findings:

- CML will periodically report any changes in the drilling and completion plan or subsea infrastructure installation plan, including the impact of such changes on the environment.

5.8 COORDINATION TEAM

CML will periodically report any changes in the drilling and completion plan, including the impact of such changes on the environment.

Chapter 6: Literature Cited

Al-Mutaz, I.S. 2000. Water desalination in the Arabian Gulf region, pp. 245-265. In: M.F.A. Goosen and W.H. Shayya (eds.), Water Management Purification and Conservation Management in Arid Climates. Technomic Publishing, Lancaster, PA.

Abdel Aal, A., A. El Barkooky, M. Gerits, H.J. Meyer, M. Schwander, and H. Zaki. 2001. Tectonic evolution of the Eastern Mediterranean Basin and its significance for the hydrocarbon prospectivity of the Nile Delta Deepwater Area. GeoArabia 8(3):363-384.

ACCOBAMS. 2012. Species occurring in the ACCOBAMS area. Updated February 2023. Accessed 1 February 2024 at: https://accobams.org/category/species_cat/cetacean-species/ Alpert, P. and B. Ziv. 1989. The Sharav cyclone – observations and some theoretical considerations. Journal of Geophysical Research 94:18,495-18,514.

Ambrasseys, N.N. 1962. Data for the investigation of the seismic sea-waves in the Eastern Mediterranean. Bulletin of the Seismological Society of America 52(4):895-913.

Anderson, C.M., M. Mayes, and R.P. LaBelle. 2012. Update of Comparative Occurrence Rates for Offshore Oil Spills. U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, VA. OCS Report BOEM 2012-069.

Baird, P.H. 1990. Concentrations of seabirds at oil-drillships. Condor 92:768-771.

Bakke, T., J. Klungsøyr, and S. Sanni. 2013. Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry. Marine Environmental Research 92:154-169.

Bell, K.L.C. and S.A. Fuller. 2011. New Frontiers in Ocean Exploration: The E/V Nautilus 2010 Field Season. Oceanography 24(1), supplement, 40 pp.

BirdLife International. 2025a. Israel: Seabirds. Accessed 15 January 2025 at: https://datazone.birdlife.org/species/results?cty=104&cri=&fam=0&gen=0&spc=&cmn=&bt=&rec=N&vag=N&stsea=Y&wat=&aze=.

BirdLife International. 2025b. Israel: migratory birds. Accessed 15 January 2025 at: https://datazone.birdlife.org/species/results?cty=104&cri=&fam=0&gen=0&spc=&cmn=&bt=&rec=N&vag=N&sea=&wat=&aze=&lab=&enb=&stmig=Y.

BirdLife International. 2025c. Israel: Important Bird and Biodiversity Areas (IBAs). Accessed 15 January 2025 at: https://datazone.birdlife.org/country/israel/ibas.

Biswas, A.K. and C. Tortajada. 2012. Impacts of the High Aswan Dam, Chapter 17. In: C. Tortajada et al. (eds.), Impacts of Large Dams: A Global Assessment. Water Resources Development and Management. Springer-Verlag, Berlin. doi: 10.1007/978-3-642-23571-9_17.

Boehm, P.D., D. Turton, A. Ravel, D. Caudle, D. French, N. Rabalais, R. Spies, and J. Johnson. 2001. Deepwater Program: Literature Review, Environmental Risks of Chemical Products Used in Gulf of Mexico Deepwater Oil and Gas Operations. Vol. 1. Technical Report. OCS Study MMS 2001-011. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Bolten, A.B. and B.E. Witherington (eds.). 2003. Loggerhead Sea Turtles. Smithsonian Books, Washington DC. 319 pp.

Buchman, M.F. 2008. Screening quick reference tables (SQuiRTs). NOAA OR&R Report 08-1. Office of Response and Restoration. Seattle, WA. 34 pp. Accessed 15 January 2025 at https://repository.library.noaa.gov/view/noaa/9327

Bureau of Ocean Energy Management. 2012. Gulf of Mexico OCS Oil and Gas Lease Sales: 2012-2017. Western Planning Area Lease Sales 229, 233, 238, 246, and 248; Central Planning Area Lease Sales 227, 231, 235, 241, and 247. Final Environmental Impact Statement. OCS EIS/EA BOEM 2012-019. July 2012.

Bureau of Ocean Energy Management. 2020. Gulf of Mexico Air Emissions for EP's. Form 0138. Accessed 15 January 2025 at: https://www.boem.gov/BOEM-0138/.

Byles, R.A. 1989. Satellite telemetry of Kemp's ridley sea turtle, *Lepidochelys kempi*, in the Gulf of Mexico, pp. 25-26. In: S.A. Eckert, K.L. Eckert, and T.H. Richardson (comps.), Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. 7-11 February 1989, Jekyll Island, GA. NOAA Technical Memorandum NMFS-SEFC-232. Miami, FL. 306 pp.

Carr, A. and A.B. Meylan. 1980. Evidence of passive migration of green turtle hatchlings in *Sargassum*. Copeia 2:366-368.

Castellote, M., C.W. Clark, and M.O. Lammers. 2010. Potential negative effects in the reproduction and survival on fin whales (*Balaenoptera physalus*) by shipping and airgun noise. International Whaling Commission Report SC/62/E3. Accessed 15 January 2025 at: http://www.researchgate.net/publication/242570491_Potential_negative_effects_in_the_reproduction_and_survival_on_fin_whales_%28_Balaenoptera_physalus_%29_by_shipping_and_airgun_noise.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Continental Shelf Associates, Inc. 2004. Final Report: Gulf of Mexico Comprehensive Synthetic Based Muds Monitoring Program. Report prepared for SBM Research Group, Houston, TX. October 2004. 3 vols.

Continental Shelf Associates, Inc. 2006. Effects of Oil and Gas Exploration and Development at Selected Continental Slope Sites in the Gulf of Mexico. Volume I: Executive Summary; Volume II: Technical Report; Volume III: Appendices. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-044 (51 pp.), 2006-045 (636 pp.), and 2006-046 (938 pp.).

Croghan, C.W. and P.P. Egeghy. 2003. Methods of dealing with values below the limit of detection using SAS. In: SESUG 2003: The Proceedings of the SouthEast SAS Users Group, St. Petersburg Beach, FL. Accessed 15 January 2025 at: http://analytics.ncsu.edu/sesug/2003/SD08-Croghan.pdf.

CSA International, Inc. 2011. Leviathan-3 Wellsite Offshore Israel Video Transect Baseline Survey. Prepared for Noble Energy International Ltd.

CSA International, Inc. 2012. Leviathan-4 Environmental Baseline Survey, Offshore Israel. Prepared for Noble Energy Mediterranean Ltd.

CSA Ocean Sciences Inc. 2013a. Leviathan-2 Monitoring Program Offshore Israel, November 2012 Post-Abandonment Survey. Report submitted to Noble Energy International Ltd. July 2013.

CSA Ocean Sciences Inc. 2013b. Leviathan-4 Environmental Monitoring Program Post-Drill Survey. Prepared for Noble Energy Mediterranean Ltd.

CSA Ocean Sciences Inc. 2014a. Leviathan-2 Monitoring Program, Offshore Israel. February 2014 Post-Abandonment Survey. June 2014. Prepared for Noble Energy Mediterranean Ltd.

CSA Ocean Sciences Inc. 2014b. Leviathan-2 Monitoring Program, Offshore Israel. June 2014 Post-Abandonment Hydrographic Survey. September 2014. Prepared for Noble Energy Mediterranean Ltd.

CSA Ocean Sciences Inc. 2014c. Mitigation and Marine Fauna Observations Conducted for Leviathan Field Development Project, Israel Bathymetric Survey from 26 September to 24 October 2014. Prepared for Noble Energy Mediterranean Ltd. December 2014.

CSA Ocean Sciences Inc. 2015a. Leviathan Field Development Background Monitoring Survey Report: Drilling Component. Prepared for Noble Energy Mediterranean Ltd. 110 pg.

CSA Ocean Sciences Inc. 2015b. Leviathan-2 Monitoring Program, Offshore Israel. January 2015 Post-Abandonment Survey. January 2015. Prepared for Noble Energy Mediterranean Ltd.

CSA Ocean Sciences Inc. 2016. Environmental Impact Report for Production Drilling, Production Tests, and Completion – Leviathan Field. Prepared for Noble Energy International Ltd. 277 pp. + apps.

CSA Ocean Sciences Inc. 2019a. Leviathan-3 Post-Drilling Environmental Survey. Prepared for Noble Energy International Ltd.

CSA Ocean Sciences Inc. 2019b. Leviathan-7 Post-Drilling Environmental Survey. Prepared for Noble Energy International Ltd.

CSA Ocean Sciences Inc. 2023. Leviathan-8 Post-Drilling Environmental Survey. Prepared for Chevron Mediterranean Limited.

Dannheim, J., L. Bergstrom, S.N.R. Birchenough, R. Brzana, A.R. Boon, J.W.P. Coolen, J.-C. Dauvin, I. De Mesel, J. Derweduwen, A.B. Gill, Z.L. Hutchison, A.C. Jackson, U. Janas, G. Martin, A. Raoux, J. Reubens, L. Rostin, J. Vanaverbeke, T.A. Wilding, D. Wilhelmsson, and S. Degraer. 2020. Benthic effects of offshore renewables: identification of knowledge gaps and urgently needed research. ICES Journal of Marine Science 77: 1092-1108.

Dayan, U. and I. Levy. 2002. Relationship between synoptic-scale atmospheric circulation and ozone concentrations over Israel. Journal of Geophysical. Research 107(D24):31/1-31/8.

Dilek, Y. and E. Sandvol. 2009. Seismic structure, crustal architecture and tectonic evolution of the Anatolian-African Plate Boundary and the Cenozoic Orogenic Belts in the Eastern Mediterranean Region. Geological Society, London, Special Publications 327:127-160.

Dinevich, L. and Y. Leshem. 2010. Radar monitoring of seasonal bird migration over central Israel. The Ring 32:1-2.

Douglas, A.B., J. Calambokidis, S. Raverty, S.J. Jeffries, D.M. Lambourn, and S.A. Norman. 2008. Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association UK 88(06):1,121-1,132.

Dow Piniak, W.E., D.A. Mann, S.A. Eckert, and C.A. Harms. 2012. Amphibious hearing in sea turtles, pp. 83-87. In: Popper, A.N. and A. Hawkins (eds.), The Effects of Noise on Aquatic Life. Advances in Experimental Medicine and Biology, Vol. 730. Springer.

DP World. 2023. DP World Limassol Performance 2022 (infographic). Accessed at: https://www.dpworld.com/cyprus/media/news-events/dp-world-limassol-infographic-performance-2022. Accessed: February 2025.

Eckle, P., P. Burgherr, and E. Michaux. 2012. Risk of large oil spills: A statistical analysis in the aftermath of *Deepwater Horizon*. Environmental Science & Technology 46(23):13,002-13,008.

Efroymson, R.A., W.H. Rose, S. Nemeth, and G.W. Suter II. 2000. Ecological Risk Assessment Framework for Low-Altitude Overflights by Fixed-Wing and Rotary-Wing Military Aircraft. ORNL/TM-2000/289. Oak Ridge, TN: Oak Ridge National Laboratory. 115 pp.

Ellison, W.T., B.L. Southall, C.W. Clark, and A. Frankel. 2012. A new context-based paradigm to assess behavioral responses of marine mammals to sound. Conservation Biology 26:21-28.

Fay, R.R. and A.N. Popper. 2000. Evolution of hearing in vertebrates: The inner ears and processing. Hearing Research 149:1-10.

Federal Aviation Administration. 2004. Advisory Circular 91-36D. Visual flight rules (VFR) flight near noise-sensitive areas. September 17, 2004. 2 pp. Accessed 15 January 2025 at: https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/23156.

Flight Safety Foundation. 2016. Basic Aviation Risk Standard, Offshore Helicopter Operations, Safety Performance Requirements. Version 3, December 2016. Flight Safety Foundation, Alexandria, Virginia, US. 221 pp.

Flocas, H.A., I. Simmonds, J. Kouroutzoglou, K. Keay, M. Hatzaki, D. Asimakopoulos, and V. Bricolas. 2010. On cyclonic tracks over the eastern Mediterranean. Journal of Climate 23:5,243-5,257.

Flocas, H.A., I. Simmonds, J. Kouroutzoglou, K. Keay, M. Hatzaki, V. Bricolas, and D. Asimakopoulos. The passage of storms through the Eastern Mediterranean. https://www.wcrp-climate.org/WGNE/BlueBook/2011/individual-articles/02_Flocas_Helena_wgne_2011_east_med_cyclone_tracks_flocas_simmonds_et_al.pdf.

Food and Agriculture Organization of the United Nations. 2023. Fishery and Aquaculture Country Profiles: Israel. The State of Israel – National Fishery Country Profiles. GLOBEFISH Market Profile – 2020. Accessed 15 January 2025 at: https://openknowledge.fao.org/server/api/core/bitstreams/b1b9b12c-0c87-4ab2-b9fa-8ffd3eb2b7a0/content

Fraser, G.S., J. Russell, and W.M. Von Zharen. 2006. Produced water from offshore oil and gas installations on the Grand Banks, Newfoundland and Labrador: Are the potential effects to seabirds sufficiently known? Marine Ornithology 34:147-156.

Froese, R. and D. Pauly (eds.). 2024. FishBase. World Wide Web electronic publication, version 10/2024. Accessed 15 January 2024 at: https://fishbase.mnhn.fr/search.php.

Galil, B.S. 2004. The limit of the sea: the bathyal fauna of the Levantine Sea. Scientia Marina 68:63-72.

Galil, B.S. and M. Goren. 1994. The deep sea Levantine fauna. New records and rare occurrences. Senckenbergiana marit. 25(1/3):41-52.

Gallaway, B.J. and G.S. Lewbel. 1982. The Ecology of Petroleum Platforms in the Northwestern Gulf of Mexico: A Community Profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, DC. FWS/OBS-82/27. 92 pp.

Gallaway, B.J., J.G. Cole, and L.R. Martin. 2008. Platform Debris Fields Associated with the Blue Dolphin (Buccaneer) Gas and Oil Field Artificial Reef Sites Offshore Freeport, Texas: Extent, Composition, and Biological Utilization. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study 2008-048.

Gardosh, M., Z. Garfunkel, Y. Druckman, and B. Buchbinder. 2008. Neotethyan rifting and its role in shaping the Levant Basin and Margin. Annual Meeting Abstracts, Israel Geological Society Annual Meeting, Nazareth, p. 27.

Gardline Surveys Inc. 2010. 3D Geohazard Assessment, Offshore Israel, Leviathan Prospect, June 2010. Prepared for Noble Energy Inc. Gardline Project Ref. 8401. Houston, TX. September 2010.

Gardline Surveys Inc. 2015. Environmental Charts for Noble Energy Inc., Offshore Israel, Leviathan Field. Gardline Project Ref. 8401. Houston, TX. Final Rev2, July 2015.

Garfunkel, Z. 2004. Origin of the Eastern Mediterranean Basin: A Re-evaluation. Tectonophysics 391:11-34.

Genesis Oil and Gas Consultants Ltd. (Genesis). 2016. Environmental Impact Assessment for Installation, Operation and Maintenance of pipelines and Submarine Systems for Leviathan Field Development. July 2016. Prepared for Noble Energy Mediterranean Ltd. Genesis Document No. J20813A-Y-RT-24001 Rev 0.

Geologic Survey of Israel (GSI). 2023. Marine Geohazards Offshore Israel: Geological Information for Infrastructure Design. Final Report submitted for the Ministry of Energy. Report GSI/10/2023. 109 pp.

Geo-prospect Ltd. and Israel Oceanographic and Limnological Research (IOLR). 2016. Offshore Oil and Gas Exploration and Production Strategic Environmental Assessment (SEA). Prepared for the Israel Ministry of National Infrastructure, Energy and Water Resources.

Geraci, J.R. and D.J. St. Aubin. 1987. Effects of offshore oil and gas development on marine mammals and turtles, pp. 587-617. In: D.F. Boesch and N.N. Rabalais (eds.), Long Term Environmental Effects of Offshore Oil and Gas Development. Elsevier Applied Science Publishers Ltd., London and New York.

Geraci, J.R. and D.J. St. Aubin. 1990. Sea Mammals and Oil: Confronting the Risks. Academic Press, San Diego, CA.

Golani, D. 2005. Checklist of the Mediterranean Fishes of Israel. Zootaxa 947. 90 pp.

Golder Associates, ABR, Inc. Environmental Research & Services, and Rolf Bergman Consulting. 2007. Literature Review, Synthesis, and Design of Monitoring of Ambient Artificial Light Intensity on the OCS Regarding Potential Effects on Resident Marine Fauna. Report for the U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, Anchorage, AK. OCS Study MMS 2007-055.

Greene, C.R. 1987. Underwater sounds from the submersible drill rig SEDCO 708 drilling in the Aleutian Islands. American Petroleum Institute. 120 pp.

Greer, R.D., R.H. Day, and R.S. Bergman. 2010. Effects of Ambient Artificial Light on Arctic Marine Fauna. Interaction of Oil and Gas Activities with Sensitive Coastal Habitats, Northern Oil and Gas Research Forum, December 1, 2010.

Haifa Port. 2024. Haifa Port – Our Story. Accessed 15 January 2025 at https://www.haifaport.co.il/en/our-story/.

He, R., A. Tsouvalas, X. Xu, and L. Dong. 2023. Editorial: Noise and vibrations in offshore wind farms and their impact on aquatic species. Front. Mar. Sci. 10:1293733. doi: 10.3389/fmars.2023.1293733.

Higashi, G.R. 1994. Ten years of fish aggregating device (FAD) design and development in Hawaii. Bulletin of Marine Science 55(2-3):651-666.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Holland, K.R., R.W. Brill, and R.K. Chang. 1990. Horizontal and vertical movements of yellowfin and bigeye tuna associated with fish aggregating devices. Fishery Bulletin 88:493-507.

Hsü, K.J., W.B. Ryan, and M.B. Cita. 1973. Late Miocene dessication of the Mediterranean. Nature 242:240-244.

International Association of Oil & Gas Producers. 2010. Risk assessment data directory: Blowout frequencies. IAGP Report No. 434-2. March 2010.

International Bird Rescue. 2014. How oil affects birds. Accessed 15 January 2025 at: https://www.birdrescue.org/our-work/research-and-innovation/how-oil-affects-birds/.

International Maritime Organization. 2004. International Convention for the Control and Management of Ship's Ballast Water and Sediments (BWM).

International Organization for Standardization. 2004. ISO 14001. Environmental Management Systems – Requirements with Guidance for Use. Reference No. ISO 14001.2004(E).

International Union for Conservation of Nature (IUCN). 2025. The IUCN Red List of Threatened Species. Version 2024-2. Accessed 15 January 2025 at: http://www.iucnredlist.org.

IPIECA and International Association of Oil & Gas Producers. 2024. Invasive alien species and the energy industry: Guidance for prevention and management. Accessed 15 January 2025 at https://www.ipieca.org/resources/invasive-alien-species-and-the-energy-industry.

Israel Oceanographic and Limnological Research (IOLR). 2015. Strategic Environmental Survey for Exploration and Production of Oil and Natural Gas at Sea. Part C. Report H20/2015.

Jacquet, N., S. Dawson, and E. Slooten. 1998. Diving behaviour of male sperm whales: foraging implications. International Whaling Commission, Scientific Committee Doc. SC/50/CAWS 38. 20 pp.

Kallos, G., P. Kassomenos, and R.A. Pielke. 1993. Synoptic and mesoscale weather conditions during air pollution episodes in Athens, Greece. Boundary-Layer Meteorology 62:163-184.

Kassomenos, P., V. Kotroni, and G. Kallos. 1995. Analysis of climatological and air quality observations from Greater Athens Area. Atmospheric Environment 29:3,671-3,688.

Keinath, J.A. and J.A. Musick. 1993. Movements and diving behavior of a leatherback turtle, *Dermochelys coriacea*. Copeia 1993(4):1,010-1,017.

Keinath, J.A., J.A. Musick, and D.E. Barnard. 1996. Abundance and Distribution of Sea Turtles off North Carolina. Prepared for the U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 95-0024. 156 pp.

Kelletat, D. and G. Schellmann. 2002. Tsunamis on Cyprus: field evidences and 14C-dating results. Zeitschrift f. Geomorphologie NF 46(1):19-34.

Kerem, D., N. Hadar, O. Goffman, A. Scheinin, R. Kent, O. Boisseau, and U. Schattner. 2012. Update on the cetacean fauna of the Mediterranean Levantine Basin. Open Marine Biology Journal 6:6-27.

Kress, N., A. Golik, B. Galil, and M.D. Krom. 1993. Monitoring the disposal of coal fly ash at a deep water site in the eastern Mediterranean Sea. Mar. Poll. Bull. 26(8):447-456.

Kröncke, I., M. Türkay, and D. Fiege. 2003. Macrofauna communities in the eastern Mediterranean deep sea. Marine Ecology 24(3):193-216.

Ladewig, B. and B. Asquith. 2012. Desalination Concentrate Management. Springer, New York. 57 pp.

Laist, D.W. 1996. Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestions records, pp. 99-139. In: J.M. Coe and D.R. Rogers (eds.), Marine Debris: Sources, Impacts, and Solutions. Springer-Verlag, New York.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17:35-75.

Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2012. Hearing capabilities of loggerhead sea turtles (*Caretta caretta*) throughout ontogeny, pp. 89-92. In: A.N. Popper and A.D. Hawkins (eds.), The Effects of Noise on Aquatic Life. Springer Science + Business Media, LLC, New York.

Leshem, Y. and I. Atrash. 1998. Palestine-Israel: A crossroad for bird migration. Palestine-Israel Journal 5(1).

Levy, Y. 2011. Summary of recovery actions for sea turtle populations in the Mediterranean Sea. Israel Nature and Parks Authority.

Lohoefener, R., W. Hoggard, K. Mullin, C. Roden, and C. Rogers. 1990. Association of Sea Turtles with Petroleum Platforms in the North-central Gulf of Mexico. OCS Study/MMS 90-0025. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Regional Office, New Orleans, LA.

Lovell, S.J. and S.F. Stone. 2005. The Economic Impacts of Invasive Species: A Review of the Literature. National Center for Environmental Economics, Working Paper #05-02. January 2005.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival, pp. 387-410. In: P.L. Lutz and J.A. Musick (eds.), The Biology of Sea Turtles. CRC Press, Boca Raton, FL. 432 pp.

Makris, J., Z. Ben-Avraham, A. Behle, A. Ginzburg, P. Giese, L. Steinmetz, R.B. Whitmarsh, and S. Eleftheriou. 1983. Seismic Refraction Profiles between Cyprus and Israel and their Interpretation. Geophysical Journal of the Royal Astronomical Society 75:575-591.

Martin, K.J., S.C. Alessi, J.C. Gaspard, A.D. Tucker, G.B. Bauer, and D.A. Mann. 2012. Underwater hearing in the loggerhead turtle (*Caretta caretta*): a comparison of behavioural and auditory evoked potential audiograms. Journal of Experimental Biology 215:3,001-3,009.

Malanotte-Rizzoli, P. and A. Bergamasco. 1991. The wind and thermally driven circulation of the eastern Mediterranean Sea. Part II: the baroclinic case. Dynamics of Atmospheres and Oceans 15:355-419.

Mandel, M., P. Alpert, and I. Osetinsky. 2006. Assessing the eastern Mediterranean mesoscale circulation by clustering the daily weather. The Annual Meeting of Israel Meteorological Society, 23 March 2006, Basel Hotel, Tel Aviv.

Marangoni, L.F.B., T. Smyth, A. Rodríguez, M. Hamann, C. Duarte, K. Pendoley, J. Berge, E. Maggi, and O. Levy. 2022. Impacts of artificial light at night in marine ecosystems - a review. Global Change Biology 28: 5346-5367. doi: 10.1111/gcb.16264.

Marine Mammal Commission. 2012. Annual Report to Congress, 2012. Accessed 15 January 2025 at: https://www.mmc.gov/wp-content/uploads/annualreport_2012.pdf.

Marine Ventures International, Inc. 2017. Environmental Impact Document, Leviathan Development Drilling EIA - Amendment. 301 pp.

Marine Ventures International, Inc. 2018. Leviathan Field Development Project: Pockmarks ROV Survey. Prepared for Noble Energy Mediterranean Ltd.

Marine Ventures International, Inc. 2019. Leviathan-3 Post-Drilling Environmental Survey. Prepared for Noble Energy Mediterranean Ltd.

Marine Ventures International, Inc. 2021a. Environmental Assessment for the Mari-B, Noa, and Pinnacles Plug and Abandonment Program, Offshore Israel. March 2021. Prepared for Noble Energy Mediterranean Ltd. 462 pp. + appendices.

Marine Ventures International, Inc. 2021b. Environmental Monitoring Program Leviathan Field, Offshore Israel: December 2020 Marine environmental monitoring report. Prepared for Noble Energy Mediterranean Ltd.

Martinez, J.F., J. Cartwright, and B. Hall. 2005. 3D seismic interpretation of slump complexes: examples from the continental margin of Israel. Basin Research 17:83-108.

Mascle, J., O. Sardou, L. Loncke, M. Sebastien, L. Caméra, and V. Gaullier. 2006. Morphostructure of the Egyptian continental margin: insights from swath bathymetry surveys. Marine Geophysical Research 27:49-59.

McDonald, M.A., J.A. Hildebrand, and S.M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America 120(2):711-718.

McKenna, M.F., D. Ross, S.M. Wiggins, and J.A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. Journal of the Acoustical Society of America 131(1):92-103.

Meral Ozel, N., N. Ocal, Y.A. Cevdet, D. Kalafat, and M. Erdik. 2011. Tsunami hazard in the eastern Mediterranean and its connected seas: toward a tsunami warning center in Turkey. Soil Dynamics and Earthquake Engineering 31(4):598-610.

Miles, P.R., C.I. Malme, and W.J. Richardson. 1987. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea. Contract No. 14 12-0001-30295. Report No. 6509. OCS Study MMS 87-0084.

Millero, F.J. 2005. Chemical Oceanography. Third Edition. CRC Press, Boca Raton FL. 520 pp.

Milton, S., P. Lutz, and G. Shigenaka. 2003. Oil toxicity and impacts on sea turtles, Chapter 4. In: G. Shigenaka (ed.), Oil and Sea Turtles: Biology, Planning, and Response. National Oceanic and Atmospheric Administration, NOAA Ocean Service, Office of Response and Restoration, Silver Spring, MD.

Minerals Management Service. 2007. Gulf of Mexico OCS Oil and Gas Lease Sales: 2007-2012. Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222. Final Environmental Impact Statement. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region. OCS EIS/EA MMS 2007-018. April 2007.

Ministry of Environmental Protection. 2002. Standards for Environmental Quality of Israel's Mediterranean Coastal Waters. Marine and Coastal Environment Division, State of Israel.

Mission Blue. 2022. New Marine Protected Area Announced in Israels Palmahim Slide Hope Spot. Accessed 15 January 2025 at: https://missionblue.org/2022/09/new-marine-protected-area-in-israel-in-the-palmahim-slide-hope-spot/.

Montevecchi, W.A., F.K. Wiese, G. Davoren, A.W. Diamond, F. Huettmann, and J. Linke. 1999. Seabird Attraction to Offshore Platforms and Seabird Monitoring from Offshore Support Vessels and Other Ships: Literature Review and Monitoring Designs [unpublished report]. Report No. 138. Environmental Studies Research Funds, Calgary, Canada. 56 pp.

Mudge, T.D. and J. Lawrence. 2014. Waves and Ocean Currents Observations for Leviathan: Data Reports 1-8. Report for Noble Energy, Houston, TX, USA by ALS Environmental Sciences Inc., Victoria, BC, Canada

National Marine Fisheries Service (NMFS). 1991. Final Recovery Plan for the Humpback Whale (*Megaptera novaeangliae*). Prepared by the Humpback Whale Recovery Team for the National Marine Fisheries Service, Silver Spring, MD. 105 pp.

National Marine Fisheries Service (NMFS). 2007. Endangered Species Act, Section 7 Consultation – Biological Opinion. Gulf of Mexico Oil and Gas Activities: Five-Year Leasing Plan for Western and Central Planning Areas 2007-2012.

National Marine Fisheries Service (NMFS). 2010. Final Recovery Plan for the Sperm Whale (*Physeter macrocephalus*). Silver Spring, MD. 165 pp. Accessed 15 January 2025 at: https://repository.library.noaa.gov/view/noaa/15976.

National Marine Fisheries Service (NMFS). 2024. 2024 Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0); Underwater and In-Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. NOAA Technical Memorandum NMFS-OPR-71 October 2024. 193 pp.

National Oceanic and Atmospheric Administration, Office of Response and Restoration, Marine Debris Program. 2024. Why is Marine Debris a Problem? Accessed 15 January 2025 at https://marinedebris.noaa.gov/discover-marine-debris/why-marine-debris-problem.

National Oceanic and Atmospheric Administration. 2023. Small Diesel Spills (500-5,000 gallons). NOAA. National Ocean Service. Office of Response and Restoration. 3 pp.

National Oceanic and Atmospheric Administration. 2010. Characteristic Coastal Habitats: Choosing Spill Response alternatives. Revised 2010, reprinted March 2017. Accessed 15 January 2025 at: http://response.restoration.noaa.gov/sites/default/files/Characteristic_Coastal_Habitats.pdf.

National Oceanic and Atmospheric Administration. 2014. ESI Shoreline Types. Accessed 15 January 2025 at: http://response.restoration.noaa.gov/esi-shoreline-types.

National Research Council. 1983. Drilling Discharges in the Marine Environment. National Academy Press, Washington, DC. 180 pp.

National Research Council. 1990. Decline of the Sea Turtles: Causes and Prevention. National Academy Press, Washington, DC. 259 pp.

National Research Council. 2003. Ocean Noise and Marine Mammals. Washington, DC: National Academies Press. 151 pp. + app. Accessed 15 January 2025 at http://www.nap.edu/openbook.php?isbn=0309085365.

National Research Council. 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects. Washington, DC: The National Academies Press. 99 pp. + apps. Accessed 15 January 2025 at: http://www.nap.edu/openbook.php?record_id=11147&page=1.

National Research Council. 2008. Tackling Marine Debris in the 21st Century. National Academies Press, Washington, DC. 218 pp.

Natural Resources Administration, Ministry of Energy. 2025. Leviathan Expansion Project Environmental Impact Assessment Guidelines. 19 pp.

Neff, J.M. 1987. Biological effects of drilling fluids, drill cuttings and produced waters, pp. 469-538. In: D.F. Boesch and N.N. Rabalais (eds.), Long-Term Effects of Offshore Oil and Gas Development. Elsevier Applied Science Publishers, London.

Neff, J.M., S. McKelvie, and R.C. Ayers, Jr. 2000. Environmental Impacts of Synthetic Based Drilling Fluids. Prepared by Robert Ayers & Associates, Inc. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2000-064. 118 pp.

Neff, J.M. 2005. Composition, Environmental Fates, and Biological Effects of Water Based Drilling Muds and Cuttings Discharged to the Marine Environment: A Synthesis and Annotated Bibliography. Prepared for Petroleum Environmental Research Forum and American Petroleum Institute. Battelle, Duxbury, MA. 83 pp.

Neff, J.M. 2010. Fate and Effects of Water-based Drilling Muds and Cuttings in Cold-water Environments. Prepared by Neff & Associates LLC, Duxbury, MA for Shell Exploration and Production Company, Houston, TX. May 25, 2010. 309 pp.

Notarbartolo di Sciara, G. and A. Birkun, Jr. 2010. Conserving Whales, Dolphins and Porpoises in the Mediterranean and Black Seas: an ACCOBAMS status report, 2010. ACCOBAMS, Monaco. 212 pp.

Ouled-Cheikh, J., M. Coll, L. Cardona, J. Steenbeek, and F. Ramirez. 2022. Fisheries-enhanced pressure on Mediterranean regions and pelagic species already impacted by climate change. Elementa Science of the Anthropocene 10(1):00028. Accessed 15 January 2025 at https://doi.org/10.1525/elementa.2022.00028.

OSPAR Commission. 2012. Report of the OSPAR Workshop on Research into Possible Effects of Regular Platform Lighting on Specific Bird Populations. Agenda Item 5. WKBIRD 12/5/1-E. 13 pp. Accessed 15 January 2025 at: https://www.ospar.org/meetings/archive/workshop-on-research-into-the-possible-effects-of-regular-platform-lighting-on-specific-bird-populations.

Özbakir, A.D., R. Wortel, and R. Govers. 2010. The nature and location of the plate boundary between the Anatolian and African plates. Geophysical Research Abstracts 12. EGU2010-4366.

Pace, R.M. 2011. Frequency of Whale and Vessel Collisions on the U.S. Eastern Seaboard: Ten Years Prior and Two Years Post Ship Strike Rule. U.S. Dept. of Commerce, Northeast Fisheries Science Center, Ref Doc. 11-15. 12 pp.

Pareto Engineering Ltd. 2006. Sensitivity Analysis of Israel's Coastlines to Oil Pollution. Report for the Ministry of Environmental Protection. December 2006.

Payne, R. and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Annals of the New York Academy of Sciences 188:110-142.

Peabody, M.B. and C.A. Wilson. 2006. Fidelity of Red Snapper (*Lutjanus campechanus*) to Petroleum Platforms and Artificial Reefs in the Northern Gulf of Mexico. Final Report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-005. 66 pp.

Pinardi, N. and E. Masetti. 2000. Variability of the large scale general circulation of the Mediterranean Sea from observations and modelling: a review. Palaeogeography, Palaeoclimatology, Palaeoecology 158:53-173.

Polovina, J.J., E. Howell, D.M. Parker, and G.H. Balazs. 2003. Dive-depth distribution of loggerhead (*Carretta carretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin 101:189-193.

Poot, H., B.J. Ens, H. de Vries, M.A.H. Donners, M.R. Wernand, and J.M. Marquenie. 2008. Green light for nocturnally migrating birds. Ecology and Society 13(2):47.

Popper, A.N. and M.C. Hastings. 2009a. The effects on fish of human-generated (anthropogenic) sound. Integrative Zoology 4:43-52.

Popper, A.N. and M.C. Hastings. 2009b. Effects of anthropogenic sources of sound on fishes. Journal of Fish Biology 75:455-498.

Popper, A.N. and A. Hawkins (eds.). 2012. The Effects of Noise on Aquatic Life. Springer Science + Business Media, LLC, New York.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, M.B. Halvorsen, S. Løkkeborg, P.H. Rogers, B.L. Southall, D.G. Zeddies, and W.N. Tavolga. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA S3/SC1.4 TR-2014. ASA Press and Springer, New York.

Potter, J.R., T.W. Lim, and M. Chitre. 1997. Ambient noise environments in shallow tropical seas and the implications for acoustic sensing, pp. 191-199. In: Oceanology International 97 Pacific Rim, Singapore.

Renaud, M.L. and J.A. Carpenter. 1994. Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. Bulletin of Marine Science 55: 1-15.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA. 576 pp.

Ridgway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtle, *Chelonia mydas*. Proceedings of the National Academy of Sciences 64:884-890.

Rindlisbacher, T. and L. Chabbey. 2015. Guidance on the Determination of Helicopter Emissions. Swiss Confederation Federal Office of Civil Aviation (FOCA), Reference: COO.2207.111.2.2015750, Bern, Switzerland.

Roberts, L. and M. Elliott. 2017. Good or bad vibrations? Impacts of anthropogenic vibration on the marine epibenthos. Science of the Total Environment 595: 255-268.

Rohling, E.J., R.H. Abu-Zied, J.S.L. Casford, A. Hayes, and B.A.A. Hoogakker. 2009. The marine environment: present and past, pp. 33-67. In: J.C. Woodward (ed.), The Physical Geography of the Mediterranean. Oxford University Press, Oxford UK.

Rosman, I., G.S. Boland, L.R. Martin, and C.R. Chandler. 1987. Underwater sightings of sea turtles in the northern Gulf of Mexico. U.S. Department of the Interior, Minerals Management Service, OCS Study 87-0107. 37 pp.

Ross, D. 1976. Mechanics of Underwater Noise. Pergamon, New York. 375 pp.

Russell, R.W. 2005. Interactions between Migrating Birds and Offshore Oil and Gas Platforms in the Northern Gulf of Mexico: Final Report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2005-009. 348 pp.

Salamon, A., T. Rockwell, S.N. Ward, E. Guidoboni, and A. Comastri. 2007. Tsunami hazard evaluation of the Eastern Mediterranean: Historical analysis and selected modeling. Bulletin of the Seismological Society of America 97:705-724.

Salmon, M. and J. Wyneken. 1987. Orientation and swimming behavior of hatchling loggerhead turtles *Caretta caretta* L. during their offshore migration. Journal of Experimental Marine Biology and Ecology 109: 137-53.

Salmon, M. and J. Wyneken. 1990. Do swimming loggerhead sea turtles (*Caretta caretta*) use light cues for offshore orientation? Marine and Freshwater Behaviour and Physiology 17(4):233-246.

Schaanning, M.T., H.C. Trannum, T.F. Holth, and S. Øxnevad. 2008a. Trace Metal Mobility and Faunal Effects of Weight Materials in Water-Based Drilling Muds. Report No. OR-5680. Norwegian Institute for Water Research.

Schaanning, M.T., H.C. Trannum, S. Øxnevad, J. Carroll, and T. Bakke. 2008b. Effects of drill cuttings on biogeochemical fluxes and macrobenthos of marine sediments. Journal of Experimental Marine Biology and Ecology 361:49-57

Schwacke, L.H., C.R. Smith, F.I. Townsend, R.S. Wells, L.B. Hart, B.C. Balmer, T.K. Collier, S. De Guise, M.M. Fry, L.J. Guillette, Jr., S.V. Lamb, S.M. Lane, W.E. McFee, N.J. Place, M.C. Tumlin, G.M. Ylitalo, E.S. Zolman, and T.K. Rowles. 2014. Health of Common Bottlenose Dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the *Deepwater Horizon* Oil Spill. Environmental Science & Technology 48(1):93-103.

Shapiro, J. (ed.). 2007. The Fisheries and Aquaculture of Israel. Ministry of Agriculture and Rural Development. Department of Fisheries and Aquaculture. 48 pp.

Shepard, F.P. 1954. Nomenclature based on sediment: H-clay ratios. Journal of Sedimentary Petrology 24:151-158.

Shinn, E.A., B.H. Lidz, and C.D. Reich. 1993. Habitat Impacts of Offshore Drilling: Eastern Gulf of Mexico. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 93-0021. 73 pp.

Smit, M.G.D., K.I.E. Holthaus, H.C. Trannum, J.M. Neff, G. Kjeilen-Eilertsen, R.G. Jak, I. Singsaas, M.A.J. Huijbregts, and A.J. Hendriks. 2008. Species sensitivity distributions for suspended clays, sediment burial, and grain size change in the marine environment. Environmental Toxicology and Chemistry 27(4):1,006-1,012.

Smultea, M.A., J.A. Mobley, Jr., D. Fertl, and G.L. Fulling. 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. Gulf and Caribbean Research 20:75-80.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):411-521.

Southall, B.L. and A. Scholik-Schlomer. 2008. Final report of the NOAA International Conference: Potential Application of Vessel-Quieting Technology on Large Commercial Vessels, 1-2 May 2007, Silver Spring, MD.

Southall, B.L., D.P. Nowacek, P.J. Miller, and P.L. Tyack. 2016. Experimental field studies to measure behavioral responses of cetaceans to sonar. Endangered Species Research 31: 293-315.

Southall B.L., D.P. Nowacek, A.E. Bowles, V. Senigaglia, L. Bejder, and L. Tyack Peter. 2021. Marine mammal noise exposure criteria: assessing the severity of marine mammal behavioral responses to human noise. Aquatic Mammals 47(5):421-464.

Stanton, D.L. and J.R. Cowart. 2024. The effects of artificial light at night (ALAN) on the circadian biology of marine animals. Front. Mar. Sci. 11:1372889. doi: 10.3389/fmars.2024.1372889.

State of Israel. 2021a. Benthic habitats. Three set map series for benthic habitats (plus one map for pelagic habitats). December 2021. Accessed at: Accesssed 15 January 2025 at https://www.gov.il/en/departments/guides/enviromental_info?chapterIndex=3.

State of Israel. 2021b. Benthic habitats vulnerability to oil and gas activities. December 2021. Set of four vulnerability maps. Accessed 15 January, 2025 at: https://www.gov.il/en/departments/guides/enviromental_info?chapterIndex=3.

Tasker, M.L., P. Hope-Jones, B.F. Blake, T.J. Dixon, and A.W. Wallis. 1986. Seabirds associated with oil production platforms in the North Sea. Ringing and Migration 7:7-14

Tom, M. and M. Kanari. 2023. Integrative data system for monitoring biota and natural habitats in the Israeli Eastern Mediterranean marine environment. Environmental Monitoring and Assessment 195: 1068. Accessed 15 January 2025 at https://experience.arcgis.com/experience/40e86605ff4d4e5096ed2c901fec2a2f.

Trannum, H.C., A. Pettersen, and F. Brakstad. 2006. Field Trial at Sleipner Vest Alfa Nord: Effects of Drilling Activities on Benthic Communities. Report No. 411.3041.2. Akvaplan-niva.

Trannum, H.C., H.C. Nilsson, M.T. Schaanning, and S. Øxnevad. 2010. Effects of sedimentation from water-based drill cuttings and natural sediment on benthic macrofaunal community structure and ecosystem processes. Journal of Experimental Marine Biology and Ecology 383:111-121.

Tuxbury, S.M. and M. Salmon. 2005. Competitive interactions between artificial lighting and natural cues during seafinding by hatchling marine turtles. Biological Conservation 121:311-316.

URS Corporation. 2009. Tsunamic Hazard in Israel. Report prepared by Hong Kie Thio, URS Corporation, Pasadena, CA.73 pp.

van de Laar, F. 2007. Green Light to Birds: Investigation into the Effect of Bird-friendly Lighting. NAM Locatie L15-FA-1. December 2007. 23 pp. Accessed 15 January 2025 at: https://tethys.pnnl.gov/sites/default/files/publications/van-de-Laar-2007.pdf.

van Waerebeek, K., A.N. Baker, F. Félix, J. Gedamke, M. Iñiguez, G.P. Sanino, E. Secchi, D. Sutaria, A. van Helden, and Y. Wang 2007. Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals 6(1):43-69

Weatherspark. 2025. Average weather for Haifa, Israel. Accessed 15 January 2025 at: http://weatherspark.com/averages/32339/Haifa-Israel.

Wenz, G.M. 1962. Acoustic ambient noise in the ocean: Spectra and sources. Journal of the Acoustical Society of America 34:1,936-1,956.

Wiese, F.K., W.A. Montevecchi, G.K. Davoren, F. Huettmann, A.W. Diamond, and J. Linke. 2001. Seabirds at risk around offshore oil platforms in the north-west Atlantic. Marine Pollution Bulletin 42(12):1,285-1,290.

Wilson, C.A., A. Pierce, and M.W. Miller. 2003. Rigs and Reefs: A Comparison of the Fish Communities at Two Artificial Reefs, a Production Platform, and a Natural Reef in the Northern Gulf of Mexico. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-009. 95 pp.

Wilson, C.A., M.W. Miller, Y.C. Allen, K.M. Boswell, and D.L. Nieland. 2006. Effects of Depth, Location, and Habitat Type on Relative Abundance and Species Composition of Fishes associated with Petroleum Platforms and Sonnier Bank in the Northern Gulf of Mexico. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-037. 85 pp.

Wilson, D., R. Billings, R. Oommen, and R. Chang. 2007. Year 2005 Gulfwide Emission Inventory Study. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-067. 149 pp.

Witherington, B.E. 1997. The problem of photo pollution for sea turtles and other nocturnal animals, pp. 303-328. In: J.R. Clemmons and R. Buchholz (eds.), Behavioral Approaches to Conservation in the Wild. Cambridge University Press, Cambridge, England.

Wolfson, A., G.R. VanBlaricom, N. Davis, and G.S. Lewbel. 1979. The marine life of an offshore oil platform. Marine Ecology Progress Series 1:81-89.

Ytreberg, E., M. Eriksson, I. Maljutenko, J.-P. Jalkanen, L. Johansson, I.-M. Hassellöv, and L. Granhag. 2020. Environmental impacts of grey water discharge from ships in the Baltic Sea. Marine Pollution Bulletin 152 (2020). doi: 10.1016/j.marpolbul.2020.110891.

Zavatarielli, M. and G.L. Mellor. 1995. A numerical study of the Mediterranean Sea circulation. Journal of Physical Oceanography 25(6):1,384-1,414.

Zelick, R., D. Mann, and A.N. Popper. 1999. Acoustic communication in fishes and frogs, pp. 363-411. In: R.R. Fay and A.N. Popper (eds.), Comparative Hearing: Fish and Amphibians. New York: Springer-Verlag.

Appendices

Appendix A: Guidelines for Preparing the Environmental Impact Assessment in the Israeli Exclusive Economic Zone (EEZ) – Leviathan Expansion Project (09 January 2025)

Appendix B: List of Preparers and Qualifications

Appendix C: Leviathan Field Environmental Baseline Survey Report

Appendix D: Bathymetry and Seafloor Morphology Charts

Appendix E: Mineral Oil-Based Mud Information

Appendix F: Examples of Project Vessels and Helicopter Specifications

Appendix G: Safety Data Sheets

Appendix H: Discharge Ecological Information

Appendix I: Leviathan-8 Drilling Effluent Testing Results

Appendix J: Worst Case Discharge Scenario

Appendix K: Modeling of Drilling Mud and Cuttings Discharges

Appendix L: Israeli Antiquity Authority Approval Letter

Appendix M: Leviathan Field 2020 Monitoring Survey Offshore Israel Scope of Work/Sampling Analysis Plan