Environmental Impact Report for Production Drilling, Production Tests, and Completion – Leviathan Field

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Prepared for:

Noble Energy Mediterranean Ltd
Ackerstein Towers, Building D
12 Abba Eben Boulevard
Herzliya Pituach, Israel 46725

Prepared by:

CSA Ocean Sciences Inc.
8502 SW Kansas Avenue
Stuart, Florida 34997

ENVIRONMENTAL IMPACT REPORT FOR PRODUCTION DRILLING, PRODUCTION TESTS, AND COMPLETION – LEVIATHAN FIELD

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

Noble Energy Mediterranean Ltd (Noble Energy) plans to conduct well drilling and completion activities for gas and condensate production in the Leviathan Field offshore Israel. This Environmental Impact Assessment (EIA) was prepared for the Ministry of National Infrastructures, Energy and Water Resources (MNIEWR) and the Ministry of Environmental Protection (MoEP) in accordance with the "Guidelines for Preparation of Environmental Impact Document for Production Drilling, Production Tests and Completion – Development of Leviathan Field (Leases I/14 and I/15)" dated 5 October 2014.

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 (**Figure ES-1**) in the Mediterranean Sea at a water depth of 1,540 to 1,800 m (**Figure ES-2**). The Application Area consists of the entire Leviathan Field, including the water column, seafloor, subseafloor, and any proposed or future drillsites within the field.

ES.2 PROJECT DESCRIPTION

Drilling and Completion Locations

Noble Energy's development plan includes the drilling and completion of up to 29 wells for full field depletion. The final number and locations of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and future appraisal. If a final well location is changed due to these factors, a revised map will be submitted by Noble Energy.

Eight wellsites were selected for the initial drilling and completion activities (**Figure ES-2**). Noble Energy plans to drill and complete six new wells (Leviathan-5 through Leviathan-10), drill a second sidetrack (ST02) of the existing Leviathan-3 well, and complete the existing Leviathan-4 ST01 sidetrack well for a total of eight early producers.

Drilling Rigs and Schedule

Two drilling rigs will be needed to conduct the initial drilling and completion operations. One rig will drill the wells, and the second rig will perform the well completions. Noble Energy has not selected specific drilling rigs but plans to use a dynamic positioning (DP) drillship or DP semisubmersible.

The total time for drilling and completing the initial eight wells is estimated to be 556 days. Drilling operations by the first drilling rig will require an estimated 480 days. The completion operations by the second drilling rig will require an estimated 320 days. There will be a period of approximately 236 days during which both drilling rigs will be operating in the Leviathan Field.

The drilling program will be supported by two supply vessels operating out of the port of Haifa. Helicopter support will operate out of Haifa Airport.

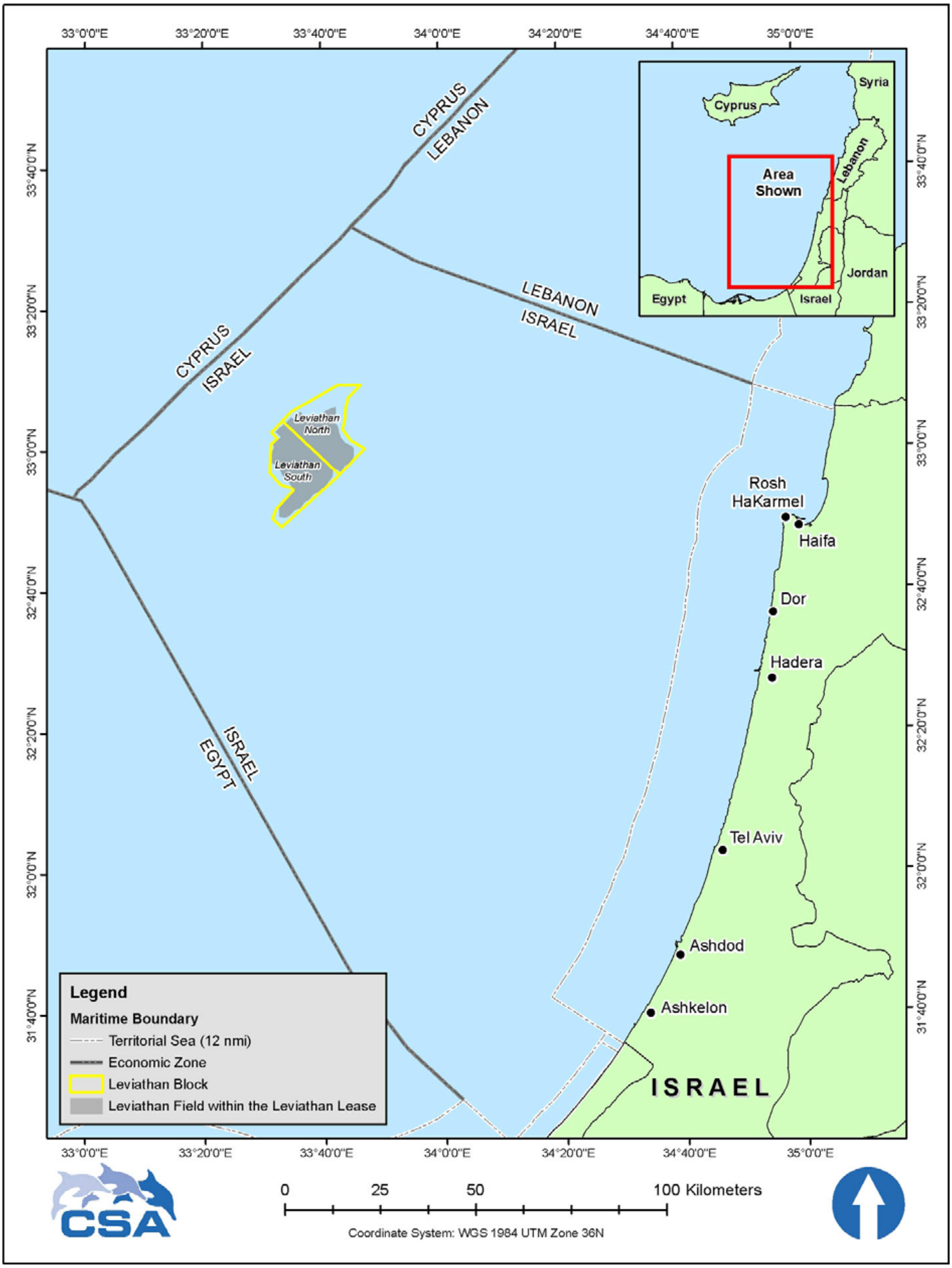

Figure ES-1. Location of the Leviathan Field, offshore Israel.

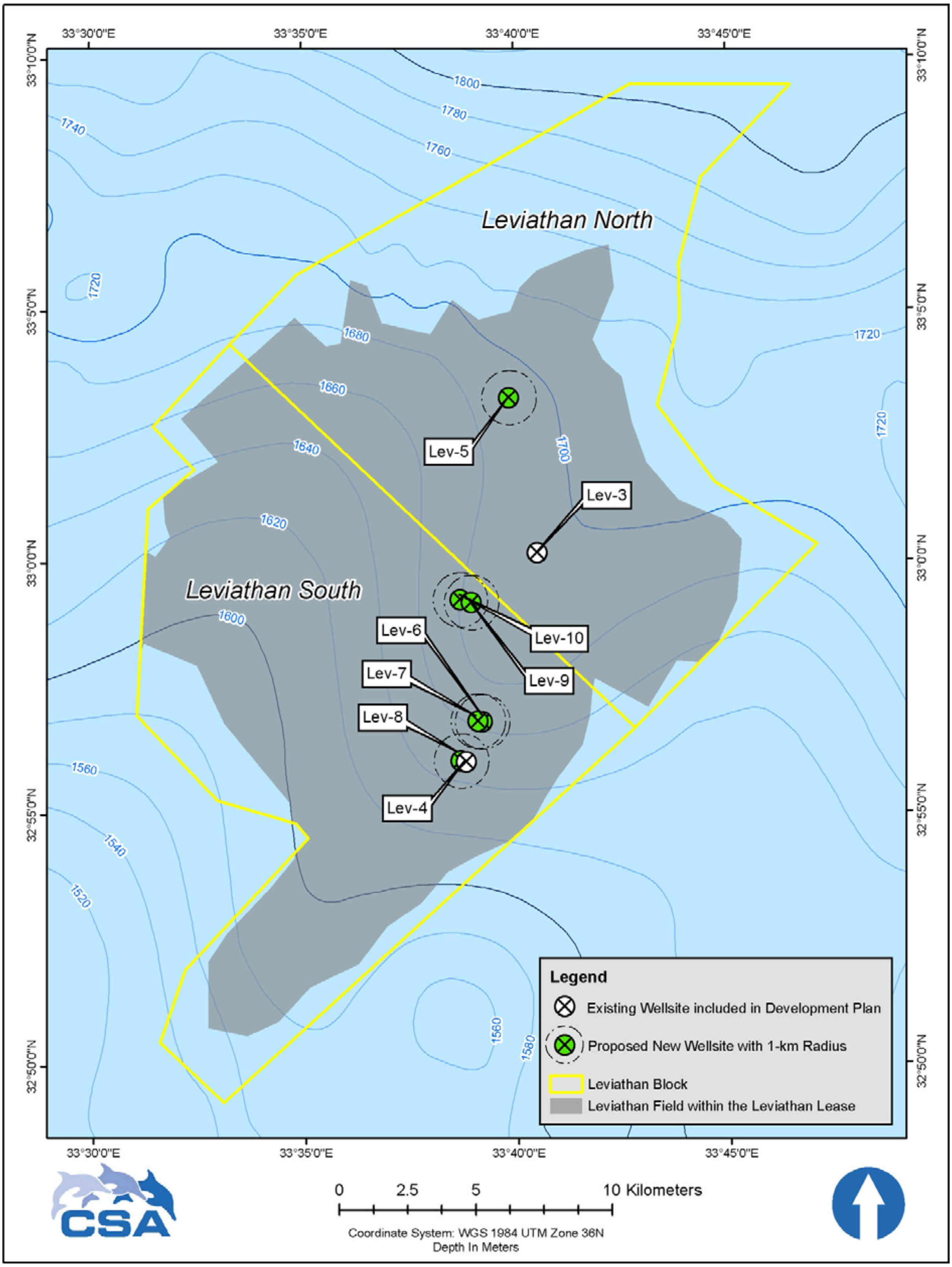

Figure ES–2. Schematic locations of initial wellsites included in the Leviathan Field Development Plan (final surface locations may change).

Safe Drilling Practices and Oil Spill Contingency Plan

Best industry practice will be used during all drilling phases.

After each new well is drilled, it will be temporarily abandoned and secured with multiple barriers pending completion operations by the second drilling rig. Temporary abandonment will be conducted in accordance with MNIEWR guidelines.

Noble Energy's Oil Spill Contingency Plan (OSCP) provides detailed information about the response capabilities and methods that Noble Energy would use to minimize the potential for significant impacts in the event of a spill. The OSCP includes the following elements:

- Procedures for assessing and monitoring an unintentional release and for predicting its movement in the marine environment;
- Identification of resources at risk;
- Waste and debris removal and disposal procedures;
- Dispersant use and monitoring plan;
- Incident reporting and notification procedures;
- Response team organization;
- Required equipment, supplies, and services, and their availability; and
- Training and exercise procedures.

The OSCP contains detailed information concerning three levels of incident response from local (Tier 1), to regional (Tier 2), to national/international (Tier 3). This classification is in alignment with the IPIECA (formerly International Petroleum Industry Environmental Conservation Association) Guide to Tiered Preparedness and Response.

Drilling and Completion Discharges

Noble Energy plans to drill the new wells (Leviathan-5 through Leviathan-10) using a combination of water-based mud (WBM) and mineral oil-based mud (MOBM). For the two initial sections (before riser installetion) WBM will be used and the rest of the drill will be completed by MOBM. The Leviathan-3 sidetrack well (Leviathan-3 ST02) would be drilled with WBM only. Completion of the Leviathan-4 ST01 well will not require additional drilling muds.

[redacted]

Noble Energy will conduct testing to verify that TCC-treated cuttings comply with the 1% retention on cuttings limit in accordance with OSPAR Decision 2000/3. The analytical methodology will be agreed upon with the MNIEWR. In addition, chemical testing of drilling muds will be conducted in compliance with discharge permit requirements.

Other Discharges and Wastes

Other routine discharges from the drilling rigs will include sanitary waste, gray water, organic (food) waste, cooling water, desalination brine, and deck drainage (runoff). All discharges will be consistent with best industry practice and in compliance with applicable standards including the International Convention for the Prevention of Pollution from Ships (MARPOL).

All wastes will be handled and disposed of according to MARPOL and permit requirements. Wastes that cannot be discharged overboard under MARPOL requirements will be shipped to authorized waste disposal sites on shore in accordance with regulations. All hazardous chemicals will be handled in accordance with the guidelines specified in their Safety Data Sheets, as integrated into the drilling rig operator's guidelines for handling hazardous materials.

Alternatives

Noble Energy evaluated well location alternatives and various technological alternatives, including types of drilling rigs, drilling technology, the drilling mud program, and cuttings treatment technology. **Table ES-1** summarizes the location and technology alternatives evaluated by Noble Energy.

Table ES-1. Summary of location and technological alternatives evaluated for the Leviathan Field drilling and completion activities.

<table>
<tr><th>Subject</th><th>Proposed Action</th><th colspan="2">Alternatives Evaluated and Ratings</th><th>Reference</th></tr>
<tr><td>Well locations</td><td>Noble Energy's development plan includes the drilling and completion of up to 29 wells in the Leviathan Field. Eight well locations are proposed for the initial development. The final number and locations of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and future appraisal.</td><td colspan="2">RATING: Acceptable
Noble Energy considered alternate placement of wells and larger and smaller total numbers of wells to develop the field. The number and location of initial wells were selected to satisfy early production needs, provide optimal drainage of gas, and provide reservoir surveillance. Table 2-2 summarizes the factors considered. Initial well locations were 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.</td><td>Section 2.2
Section 3.2</td></tr>
<tr><td>Type of drilling rig</td><td>Two drilling rigs are required (one for drilling and one for well completions). Due to the water depths in the Leviathan Field, Noble Energy plans to use a dynamically positioned (DP) drillship or semisubmersible. Drilling rigs have not been selected but Noble Energy has issued detailed specifications.</td><td>DP Drillship or DP Semisubmersible
RATING: Acceptable
A DP drillship or semisubmersible can meet Noble Energy's specifications.</td><td>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.</td><td>Section 3.2.2</td></tr>
<tr><td>Drilling technology</td><td>The initial drilling plan includes vertical and sidetrack (directional) wells. The new wells (Leviathan-5 through Leviathan-10) are planned as vertical wells where possible but directional where required to avoid shallow hazards. A directional pilot hole will be drilled to total depth, the reservoir will be evaluated, and the wellbore will be sidetracked back to vertical, offsetting the original wellbore, down to the top of the reservoir, as required. Key drilling technologies include rotary steerable systems, polycrystalline diamond compact bits, modular mud motors, near-bit sensors, measurement while drilling, and logging while drilling.</td><td colspan="2">RATING: Acceptable
The design of individual wells was based on Noble Energy's evaluation of reservoirs and is intended to satisfy early production needs, result in optimal drainage of gas, and provide reservoir surveillance. Drilling technologies were selected based on Noble Energy's experience as most suitable for the safety and efficiency of the drilling program.</td><td>Section 3.2</td></tr>
<tr><td>Drilling mud selection</td><td>Noble Energy plans to use a combination of water-based mud (WBM) and mineral oil-based mud (MOBM). [redacted]</td><td>WBM and MOBM Combination:
RATING: Acceptable
This alternative will allow Noble Energy 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. [redacted] highly refined product with low toxicity and very low aromatic content; it is readily biodegradable and not expected to exhibit chronic toxicity to marine organisms.</td><td>WBM Only:
RATING: Less Suitable
Using WBM exclusively would be less efficient, extend drilling time, and would require the use of numerous specialty chemicals.</td><td>Section 2.3.3
Section 3.7.2
Appendix G</td></tr>
</table>

Table ES-3. (Continued).

Subject	Proposed Action	Alternatives Evaluated and Ratings			Reference
Cuttings treatment and disposal	Noble Energy proposes to discharge cuttings to the ocean at the drillsites. Cuttings from MOBM well intervals will be treated in a thermomechanical cuttings cleaner (TCC) on board the drilling rig to reduce the MOBM retention on cuttings to less than 1% by dry weight in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3).	**Offshore Disposal RATING: Acceptable** The proposed offshore disposal of TCC-treated cuttings to the ocean at the drillsites, subject to MNIEWR approval, is the most efficient alternative and meets Noble Energy's environmental goals by reducing the retention on cuttings to less than 1% in accordance with OSPAR guidelines.	**Onshore Disposal RATING: Less Suitable** This would entail an energy cost that would add to the environmental footprint of the project. The cuttings would need to be disposed at the Ramat Havav. The cuttings would contribute to filling up the Ramat Havav facility.	**Cuttings Reinjection: RATING: Not Feasible** Reinjection requires a dedicated well that has the ability to absorb the residual slurry. During drilling, such wells generally are not available because they need a continuous flow of materials to make them feasible. Additionally, high solids content of injected material makes it difficult to keep such wells operational.	Section 2.3.3 Section 3.7.2 Appendix F
Blowout preventer (BOP) technology	Detailed BOP specifications will depend on the drilling rig. Noble Energy's rig tender included the following specifications: 1) minimum well control equipment rated at 10,000 psi capacity; and 2) 18¾-inch BOP system with dual annulars and four ram-type preventers. Noble Energy and the rig's owner will engage in a comprehensive inspection and testing of the rig's subsea BOP system to ensure compliance with the U.S. Bureau of Safety and Environmental Enforcement (BSEE).	**RATING: Acceptable** The BOP specifications which were selected are based on best industry practice and reflect Noble Energy's commitment to safety throughout the drilling program.			Section 3.2.5

ES.3 DESCRIPTION OF THE CURRENT MARITIME ENVIRONMENT

The EIA describes the maritime environment of the Leviathan Field based on published literature from the region and site-specific data from a background monitoring survey conducted in accordance with guidelines issued by the MNIEWR and MoEP. A regional perspective was provided by calculating Levantine Basin Baseline values for many of the parameters measured during the Background Monitoring Survey. The Levantine Basin Baseline is the mean of all unaffected (pre-drilling) samples from the region.

Meteorology, Air Quality, and Noise

The EIA uses regional data to describe representative meteorological conditions in the Leviathan Field. Israel's subtropical location generally brings long, hot, dry summers and short, cool, rainy winters, as modified locally by altitude and latitude. Because the Leviathan Field is more than 100 km from the coastline and urban areas of Israel, air quality is expected to be good. The major pollutant sources of anthropogenic origin in the Mediterranean region are located in central and southern Europe, with minor contribution from North Africa and the Middle East. There are no known special meteorological conditions that might cause conditions of dispersal that would give rise to high air pollution concentrations in the Application Area.

The most likely dominant source of ambient underwater noise in the Leviathan Field is shipping. Shipping noise is ubiquitous in the world's oceans and is the dominant source of underwater noise at frequencies below 300 Hz in many areas. The Eastern Mediterranean region is one of the busiest sea routes in the world, with a number of high-volume port facilities and crowded shipping lanes.

Oceanography and Hydrography

The Leviathan Field is located in the eastern Mediterranean Sea, where the deepwater environment is characterized by relatively high salinity, low turbidity, low nutrients, and high dissolved oxygen. The yearly ranges for surface salinity and temperature in the eastern Mediterranean Sea are approximately 39.0 to 39.5 and 17°C to 28°C, respectively. Salinity remains fairly constant with depth, while temperature decreases with depth to 14°C to 17°C. The entire water column is well oxygenated; even the deep waters (e.g., 1,000 m depth) have saturation values greater than 70% to 80%. Dissolved oxygen concentrations generally range from approximately 4.8 mg/L at the surface, increasing to 5.4 mg/L through the surface-mixed layer, and gradually stabilizing to 4.1 mg/L for the remainder of the water column to the seafloor. Hydrographic data collected during the Background Monitoring Survey are consistent with and typical of deepwater conditions in the eastern Mediterranean Sea.

Seawater Quality

Based on the Background Monitoring Survey and data from previous surveys in the Levantine Basin, seawater in the Leviathan Field has low nutrient concentrations, metal concentrations that are below detection limits or below the relevant criteria and standards, concentrations of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) that are below detection limits, and radionuclide concentrations that are below the U.S. Environmental Protection Agency (USEPA) established maximum contaminant levels.

Sediment Quality

Sediment sampling was conducted at 79 stations in the Leviathan Field during the Background Monitoring Survey. Sediment samples were analyzed for grain size, total organic carbon (TOC), metals, hydrocarbons (TPH and PAHs), radionuclides, and polychlorinated biphenyls (PCBs). Data are also available from previous surveys. The findings are summarized as follows:

- Seafloor sediments in the Leviathan Field are mainly clay and silt, except for sediments near two previous wellsites (Leviathan-2 and Leviathan-4), which had higher percentages of sand.
- Sediment TOC concentrations were low and uniform (0.43% ± 0.05%) throughout the Leviathan Field.
- Concentrations of most metals (aluminum, arsenic, beryllium, chromium, copper, iron, mercury, nickel, vanadium, and zinc) were within the upper 99% confidence limit of the Levantine Basin Baseline.
- Barium concentrations were elevated near two wellsites due to barite, an environmentaly inert substance that is used in drilling mud. Away from these two wellsites, barium concentrations ranged from 113 to 375 parts per million (ppm) and were within the upper 99% confidence limit of the Levantine Basin Baseline.
- Cadmium concentrations were slightly elevated at various locations throughout the field when compared to the upper 99% confidence limit of the Levantine Basin Baseline. Elevated concentrations near two wellsites may be due to drilling muds as cadmium is a component of drilling mud barite. However, other areas of elevated cadmium concentrations were far from drilling activities and patchy in distribution, indicating that at least some of the elevated values may be due to natural variations.
- Lead concentrations generally were within the 99% confidence limit of the Levantine Basin Baseline, with the exception of locations near two wellsites. Lead is a component of drilling mud barite and has been found in cuttings, so its presence near the previous wellsites may be related to drilling activities.
- Sediment TPH concentrations within the Leviathan Field ranged from 4.0 to 27.1 ppm and were within the 99% confidence limit of the Levantine Basin Baseline.

- Total PAH concentrations within the Leviathan Field were 72.9 ± 45.4 parts per billion (ppb) (mean ± standard deviation) and were within the 99% confidence limit for the Levantine Basin Baseline.
- Radionuclide concentrations (radium and thorium) generally were similar to the Levantine Basin Baseline concentrations, with all but one sample being within the upper 99% confidence limit.
- PCBs were not detected in the sediment samples analyzed from the Leviathan Field.

Geology and Geohazards

Water depth in the Leviathan Field varies from 1,540 m in the south to 1,800 m in the north. Seafloor gradients average approximately 2° and locally increase to more than 15° on the flanks of seafloor drainage channels and seafloor ridges. The seafloor in the Leviathan Field consists primarily of soft sediments (clay and silt with localized sand). No rocky substrates or hard bottom outcrops were observed within the survey area.

Gardline Surveys Inc. conducted an area-wide geohazard assessment of the Leviathan Field. That assessment was one of the screening tools used by the Subsurface Team for early screening of well locations. Subsequently, none of the locations proposed in the current study have significant problems according to Gardline evaluations. With careful pre-screening of potential locations and casing design, the potential issues noted in the geohazards assessment have been avoided during well siting and the design of the drilling program.

Benthic Communities

Soft bottom assemblages are composed of biota (typically fauna in depths below the photic zone) living within the sediments (infauna) and on the sediment surface (epifauna). Several studies have documented the composition of these communities in the general area of the Leviathan Field. These studies, as well as other Noble Energy surveys, have shown that infauna and epifauna generally are in low abundance compared to nearshore environments. During the Background Monitoring Survey, infaunal density averaged 107 individuals/m^2 and was generally within the 99% confidence limit of the Levantine Basin Baseline. The dominant phyla were Annelida and Arthropoda, which composed 63.59% and 25.87% of the total fauna, respectively. No hard bottom outcroppings or deepwater coral communities were observed during the visual survey of sites located within the Leviathan Field.

Marine Mammals, Sea Turtles, and Birds

There are no site-specific marine mammal data from the Leviathan Field. However, based on a literature review, several marine mammal species may be present. Small cetacean species that are considered regular species or visitors in the Levantine Basin include the common bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphus*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), striped dolphin (*Stenella coeruleoalba*), and false killer whale (*Pseudorca crassidens*). Large cetaceans that are considered regular residents or visitors in the Levantine Basin include the fin whale (*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), and sperm whale (*Physeter macrocephalus*).

There are no site-specific sea turtle data from the Leviathan Field. However, based on a literature review, three sea turtle species are known to occur in the Levantine Basin: green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*). The loggerhead and green turtles are listed as endangered by the International Union for Conservation of Nature (IUCN), and leatherback turtles are listed as vulnerable. The hawksbill turtle (*Eretmochelys imbricata*), a critically endangered species, also occurs occasionally in the Mediterranean Sea but would not be expected within the Levantine Basin.

There are no site-specific bird data from the Leviathan Field. However, the Mediterranean is home to several hundred bird species, many of which could occur in the area. This discussion includes seabirds as well as migratory birds that pass through the area. Because the Leviathan Field is more than 100 km offshore, the avifauna is likely to consist mainly of pelagic seabirds – those that spend most of their life cycle in the marine environment, often far offshore over the open ocean. Examples of pelagic seabirds 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*). Other seabirds, including various species of gulls, terns, pelicans, and cormorants, could occur in the Leviathan Field but are likely to be more abundant in coastal waters.

Fishes, Fishing, and Marine Farming

The Mediterranean Sea supports more than 700 fish species. There are 636 marine fish species reported from Israeli waters, including 582 natives and 54 introduced species. The distribution of these species varies in relation to hydrography, physiography, and environmental factors over multiple basins and ridges that shape the Mediterranean Sea. A broad pattern within the Mediterranean Sea is that the number of species decreases from west to east. This gradient of richness is thought to be correlated with gradients of increasing temperature and salinity and decreasing productivity. The waters of the Levantine Basin are considered oligotrophic (nutrient-starved) and do not support particularly rich fisheries.

No fishing areas are known within the Leviathan Field due to water depth and distance from shore.

Culture and Heritage Sites

Noble Energy contracted Geoscience Earth & Marine Services to conduct an archaeological assessment in the Leviathan Field. The archaeological assessment delineated nine side-scan sonar contacts that may represent possible cultural resources with potential archaeological significance. All of the information about side-scan sonar contacts was submitted to the Marine Archaeology Unit at Israel Antiquities Authority for further assessment and evaluation.

Coastal Habitats and Infrastructure

The Leviathan Field is located approximately 120 km from the shoreline and therefore, coastal habitats are not within or near the Application Area. However, coastal habitats are relevant to the extent that they could be contacted by an accidental spill. The EIA reviews the general distribution of coastal habitats including shoreline sensitivities to oiling. Approximately 30% of the total shoreline length is fine-grained sand beaches and this is the predominant type along most shoreline segments, especially south of Haifa. Coarse-grained sand beach and mixed sand/gravel beaches account for another approximately 18%. Rip-rap and other man-made shoreline structures account for approximately 24% of the shoreline length and are predominant near Haifa, Tel Aviv, and Ashdod.

The shorelines of Israel include a variety of 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 ports within the region are Haifa and Ashdod, and there are smaller ports at Acre, Ashkelon, Jaffa, and Tel Aviv. In addition to cities such as Haifa, Tel Aviv, Acre, Ashdod, Ashkelon, and Netanya, there are numerous coastal villages along the potentially affected shoreline. These areas serve coastal and marine-related tourism with lodging, restaurants, and other facilities.

ES.4 EVALUATION OF ENVIRONMENTAL IMPACTS

The impact assessment included routine activities and accidental events. The following aspects (impact sources) and environmental resources were included in the analysis:

Aspects (impact sources):

- Production testing;
- Seafloor disturbance;
- Drilling discharges;
- Other discharges;
- Air emissions;
- Safety and protection zones;
- Noise hazards;
- Light hazards;
- Waste and marine debris;
- Well closure (temporary abandonment);
- Support vessel traffic;
- Helicopter traffic;
- Accidental fuel spill; and
- Accidental condensate spill from well blowout.

Resources:

- Air quality;
- Water quality;
- Sediment quality;
- Benthic communities;
- Marine mammals;
- Sea turtles;
- Seabirds and migratory birds;
- Fishes;
- Fishing activities and marine farming;
- Culture and heritage sites;
- Marine transportation and infrastructure; and
- Coastal habitats and infrastructure.

As part of the evaluation of impacts from routine activities, drilling discharges were modeled by ASA using a representative location. The modeling was conducted using the MUDMAP 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 Noble Energy for MOBM well cuttings treated in a TCC unit.

Spill modeling was conducted by Dr. Steve Brenner of Bar-Ilan University using representative locations. Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a blowout. The fuel spill scenario assumed an instantaneous release of 8,415.6 m^3 from the drilling rig. The condensate spill scenario assumed a blowout resulting in the release of [redacted] continuing for a period of 30 days. Four representative seasonal time periods were modeled in accordance with MNIEWR guidelines.

Table ES-2 summarizes the potential environmental impacts analyzed in this EIA. Each impact was assessed using a risk matrix that combines the likelihood (probability) and consequence (severity) of an impact. Each impact was assigned a color-coding rating of Low, Moderate, or High. The table also lists mitigation measures to avoid or reduce impacts.

High Risk Impacts

No High risk impacts were identified in the evaluation from routine activities or accidental events.

Moderate Risk Impacts from Routine Activities

Drilling discharges are the only aspect of routine activities identified as having Moderate risk impacts. Specifically, the impacts of drilling discharges on water quality, fishes, sediment quality, and benthic communities were evaluated as Moderate.

Drilling discharges will produce intermittent turbidity that could extend up to a few kilometers from each drillsite. Water quality impacts would be transient and would not persist for more than a few hours after the discharges cease. Suspended cuttings in the water column could affect fish, plankton, and other pelagic organisms, mainly due to the physical stress of particles rather than toxicity. However, any ecological impacts are expected to be insignificant due to the low toxicity of the proposed MOBM system, the low percentage of MOBM retained on cuttings (1% or less), and the rapid dispersal of the suspended cuttings particles in the water column.

Drilling discharges are likely to produce detectable, persistent impacts on the benthic environment in a small area around each drillsite. Assuming an impact threshold of 6.3 mm for burial of benthic organisms, the discharges are predicted to affect approximately 0.01 km^2 around each drillsite and would extend approximately 65 m from the discharge point. The benthic communities around all of the wellsites are expected to consist of soft bottom organisms. The Background Monitoring Survey confirmed that there are no deepwater coral or other hard bottom communities present. Soft bottom areas buried by cuttings eventually will be recolonized through larval settlement and migration from adjacent areas. Recovery may require several years and depends 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.

Moderate Risk Impacts from Accidental Events

Both of the accidental spill scenarios (a fuel spill and a condensate spill from a blowout) were evaluated as having several Moderate impacts. For the fuel spill, potential impacts on seabirds and migratory birds as well as coastal habitats and infrastructure were rated as Moderate. For the condensate spill, potential impacts on marine mammals, sea turtles, fishes, seabirds and migratory birds, fishing activities and marine farming, and coastal habitats and infrastructure were rated as Moderate. The condensate spill has the potential for greater consequences because of the extended time period (30 days) for the spill event and the greater volumes of oil potentially reaching the shoreline.

The Moderate ratings for potential impacts on coastal habitats, wildlife, and infrastructure are based on simulation modeling that does not take into account any response measures to disperse a spill or prevent it from reaching sensitive shorelines. The Leviathan Field is approximately 120 km from the nearest shoreline and the modeling predicts the earliest landfall would be 7.5 days for a condensate spill and 12 days for a fuel spill. Noble Energy expects that, in the event of a spill, most significant impacts would be avoided (or the likelihood of impacts would be substantially reduced) through the implementation of the response measures included in the OSCP.

Low Risk Impacts

All remaining impacts summarized in **Table ES-2** are rated as Low risk. These include all impacts of routine activities other than drilling discharges as well as impacts of accidental spills on air quality, water quality, sediment quality, benthic communities, culture and heritage sites, and marine transportation and infrastructure.

Table ES-2. Summary of potential impacts and mitigation.

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Seafloor Disturbance						
Seafloor disturbance	Sediment quality	Physical disruption and resuspension of sediments.	None recommended	3	1	3 Low
	Benthic communities	Localized burial and crushing of individual organisms.	None recommended	3	1	3 Low
	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 (actual distances are more than 3.0 km away)	2	2	4 Low

Table ES-2. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Drilling Discharges						
Drilling discharges (treated cuttings)	Water quality; fishes	Turbidity within a few tens of meters to a few kilometers of drilling rigs during discharges.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings , in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3)	5	1	5 Mod
	Sediment quality	Deposition of cuttings particles on the seafloor, causing changes in grain size and mineralogy.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings , in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3)	4	2	8 Mod
	Benthic communities	Localized burial and smothering of benthic organisms. Burial impacts are most likely within 61 to 65 m of drillsites. Anoxia and other benthic impacts may occur due to adhering MOBM and changes in sediment grain size.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings , in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3) • Background monitoring survey conducted to verify there are no deepwater coral or other hard bottom communities present	4	2	8 Mod
	Culture and heritage sites	Possible burial or contamination of wreck sites.	• 305-m avoidance zone for potential sites	2	2	4 Low
Other Discharges						
Sanitary waste and gray water, organic food waste, cooling water, desalination brine, deck drainage	Water quality; fishes	Localized, transient impacts on water quality within a few meters to a few hundred meters of drilling rigs.	• Compliance with MARPOL requirements	3	1	3 Low
Ballast water	Fishes; benthic communities	Potential introduction of alien invasive species in ballast water.	• Noble will operate in accordance with guidelines developed by IPIECA and OGP (2010) to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. Drilling rigs will have a Ballast Water Management Plan and be equipped with an IMO-approved ballast water management system	3	1	3 Low

Table ES-2. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Light Hazards						
Artificial lighting on drilling rigs and support 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 (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 rig 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						
Noise from drilling rigs, support vessels, and helicopters	Marine mammals	Behavioral responses such as avoidance; potential for auditory masking.	None recommended	3	1	3 Low
	Sea turtles	Behavioral responses such as avoidance; potential for auditory masking.	None recommended	3	1	3 Low
	Fishes	Behavioral responses such as avoidance; potential for auditory masking.	None recommended	3	1	3 Low
Vessel Traffic						
Support vessel traffic between shore base (Haifa) and drilling rig(s)	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
	Fishing activities	Potential interactions with fishing vessels or gear.	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
Helicopter Traffic						
Helicopter traffic between shore base (Haifa) and drilling rig(s)	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

Table ES-2. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Marine Debris						
Marine debris accidentally lost overboard	Water quality; sediment quality; benthic communities	Potential accumulation of metal debris on the seafloor, with growth of fouling biota.	• Noble Energy's waste management procedures and rig operator's Garbage Management Plan 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 and migratory birds	Potential entanglement; ingestion.	• Noble Energy's waste management procedures and rig operator's Garbage Management Plan will minimize the potential for accidental loss of items overboard	2-3	1	2-3 Low
Air Emissions						
Air emissions from drilling rig	Air quality	Localized, transient elevations in air pollutant concentrations near drilling rig; 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 from support vessels and helicopters	Air quality	Localized, transient elevations in air pollutant concentrations along 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 from flaring during production testing (flowback)	Air quality	Localized, transient elevations in air pollutant concentrations near drilling rig; greenhouse gas emissions.	• Use of high-efficiency burner to minimize air pollutants from incomplete combustion	3	1	3 Low
	Water quality	Possible sheen on sea surface due to fallout of droplets during flaring; localized impacts due to discharge of treated effluent.	• Use of high-efficiency burner to minimize "fallout" of oil droplets • Treatment of effluent to meet standards prior to discharge	2	1	2 Low
Safety and Protection Zones						
Safety and protection zones (500-m buffer zone around drilling rig(s)	Fishing activities	Exclusion of fishing vessels from buffer zone	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
	Marine transportation system and infrastructure	Exclusion of other vessels from buffer zone.	• Provide Notice to Mariners in advance of proposed activities • Use standard navigation markings	2	1	2 Low

Table ES-2. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Accidental Spills						
Fuel spill from the drilling rig (8,415.6 m^3)	Air quality	Elevated VOC concentrations due to evaporation of volatile hydrocarbons (mostly in first 24 to 48 hours).	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Water quality	Sheen or slick on water surface; elevated hydrocarbon concentrations in water column.	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Marine mammals	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Sea turtles	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of nesting beaches)	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.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of coastal bird habitats)	2	3	6 Mod
	Fishes	Potential impacts due to direct contact with oil or ingestion of fouled prey items.	• Spill prevention measures • Drilling rig SOPEP • OSCP	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.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including notification procedures and protection of fishing and marine farming areas)	2	2	4 Low
Fuel spill from the drilling rig (8,415.6 m^3) Continued.	Culture and heritage sites	Potential contamination of culture and heritage sites (including coastal sites if spill reached shoreline).	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of coastal archaeology sites) • 305-m avoidance zone for potential wreck sites; 31-m avoidance zone for other sonar contacts (actual distances are more than 3.0 km away)	2	2	4 Low
	Marine transportation and infrastructure	Potential disruption or rerouting of ship traffic due to response activities.	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Coastal habitats and infrastructure	Potential contamination of beaches, shorelines, parks, preserves, marinas, ports, etc.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of coastal habitats and infrastructure)	2	3	6 Mod

Table ES-2. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Condensate spill from a blowout ([redacted] for 30 days)	Air quality	Elevated VOC concentrations due to evaporation of volatile hydrocarbons (mostly first 24 to 48 hours).	• Spill prevention measures • OSCP	2	2	4 Low
	Water quality	Sheen or slick on water surface; elevated hydrocarbon concentrations in water column.	• Spill prevention measures • OSCP	2	2	4 Low
	Sediment quality	Physical impact to sediments within 300 m of blowout site; sediment contamination unlikely.	• Spill prevention measures • OSCP	2	2	4 Low
	Benthic communities	Physical impact to benthic organisms within 300 m of blowout site; benthic community impacts due to sediment contamination are unlikely.	• Spill prevention measures • OSCP	2	2	4 Low
	Marine mammals	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • OSCP	2	3	6 Mod
	Sea turtles	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • OSCP (including protection of nesting beaches)	2	3	6 Mod
Condensate spill from a blowout ([redacted] for 30 days) Continued	Seabirds and migratory birds	Potential impacts due to inhalation, ingestion, direct contact with feathers, or ingestion of fouled prey items.	• Spill prevention measures • OSCP (including protection of coastal bird habitats)	2	3	6 Mod
	Fishes	Potential impacts due to direct contact with oil or ingestion of fouled prey items.	• Spill prevention measures • OSCP	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.	• Spill prevention measures • OSCP (including notification procedures and protection of fishing and marine farming areas)	2	2-3	4-6 Mod
	Culture and heritage sites	Potential contamination of heritage sites (including coastal sites if spill reached shoreline).	• Spill prevention measures • OSCP (including protection of coastal archaeological sites) • 305-m avoidance zone for potential wreck sites; 31-m avoidance zone for other sonar contacts (actual distances are more than 3.0 km away)	2	2	4 Low
	Marine transportation and infrastructure	Potential disruption or rerouting of ship traffic due to response activities.	• Spill prevention measures • OSCP	2	2	4 Low
	Coastal habitats and infrastructure	Potential contamination of beaches, shorelines, parks, preserves, marinas, ports, etc.	• Spill prevention measures • OSCP (including protection of coastal habitats and infrastructure)	2	3	6 Mod

IMO = International Maritime Organization; MARPOL = International Convention for the Prevention of Pollution from Ships; MOBM = mineral oil-based mud; OSCP = Oil Spill Contingency Plan; ROV = remotely operated vehicle; SOPEP = Shipboard Oil Pollution Emergency Plan; TCC = thermomechanical cuttings cleaner; VOC = volatile organic compound.

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List of Acronyms and Abbreviations

3D	three-dimensional
AIS	alien invasive species
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AUV	autonomous underwater vehicle
bbl	barrel
BHA	bottom hole assembly
BOEM	U.S. Bureau of Ocean Energy Management
BOP	blowout preventer
BSEE	U.S. Bureau of Safety and Environmental Enforcement
CCC	Criterion Continuous Concentration
CH_4	methane
CIM	chemical injection mandrel
CL	confidence limit
CO	carbon monoxide
CO_2	carbon dioxide
CSA	CSA Ocean Sciences Inc.
CTD	conductivity-temperature-depth (instrument)
CYCOFOS	Cyprus Coastal Ocean Forecasting and Observing System
DCM	deep chlorophyll maximum
DHPT	downhole pressure and temperature
DO	dissolved oxygen
DP	dynamically positioned
DST	Dead Sea Transform
EHS	environmental, health, and safety
EIA	environmental impact assessment
EMS	environmental management system
ERL	effects range low
ERM	effects range median
ESI	Environmental Sensitivity Index
EUCEQS	European Union Commission Environmental Quality Standard
FAD	fish aggregating device
FFPI	Fossil Fuel Pollution Index
FPSO	floating production storage and offloading (unit)
GEMS	Geoscience Earth & Marine Services
GHG	greenhouse gas
GMS	Global Management System
H_2S	hydrogen sulfide
IBA	Important Bird Area
IMO	International Maritime Organization
IOPP	International Oil Pollution Prevention
IPIECA	(formerly called) International Petroleum Industry Environmental Conservation Association
ISPP	International Sewage Pollution Prevention
IUCN	International Union for Conservation of Nature
LC_{50}	50% lethal concentration
LWD	logging while drilling
MARPOL	International Convention for the Prevention of Pollution from Ships
MASP	maximum anticipated surface pressure
MAW	Modified Atlantic Water
MD	measured depth
MD-RKB	measured depth below Rotary Kelly Bushing

List of Acronyms and Abbreviations (Continued)

MEDEVAC	medical evacuation
MEPC	Marine Environment Protection Committee
MEWQS	Mediterranean Environmental Water Quality Standards
$MIYP_{70}$	70% of the minimum internal yield pressure
MM	Middle Miocene
MMS	U.S. Minerals Management Service
MMscf	million standard cubic feet
MMscfpd	million standard cubic feet per day
MNIEWR	Ministry of National Infrastructures, Energy and Water Resources
MOBM	mineral oil-based mud
MoEP	Ministry of Environmental Protection
MWD	measurement while drilling
NADF	non-aqueous drilling fluid
NCEP	National Center for Environmental Predictions
NMFS	U.S. National Marine Fisheries Service
NO_x	nitrogen oxides
Noble Energy	Noble Energy Mediterranean Ltd
NTU	nephelometric turbidity unit
O_3	ozone
OGP	International Association of Oil & Gas Producers
OSCP	Oil Spill Contingency Plan
OSPAR	Convention for the Protection of Marine Environment in the Northeast Atlantic
OSRL	Oil Spill Response Limited
OWS	oil/water separator
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDC	polycrystalline diamond compact (bit)
PEC	predicted environmental concentration
PM	particulate matter
PNEC	predicted no effect concentration
ppb	parts per billion
ppm	parts per million
ppg	pounds per gallon
PRMP	pressure reduction and metering platform
PTS	permanent threshold shift
RDIF	reservoir drill-in-fluid
RKB	Rotary Kelly Bushing
ROV	remotely operated vehicle
SCSSV	surface-controlled subsurface safety valve
SD	standard deviation
SDS	Safety Data Sheet
SEMS	safety and environmental management system
SFRDIF	solids-free reservoir drill-in-fluid
SO_x	sulfur oxides
SOLAS	International Convention for Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	sound pressure level
ST	sidetrack well
TCC	thermomechanical cuttings cleaner
TDS	total dissolved solids
TN	total nitrogen

List of Acronyms and Abbreviations (Continued)

TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TTS	temporary threshold shift
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WBM	water-based mud

CHAPTER 1: DESCRIPTION OF THE CURRENT MARITIME ENVIRONMENT

1.1 GENERAL

Noble Energy Mediterranean Ltd (Noble Energy) plans to conduct well drilling and completion activities for gas and condensate production in the Leviathan Field offshore Israel. Noble Energy's development plan for the Leviathan Field includes the drilling and completion of up to 29 wells. The final number and locations of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and future appraisal. Eight initial development drillsites have been selected and are evaluated in detail in this Environmental Impact Assessment (EIA). However, this EIA is intended to encompass all future drilling and completion activities in the field. Production facilities and operations are excluded, as they will be covered in a separate EIA for the Leviathan Field Development.

The EIA was prepared for the Ministry of National Infrastructures, Energy and Water Resources (MNIEWR) and the Ministry of Environmental Protection (MoEP, formerly the Ministry of the Environment) in accordance with the "Guidelines for Preparation of Environmental Impact Document for Production Drilling, Production Tests and Completion – Development of Leviathan Field (Leases I/14 and I/15)" dated 5 October 2014 (**Appendix A**). A table comparing EIA sections with the guideline requirements is presented in **Appendix B**. Preparers and their qualifications are listed in **Appendix C**.

The EIA consists of five key chapters:

- **Chapter 1:** Description of the Current Maritime Environment. This chapter describes the baseline environment, including site-specific data from the Background Monitoring Survey conducted as required by the "Framework Guidelines for Preparation of a Background Monitoring Plan for the Marine Environment Accompanying a License for Exploration Purposes – Exploratory (Experimental) Drilling and Offshore Production." The detailed survey report is provided in **Appendix D**.
- **Chapter 2:** Reasons for Preference of the Location of the Proposed Plan and Possible Alternatives. This chapter reviews alternatives considered by Noble Energy, including well locations, technologies, and infrastructure for future production.
- **Chapter 3:** Project Description. This chapter describes Noble Energy's drilling program, including the schedule, drilling unit and support vessels, drilling mud program, well completion, production testing, noise hazards, air quality, hazardous materials, discharges, wastes, and abandonment plans.
- **Chapter 4:** Evaluation of Environmental Impacts. This chapter evaluates potential impacts on the environment from routine activities and accidental events.
- **Chapter 5:** Proposed Guidelines for Plan for Preservation and Prevention of Harm to the Environment. This chapter outlines environmental management and mitigation measures.

Literature cited is provided in **Chapter 6**, and supporting information is provided in the appendices, which are referenced in text where appropriate.

1.2 BOUNDARIES OF APPLICATION AND AREA OF INFLUENCE

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 (**Figure 1-1**). The Application Area consists of the entire Leviathan Field, including the water column, seafloor, sub-seafloor, and any proposed or future drillsites within the field. **Figure 1-2** shows eight initial drillsites where activities are proposed in this Application, including two existing wells (Leviathan-3 and Leviathan-4) and six proposed new wells (Leviathan-5 through Leviathan-10), the latter are shown with a 1-km radius around each drillsite because the locations are not final.

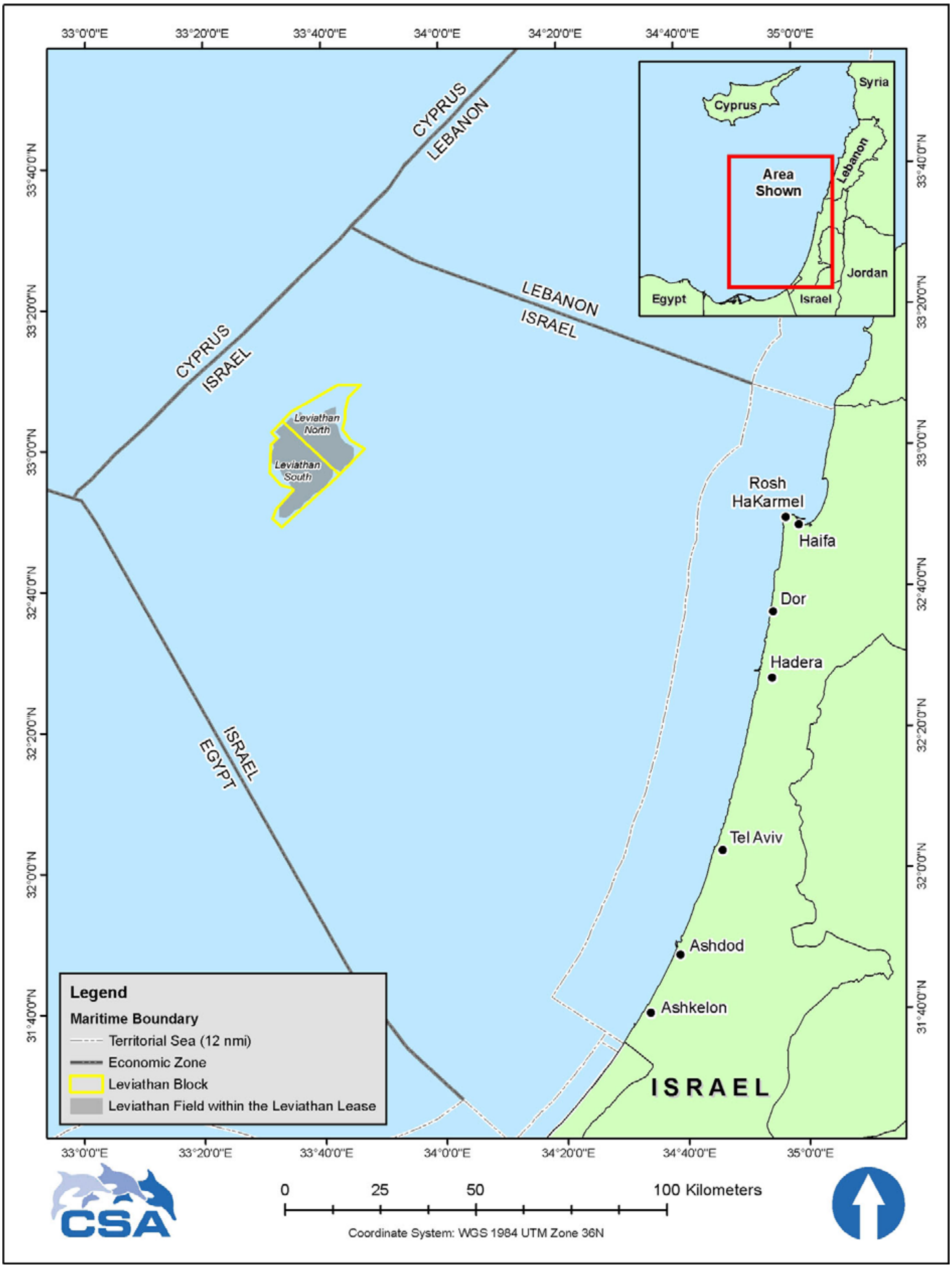

Figure 1-1. Location of the Leviathan Field, offshore Israel.

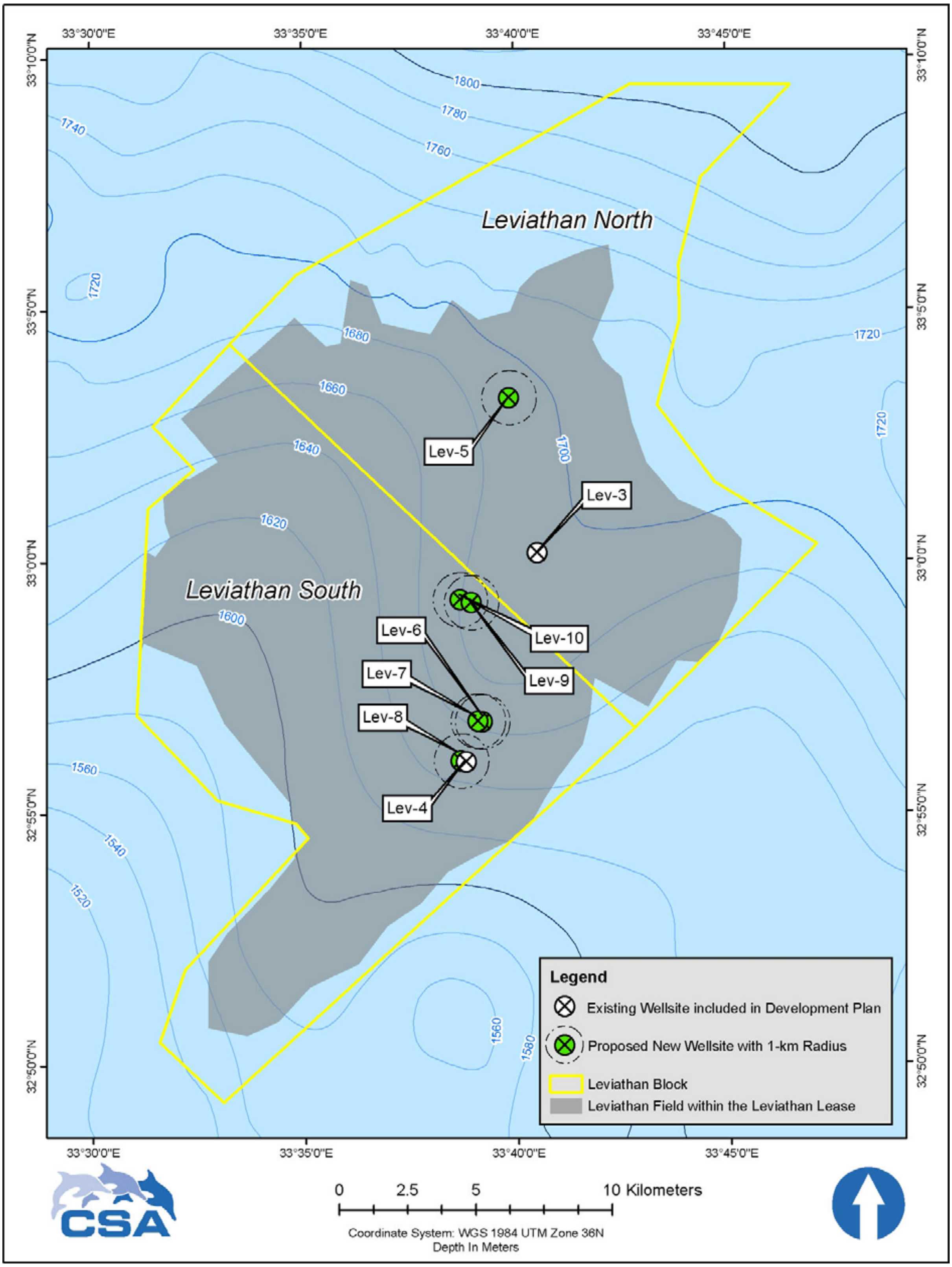

Figure 1–2. Locations of eight initial wellsites included in the Leviathan Field Development Plan. Leviathan-3 and Leviathan-4 are existing wells and locations are shown "as drilled." Leviathan-5 through Leviathan-10 are "new" proposed drillsites, and the final surface locations may change within a 1-km radius, as shown. Contours show seabed depth.

The Area of Influence of the Application includes the entire marine and coastal area that might be affected environmentally as a result of routine operations or accidental events. For routine operations, the Area of Influence is defined as the Leviathan Field and the support vessel route between the Leviathan Field and the shore base in Haifa. For accidental events such as a spill, the Area of Influence includes the eastern Mediterranean Sea within a box bounded by the following coordinates: 31°30’ N to 35°45’ N latitude, 32° E to 35°30’ E longitude. This box is based on the maximum extent of spill trajectories estimated by the simulation modeling discussed in **Section 4.3**. The actual area affected by a particular spill would be much smaller. As discussed in **Section 4.3**, 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.

1.3 MAPS

The Leviathan Field is located in the I/15 Leviathan North and I/14 Leviathan South lease areas (**Figure 1-1**), hereafter referred to as Leviathan North and Leviathan South. The water depth and distances from each drillsite to the nearest shoreline, Rosh Hacarmel, and Hadera are listed in **Table 1-1**.

Table 1-1. Water depth of proposed drillsites in the Leviathan Field and distances from each drillsite to the nearest shoreline, Rosh Hacarmel, and Hadera.

Well Name	Planned Activities	Water Depth (m)	Distances (km)[a]		
			Nearest Shoreline	Rosh Hacarmel	Hadera
Leviathan-3	Sidetrack and complete existing well (Leviathan-3 ST02)	1,670	121.26	121.93	131.49
Leviathan-4	Complete existing well (Leviathan-4 ST01)	1,619	122.93	123.63	130.54
Leviathan-5	Drill and complete Leviathan-5 and 5 ST01	1,709	123.27	123.91	135.09
Leviathan-6	Drill and complete Leviathan-6 and 6 ST01	1,626	122.49	123.19	130.61
Leviathan-7	Drill and complete Leviathan-7	1,627	122.47	123.25	130.67
Leviathan-8	Drill and complete Leviathan-8	1,619	122.60	123.57	130.47
Leviathan-9	Drill and complete Leviathan-9 and 9 ST01	1,650	123.57	124.25	132.97
Leviathan-10	Drill and complete Leviathan-10	1,649	123.62	124.30	133.03

[a] Distances were calculated using WGS84 Universal Transverse Mercator (UTM) Zone 36N.

The Leviathan Field Development Plan includes a pressure reduction and metering platform (PRMP) approximately 9.74 km from the nearest shoreline. The distance to shore from the PRMP is provided as required in the Guidelines, but the PRMP is not part of this Application and is not discussed further in this EIA.

Figure 1-3 presents a bathymetric map showing the Leviathan Field, proposed drillsites, existing and proposed maritime boundaries, and shipping routes.

Existing maritime infrastructure within the Application Area includes four previously drilled wells (Leviathan-1 through Leviathan-4) and one telecommunications cable (**Figure 1-4**). Two of these wells (Leviathan-1 and Leviathan-2) are permanently plugged and are not part of Noble Energy’s development plan in this EIA. Existing infrastructure is discussed in **Section 1.11**.

Figures 1-5 and **1-6** are regional maps of the Leviathan Field. Bathymetric maps and seafloor morphology maps of each drillsite are presented in **Figures 1-7** through **1-14**. Noble Energy will submit full size hard copies of the maps to accompany this EIA.

There is no mariculture or fish farming activity within 30 km of the Application Area, as discussed in **Section 1.12**, and therefore a map of such activities is not required. Also, because the Application Area is not located within 1 nmi of the coast, a map of the coastal zone is not required.

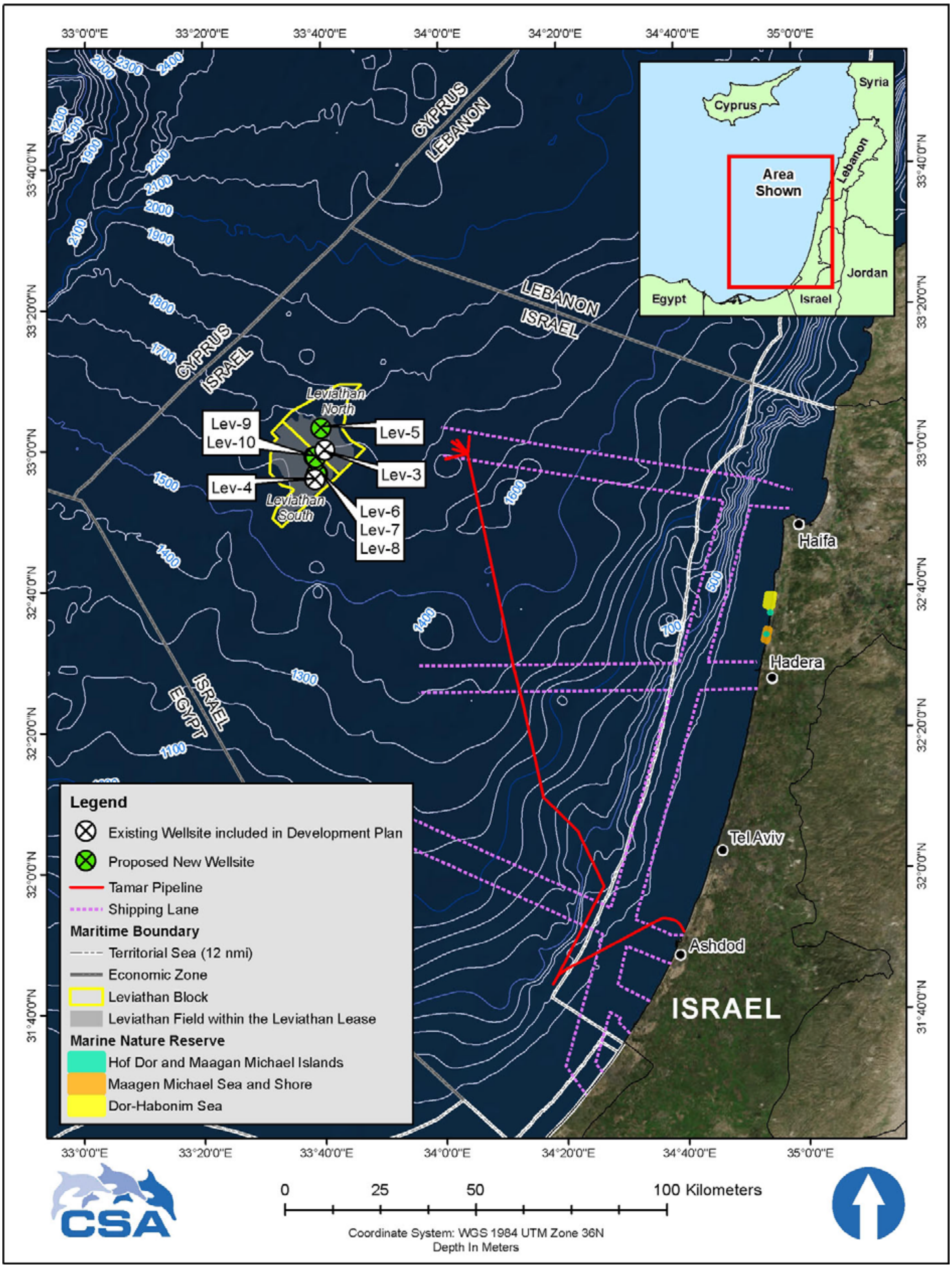

Figure 1-3. Bathymetric map showing the Leviathan Field and proposed drillsites relative to regional maritime boundaries and shipping routes. Contours show seabed depth.

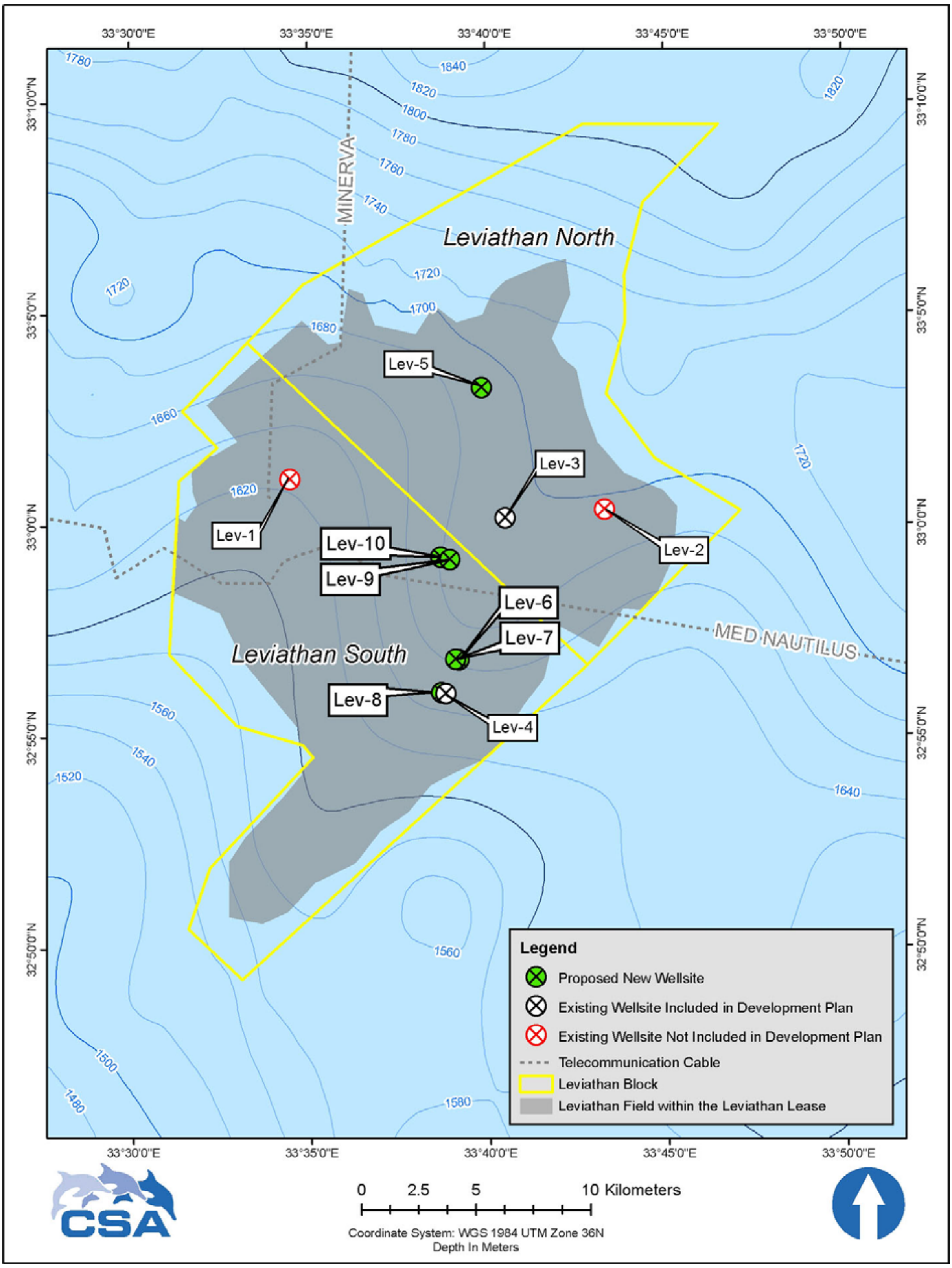

Figure 1–4. Locations of existing marine infrastructure (telecommunications cable and previous drillsites) in relation to the eight initial wellsites included in the Leviathan Field Development Plan. Proposed new wellsite locations are preliminary; final well locations may vary slightly. Contours indicate water depth in meters.

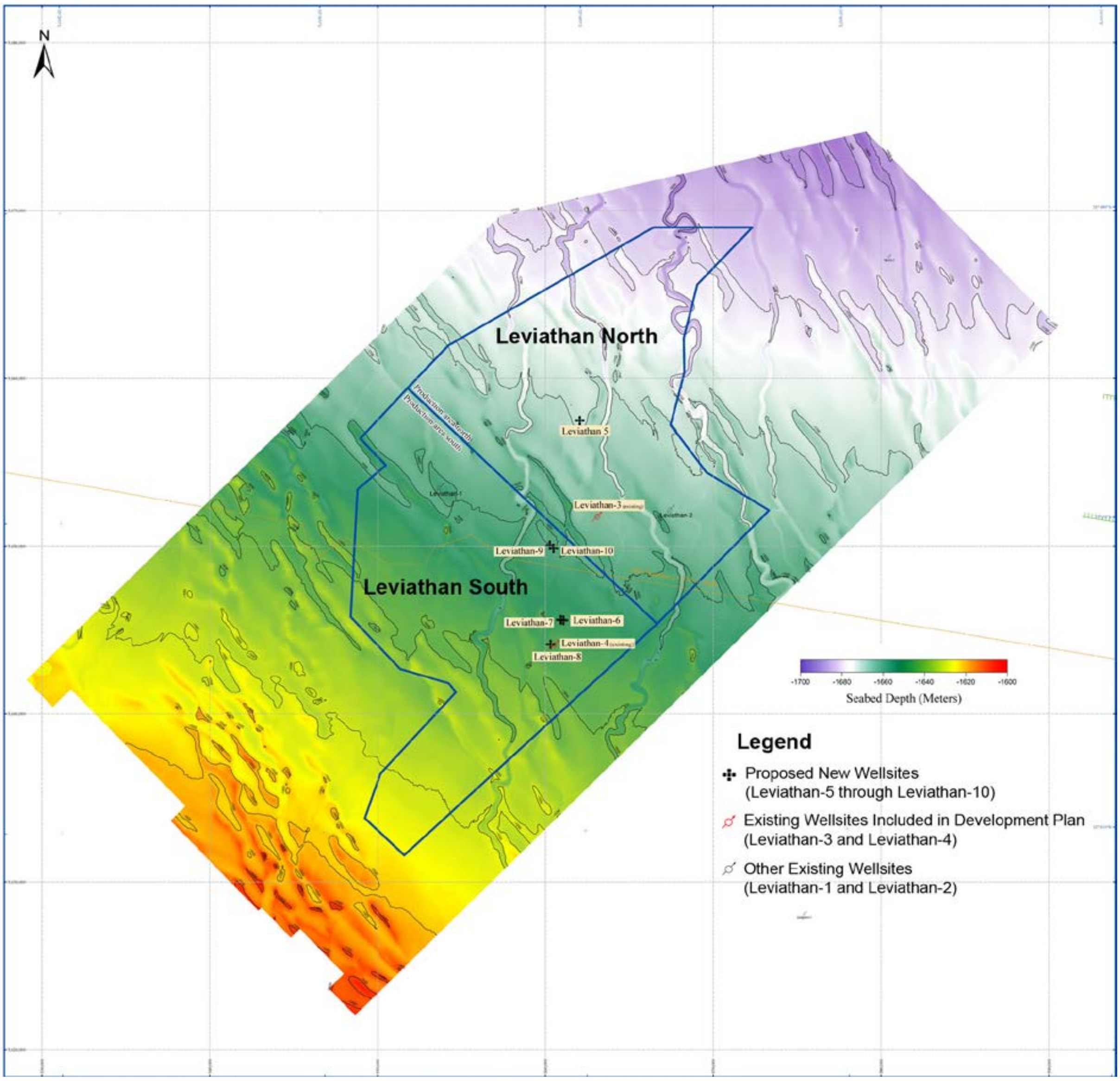

Figure 1-5. Bathymetric chart of the Leviathan Field (Adapted from: Gardline Surveys Inc., 2015). Proposed new wellsite locations are preliminary; final well locations may vary slightly.

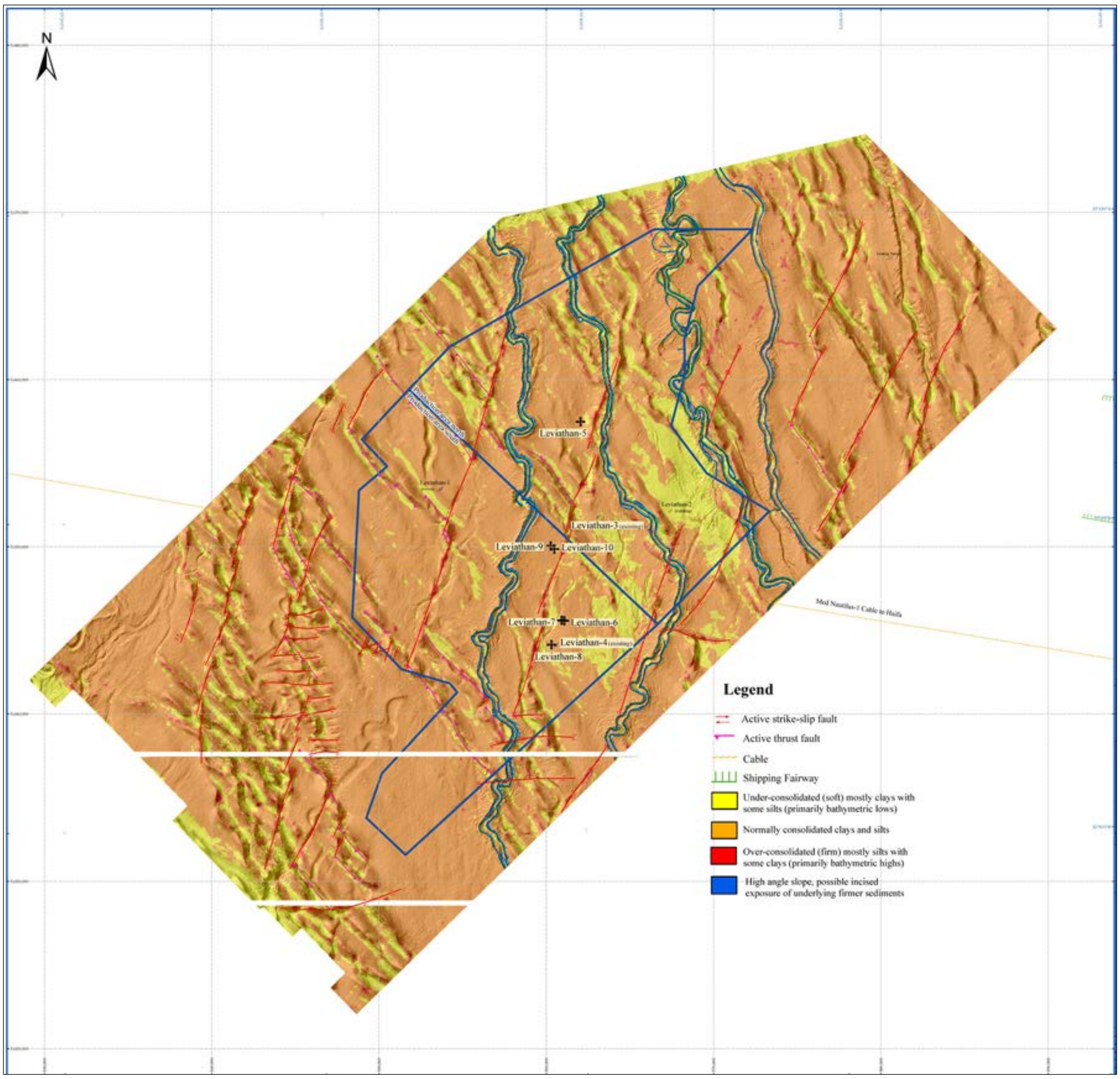

Figure 1–6. Seafloor morphology chart of the Leviathan Field (Adapted from: Gardline Surveys Inc., 2015). Proposed new wellsite locations are preliminary; final well locations may vary slightly.

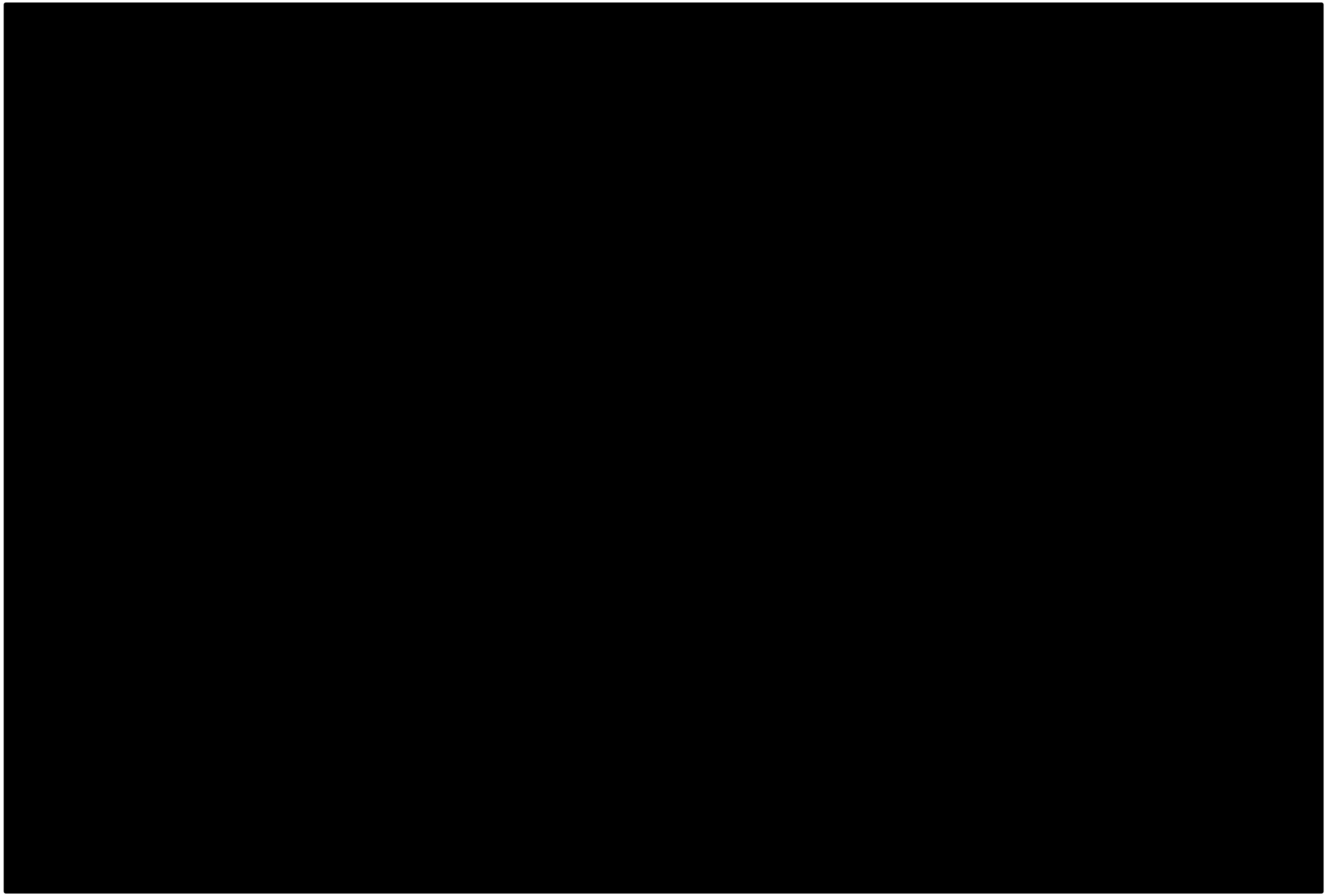

Figure 1-7. Bathymetric seafloor morphology maps of existing Leviathan-3 drillsite with 2-km radius.

[redacted]

Figure 1-8. Bathymetric and seafloor morphology maps of existing Leviathan-4 drillsite with 2-km radius.

[redacted]

Figure 1-9. Bathymetric and seafloor morphology maps of proposed Leviathan-5 drillsite with 2-km radius. Wellsite location is preliminary; final well location may vary slightly.

[redacted]

Figure 1-10. Bathymetric and seafloor morphology maps of proposed Leviathan-6 drillsite with 2-km radius. Wellsite location is preliminary; final well location may vary slightly.

[redacted]

Figure 1-11. Bathymetric and seafloor morphology maps of proposed Leviathan-7 drillsite with 2-km radius. Wellsite location is preliminary; final well location may vary slightly.

[redacted]

Figure 1-12. Bathymetric and seafloor morphology maps of proposed Leviathan-8 drillsite with 2-km radius. Wellsite location is preliminary; final well location may vary slightly.

[redacted]

Figure 1-13. Bathymetric and seafloor morphology maps of proposed Leviathan-9 drillsite with 2-km radius. Wellsite location is preliminary; final well location may vary slightly.

[redacted]

Figure 1-14. Bathymetric and seafloor morphology maps of proposed Leviathan-10 drillsite with 2-km radius. Wellsite location is preliminary; final well location may vary slightly.

1.4 GEOLOGICAL, SEISMIC, AND SEDIMENTOLOGICAL CHARACTERISTICS

1.4.1 Geologic Setting

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.4.2 Bathymetry and Seafloor Morphology

[redacted]

[redacted]

[redacted]

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[redacted]

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1.4.3 Shallow Stratigraphy

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[redacted]

[redacted]

[redacted]

Figure 1-15. Seismic line illustrating the shallow stratigraphy of the Leviathan Field (From: Gardline Surveys Inc., 2010).

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

1.4.4 Geohazards

[redacted]

[redacted]

1.4.5 Seismicity

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Figure 1–16. Locations and magnitudes of historical earthquakes in the region (1979 to 2014) relative to the Leviathan Field (Data from: U.S. Geological Survey, 2014).

1.4.6 Sediment Grain Size

Seafloor sediment in the Leviathan Field consists primarily of clay and silt with localized sand (mainly confined to the active channels mentioned previously). This interpretation is consistent with video observations from the Background Monitoring Survey, indicating that the seafloor around the proposed drillsites is smooth and relatively flat with sediments consisting primarily of clay and silt (**Appendix D**). No sand waves were observed, which would indicate low current speeds near the seafloor. No consolidated substrates (hard bottom features) were observed within the survey area.

Sediment sampling has been conducted within 117 grid cells in the Leviathan Field (**Appendix D**). 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 1-17**). The Leviathan-2 and Leviathan-4 samples included post-drilling surveys. Seafloor sediment samples were analyzed for grain size, discussed here, as well as other "sediment quality" parameters that are discussed in **Section 1.7.2**.

Figure 1-18 summarizes the seafloor grain size distribution and sediment type within the Leviathan Field. Except for post-drilling samples, samples consisted mainly of clay and silt and were classified as silty clay according to the Shepard (1954) classification system. Post-drilling samples from were affected by cuttings discharges, with higher percentages of sand and/or silt. The Levantine Basin Baseline symbol on the figure represents the regional mean of pre-drilling samples and is the representative "baseline" value.

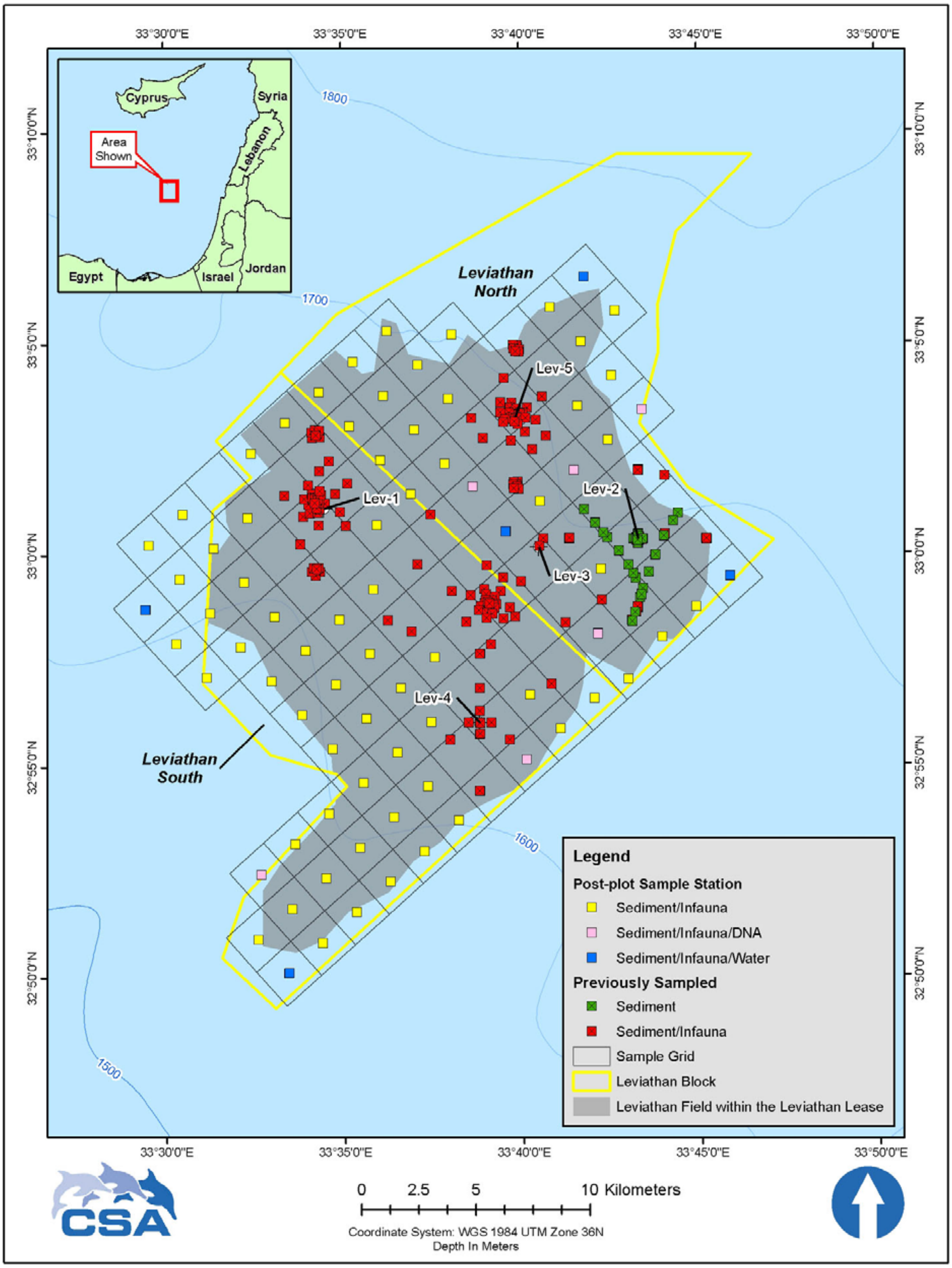


Figure 1-17. Sampling stations within the Leviathan Field, including stations sampled during the Background Monitoring Survey, including previous drillsites and possible future drilling locations. Contours show seabed depth.

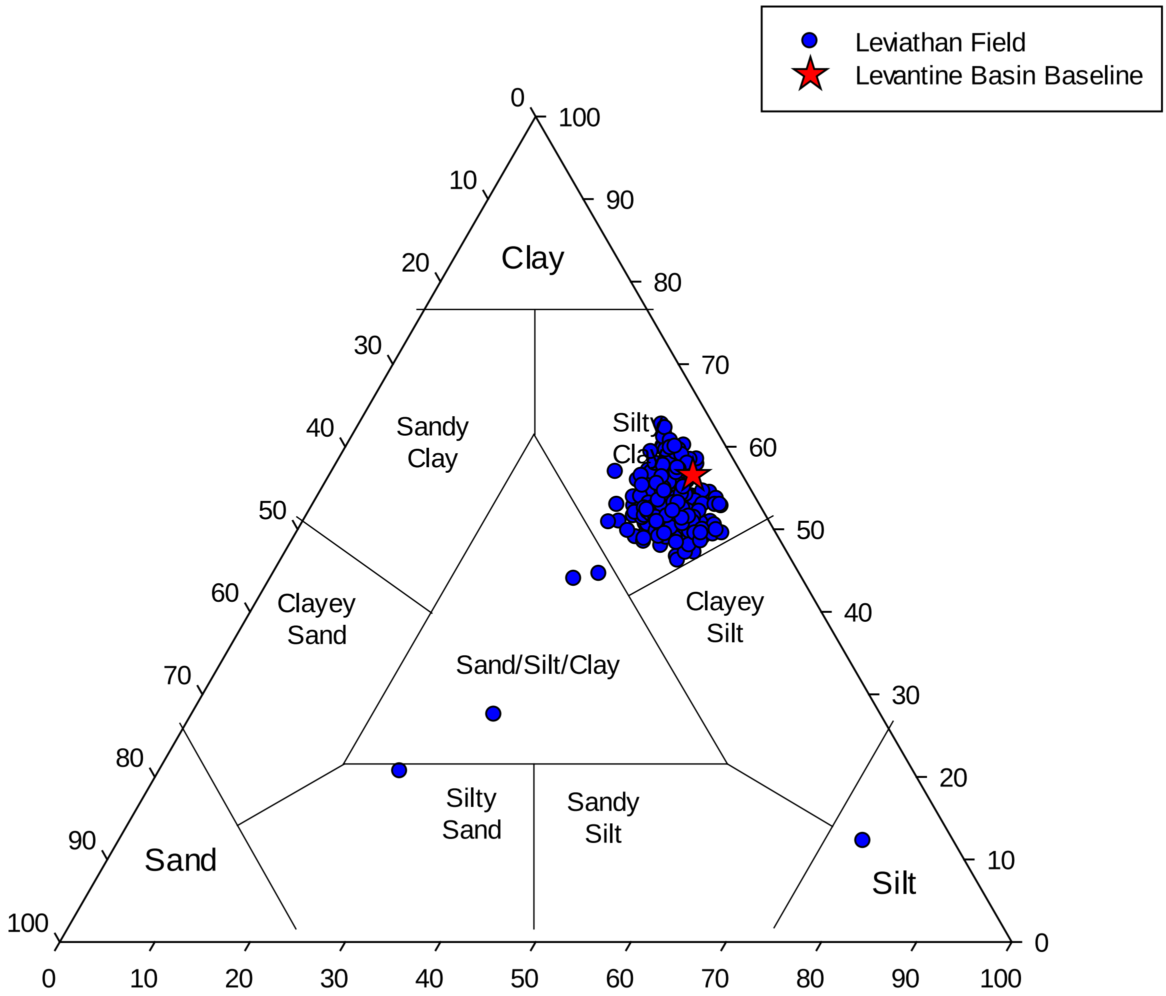


Figure 1-18. Particle size classifications (based on Shepard, 1954) for representative sediment samples collected within the Leviathan Field Relative to the Levantine Basin Baseline (mean of pre-drilling samples from the region).

1.5 HYDRODYNAMIC REGIME (PHYSICAL OCEANOGRAPHY)

1.5.1 Waves

Noble Energy is conducting wave and current observations in the Leviathan Field area (station location: 33°02’ N, 33°51’ E). The program is performed by ALS Environmental Sciences Inc. (Victoria, BC, Canada). The following text and **Table 1-2**, adapted from Mudge and Lawrence (2014), summarize the wave data from July 2011 to April 2014, divided into eight time periods:

- July to November 2011;
- November 2011 to February 2012;
- February to May 2012;
- May 2012 to August 2012;
- August 2012 to January 2013;
- January to June 2013;
- June to October 2013; and
- October 2013 to April 2014.

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 July-Nov 2011		Exceedance Nov 2011-Feb 2012		Exceedance Feb-May 2012		Exceedance May-Aug 2012		Exceedance Aug 2012-Jan 2013		Exceedance Jan-Jun 2013		Exceedance Jun-Oct 2013		Exceedance 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
0.00	2,420	100.0	1,913	100.00	2,539	100.00	2,197	100.00	3,288	100.00	3,287	100.00	2,920	100.00	4,294	100.00
0.25	2,418	99.9	1,913	100.00	2,466	97.12	2,197	100.00	3,262	99.21	3,220	97.96	2,920	100.00	4,225	98.39
0.50	2,125	87.8	1,856	97.02	1,949	76.76	1,896	86.30	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	54.10
1.00	491	20.3	1,182	61.79	992	39.07	314	14.29	908	27.62	1,568	47.70	1,189	40.72	1,593	37.10
1.25	195	8.1	1,035	54.10	740	29.15	33	1.50	612	18.61	1,159	35.26	559	19.14	1,014	23.61
1.50	112	4.6	888	46.42	584	23.00	0	0.00	504	15.33	839	25.52	238	8.15	680	15.84
1.75	64	2.6	689	36.02	501	19.73	0	0.00	410	12.47	544	16.55	100	3.42	482	11.22
2.00	32	1.3	538	28.12	426	16.78	0	0.00	325	9.88	356	10.83	31	1.06	304	7.08
2.25	16	0.7	438	22.90	365	14.38	--	--	289	8.79	215	6.54	7	0.24	177	4.12
2.50	11	0.5	362	18.92	314	12.37	--	--	251	7.63	143	4.35	0	0.00	110	2.56
2.75	5	0.2	294	15.37	244	9.61	--	--	223	6.78	87	2.65	0	0.00	85	1.98
3.00	0	0.0	231	12.08	182	7.17	--	--	182	5.54	50	1.52	0	0.00	64	1.49
3.25	--	--	174	9.10	128	5.04	--	--	160	4.87	29	0.88	--	--	50	1.16
3.50	--	--	110	5.75	99	3.90	--	--	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
4.00	--	--	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	0.00	--	--	11	0.26
4.50	--	--	18	0.94	48	1.89	--	--	37	1.13	0	0.00	--	--	8	0.19
4.75	--	--	10	0.52	38	1.50	--	--	26	0.79	0	0.00	--	--	3	0.07
5.00	--	--	9	0.47	33	1.30	--	--	17	0.52	0	0.00	--	--	0	0.00
5.25	--	--	9	0.47	24	0.95	--	--	11	0.33	--	--	--	--	--	--
5.50	--	--	6	0.31	19	0.75	--	--	8	0.24	--	--	--	--	--	--
5.75	--	--	3	0.16	12	0.47	--	--	7	0.21	--	--	--	--	--	--
6.00	--	--	1	0.05	6	0.24	--	--	5	0.15	--	--	--	--	--	--
6.25	--	--	0	0.00	1	0.04	--	--	2	0.06	--	--	--	--	--	--
6.50	--	--	--	--	0	0.00	--	--	0	0.00	--	--	--	--	--	--
6.75	--	--	--	--	0	0.00	--	--	--	--	--	--	--	--	--	--
7.00	--	--	--	--	0	0.00	--	--	--	--	--	--	--	--	--	--

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

<u>**July to November 2011**</u>: Most of the waves observed from July to November 2011 had significant wave heights between 0.4 and 1.2 m and periods between 4 and 9 s. The largest waves occurred in October when the significant wave height was 2.9 m, the maximum wave height was almost 6 m, and the peak period ranged from 10 to 12 s.

<u>**November 2011 to February 2012**</u>: Most of the waves observed between November 2011 and February 2012 had significant wave heights between 0.5 and 2.0 m and periods between 3 and 9 s. The largest waves occurred in January when the significant wave height reached 6.0 m, the maximum wave height was 11.6 m, and the peak period ranged from 10 to 12.4 s.

<u>**February to May 2012**</u>: Most of the waves observed from February to May 2012 had significant wave heights between 0.5 and 1.5 m and periods between 4 and 7 s. Large wave events were short lived, with the largest waves occurred in February when the largest significant wave height was 6.1 m. The largest maximum wave height was 12.0 m and the peak period ranged from 10 to 12.4 s.

<u>**May to August 2012**</u>: Most of the waves observed from May to August 2012 had 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.

<u>**August 2012 to January 2013**</u>: From 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.

<u>**January to May 2013**</u>: From 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.

<u>**June to October 2013**</u>: From June 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 seconds and 8.7 seconds, respectively.

<u>**October 2013 to April 2014**</u>: From 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.

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. This station is located approximately 200 km west of the Leviathan Field. Nearly all of the waves are less than 1.5 m in height, and wave direction was almost always due east at this location (mean of 116°T, standard deviation [SD] of 53°) because of the strong westerly winds. 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 1-19**).

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
0.50	1,132	18.95
0.75	2,183	36.54
1.00	1,388	23.23
1.25	565	9.46
1.50	261	4.37
1.75	140	2.34
2.00	69	1.15
2.25	52	0.87
2.50	21	0.35
2.75	14	0.23
3.00	10	0.17
3.25	11	0.18
3.50	4	0.07
3.75	7	0.12
4.00	11	0.18
4.25	9	0.15
4.50	6	0.10
4.75	1	0.02
Total	**5,975**	**100**

[1] Upper limit of bin.

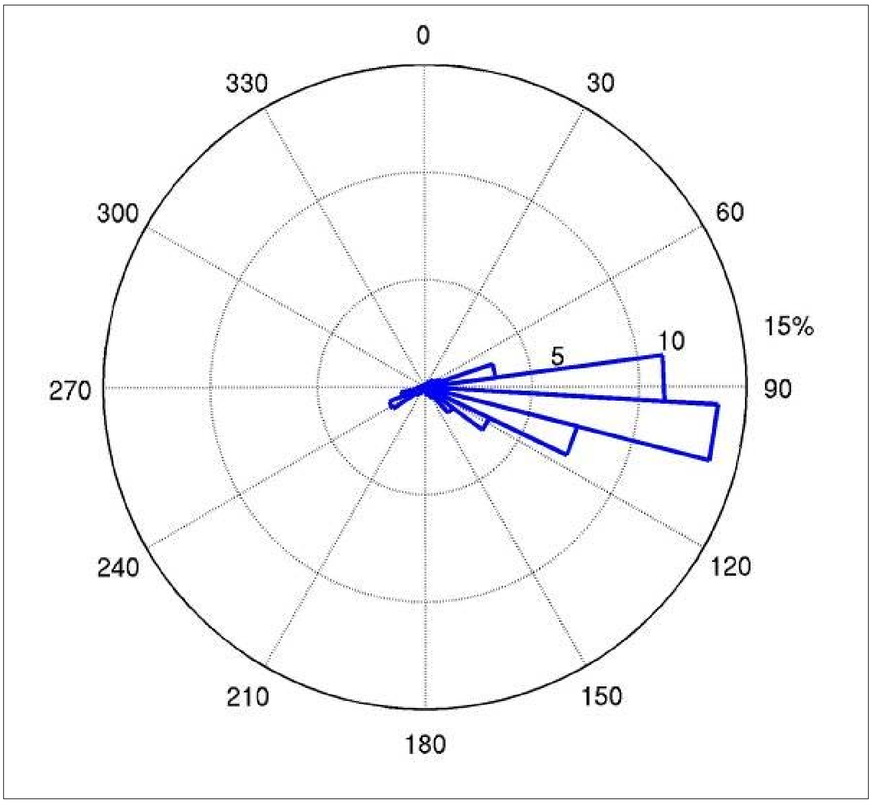


Figure 1-19. Rose diagram for annual frequency of wave direction per 10° sector across the Levantine Basin based on data from the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) MedGoos-3 buoy (33°42' N, 32°08' E).

1.5.2 Extreme Storms

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 1-20** shows the mean annual cycle of the number of storm tracks that pass through the Eastern Mediterranean region, based on an analysis of storm data for the period 1962 to 2001. Storm tracks are most numerous from December to April. The occurrence of storms decreases during the warm period, with a tendency to increase again in October. The maximum number of cyclonic tracks over the area is observed in January (11.2% of the annual total) and March (10.3%). The minimum number of tracks occurs in July (5.3%).

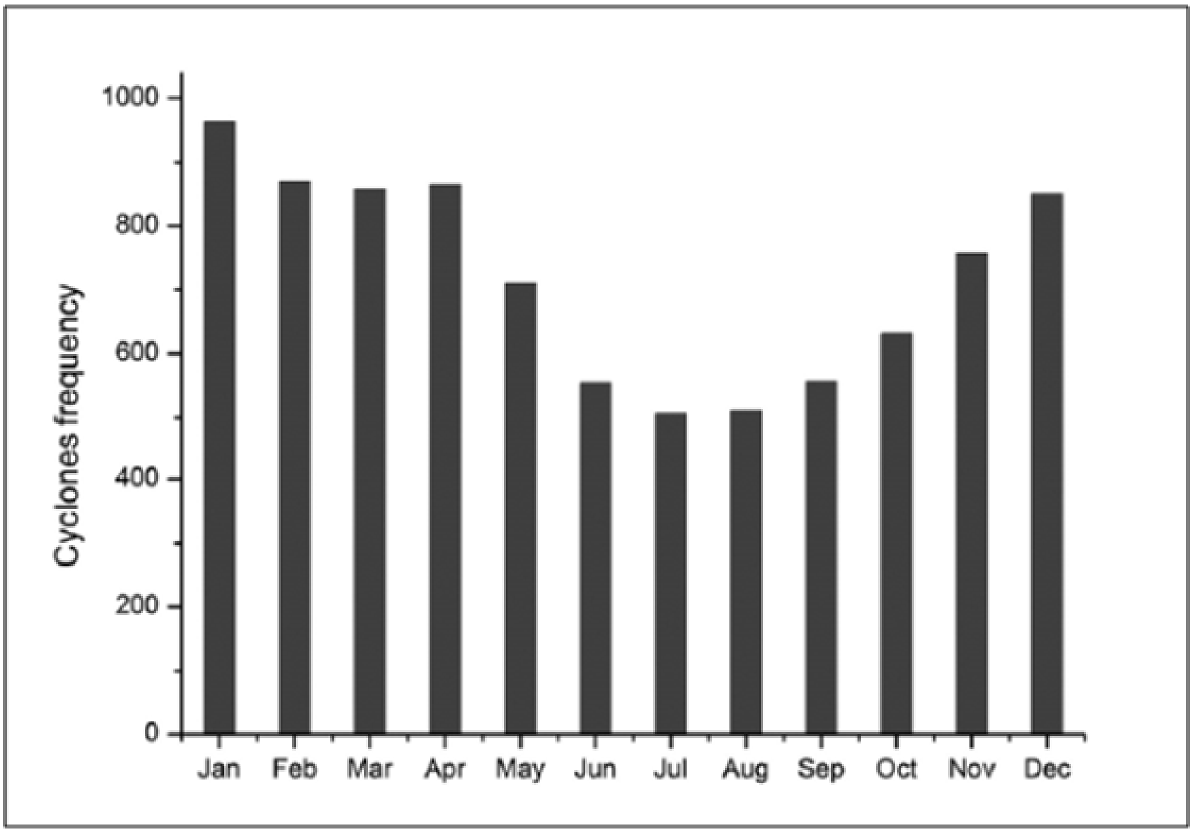


Figure 1-20. Mean annual cycle of the number of storm tracks that passed through the eastern Mediterranean, 1962 to 2001 (From: Flocas et al., 2011).

Mandel et al. (2006) described winter in the Eastern Mediterranean region as concomitantly/alternatively dominating or dominated by interconnected successions of Red Sea Trough, Winter Lows, Polar Cyclones, and Siberian and Mediterranean subtropical anticyclones. The northward and southward advance and withdrawal of the Red Sea Trough during 5 to 7 months of the year (to the Intertropical Convergence Zone) and Persian Trough variability affect the large-scale succession of the temporary cyclonic systems (i.e., Winter Lows, Cyprus Lows, and Sharav). The Red Sea Trough conditions dominate during the winter, while Winter Lows and Cyprus Lows are less prevalent.

During the summer, the Persian Trough is the dominant weather type, with subtropical anticyclones dominating at upper levels. At daily intervals, the Persian Trough has the largest persistence, rarely interrupted by other weather types. For example, the Sharav Cyclones, as temporary partners of the Persian or Red Sea Troughs, have a horizontal scale of less than 1,000 km (Alpert and Ziv, 1989), while the trajectory of Cyprus cyclones is more than 2,500 km, occurring 8 to 13 times per year and lasting 5 to 7 days (Mandel et al., 2006).

1.5.3 Currents

The Mediterranean Sea comprises three main water masses (Zavattarelli et al., 1995):

- The upper layer is called Modified Atlantic Water (MAW), having a thickness of 50 to 200 m and salinity that changes from 36.2 near Gibraltar to 38.6 in the Levantine Basin. This layer moves from west to east.

- The intermediate layer is called Levantine Intermediate Water (LIW), which is formed in the Levantine Basin, at depths between 200 and 800 m, with temperatures of 13°C to 15.5°C, and salinity of 38.4 to 39.1. This layer moves from east to west.

- The deep water layer is called Mediterranean Deep Water (MDW), which is formed in both the western and eastern basins. In the eastern Mediterranean Sea, this layer moves from west to east. The Eastern Mediterranean Deep Water (EMDW) is characterized by a temperature of 13.6°C and a salinity of 38.7.

Within the Mediterranean Sea, the incoming Atlantic water is continuously modified by interactions with the atmosphere and mixing with older surface waters and with the waters underneath. Along its course, MAW is seasonally warmed or cooled, but overall its salt content increases and it becomes denser. In autumn, in the northern parts of both basins, MAW remains at the surface. In winter, cold and dry air masses induce marked evaporation and direct cooling of MAW, resulting in a dramatic increase in its density, making it sink. This sinking occurs in a series of specific zones, generally located in the northern parts of the basins, and is responsible for the formation of the deeper waters in the Mediterranean.

The surface wind-driven currents in the eastern Mediterranean Sea are affected by the seasonal cycle present in the wind-stress curl that induces a strongly seasonal barotropic circulation covering the entire area. This seasonal gyre reverses from being cyclonic in winter to anticyclonic in summer. The inclusion of baroclinicity, however, profoundly modifies the purely wind-driven, barotropic circulation, eliminating the strong seasonality and the winter-to-summer reversal. For the Levantine Basin, thermohaline fluxes are the driving force for surface currents (Malanotte-Rizzoli and Bergamasco, 1991).

Rohling et al. (2009) provided an update of historical and current characterizations of the local oceanographic processes offshore Israel.

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 1-21** through **1-23** present compass rose plots of the directional distribution of currents at different depths from January to June 2013.

January to June 2013: From January to June 2013, the 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.

There was a series of episodes of higher flows at 328 m depth from 24 to 29 April having a periodicity of approximately 22 hours. The maximum speed of 24.4 cm/s was attained during this period and is higher in magnitude than at the 266-m depth higher in the water column. A more significant episode of high mid-water depth currents occurred at this depth in December 2011 in which the currents reached 57.3 cm/s.

Table 1-4. Summary of mean and maximum current speeds (cm/s) 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	19.0	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	35.0	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	19.0
266	5.0	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	10.0
700	3.5	11.1	2.0	5.9	2.0	8.5
1,450	3.8	12.5	2.0	6.9	2.4	9.3

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

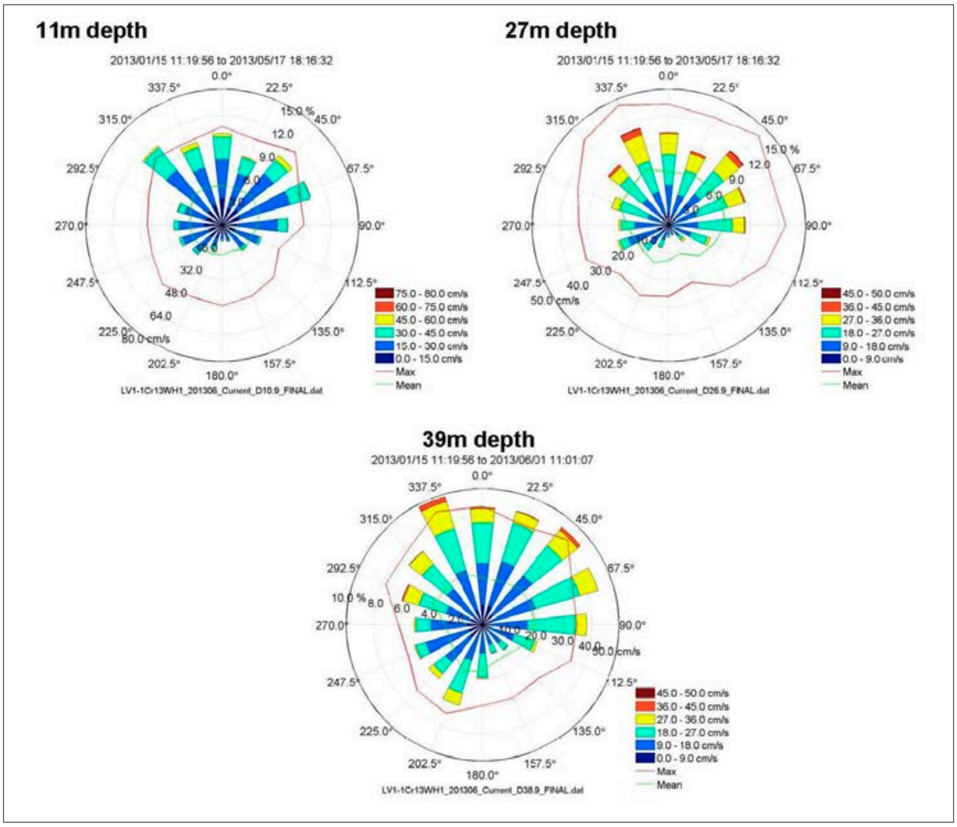


Figure 1-21. Compass rose plots of the directional distribution of currents at depths of 11 m, 27 m, and 39 m at Site LV1-1 (January to June 2013).

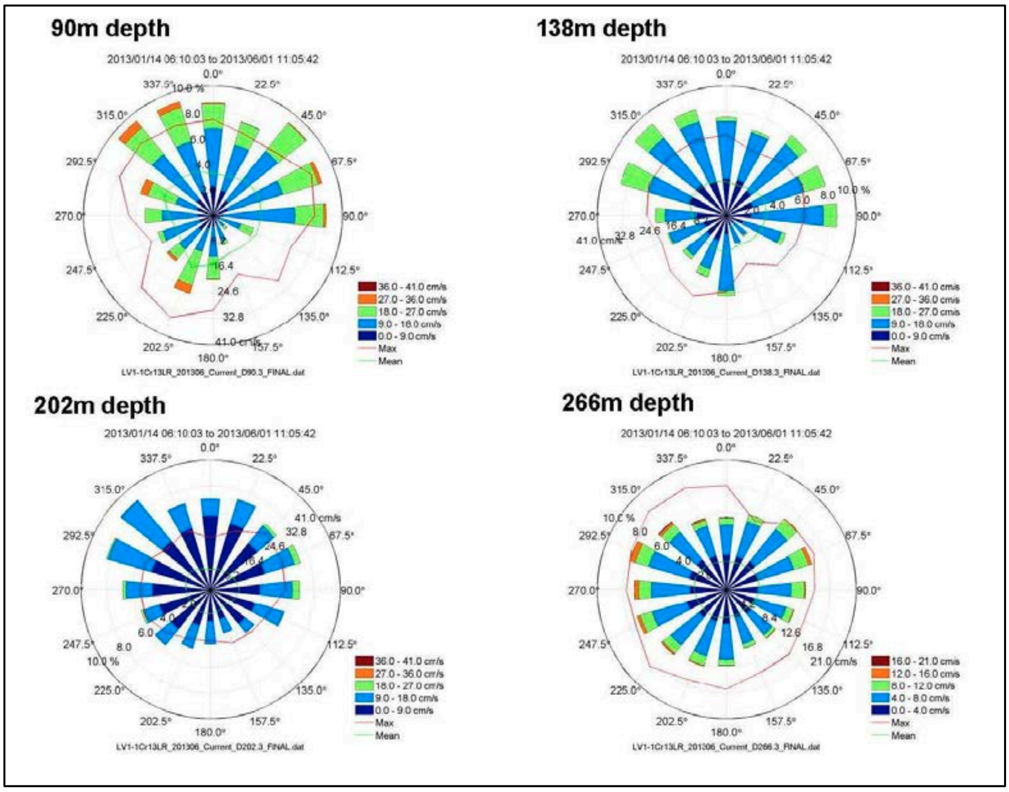


Figure 1-22. Compass rose plots of the directional distribution of currents at depths of 90 m, 138 m, 202 m, and 266 m at Site LV1-1 (January to June 2013).

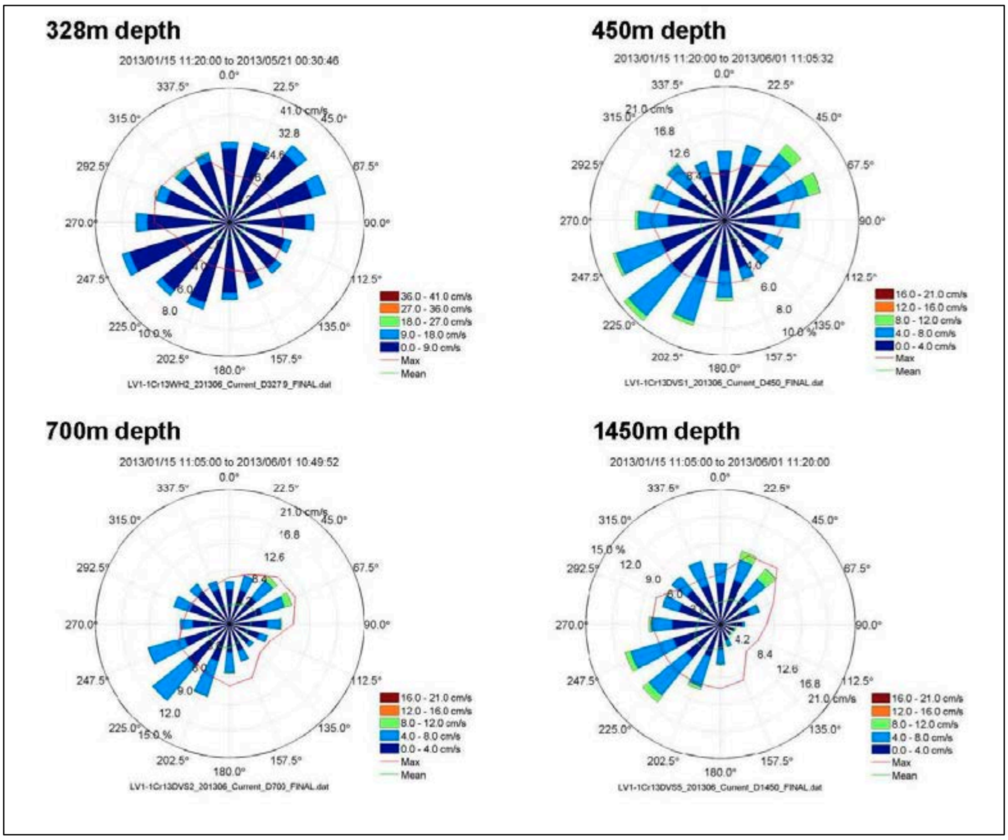


Figure 1-23. Compass rose plots of the directional distribution of currents at depths of 328 m, 450 m, 700 m, and 1,450 m at Site LV1-1 (January to June 2013).

Currents at depths above 266 m generally were directed toward the northeast and northwest. At 335 m depth and below to the near-bottom, the current was aligned along a west-southwest to east-northeast axis.

The highest current speeds were directed toward the northwest and northeast at measurement depths from 11 to 39 m. At 90 m and 138 m, the highest current speeds were toward the south-southwest; at 202 m, 266 m, and 335 m, the highest currents were toward the northeast, northwest, and west-northwest, respectively. From 450 m to the near-bottom (13 m off the seafloor), the highest current speed was toward the east-northeast.

June to October 2013: From June to October 2013, the 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. The mean current at 10 m depth was 13.2 cm/s, and the mean decreased with depth to less than 10 cm/s at 86 m and below. 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 10.0 cm/s.

Currents at depths between 26 and 198 m generally were directed toward the northeast and northwest. In the near-surface, the direction of currents was more distributed but with a slightly predominant west-southwest/east-northeast axis. From 262 to 450 m depth, currents were not highly directional, and below to the near-bottom, the current was more frequently towards the north. Overall, current speeds were moderate during this time period and there were no unusual events. In the upper water column, the maximum current was toward the north-northwest/northwest, but at other depths, the directions were scattered.

October 2013 to April 2014: Between October 2013 and April 2014, the 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 mean current at 10 m depth was 11.7 cm/s, and the mean decreased with depth to less than 10 cm/s at 86 m and below. 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.

The nearest surface instrument recorded the maximum current speed of 41.8 cm/s towards a southeast direction at a depth of 10 m during the measurement period. The most frequently observed current direction at this depth was toward the north and north-northeast, although there was not a strong directionality to the currents over the full deployment period. The predominant current direction was towards the north, northeast, and east at all depths; however, currents were not strongly directional especially below 134 m. The direction of maximum current varied with depth. Overall, the current speeds were moderate during this time period and there were no unusual events.

1.5.4 Winds

The Mediterranean Sea is located between the Westerlies and the Trade Winds. The wind regime is dominated by the Westerlies in winter and the Trade Winds in summer. The surface atmosphere flow field is characterized by subregional wind regimes, which are strongly dependent upon the interaction of the Westerlies with the local orography during winter and the land-sea temperature contrast during summer. The general wind direction is westerly during winter with a stronger northerly component during late summer over the Eastern Mediterranean region (Pinardi and Masetti, 2000).

There is no known wind dataset representative of the Leviathan Field area. In the absence of an observed dataset, wind data can be obtained from the output of a numerical atmospheric model. Data were assessed from 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) Climate Diagnostics Center. Wind speed and direction data at a 10-m height from the NCEP model grid location closest to the drillsite (approximately 50 km north-northwest) were obtained from the

Climate Diagnostics Center data server for the 10-year period from January 1999 to January 2009 as representative for the drillsite location.

Figure 1-24 shows annual and monthly wind roses developed from the NCEP model grid location. Based on the NCEP dataset, the wind regime is characterized by predominant westerly winds throughout most of the year (January through October) and varied winds in November and December. Winds are generally moderate in speed, with mean monthly speeds of approximately 5 m/s. Overall, strong seasonal variability is not evident in the wind data. Winter winds (December through February) have higher maximum speeds than the remainder of the year, but mean wind speeds are relatively comparable throughout the year.

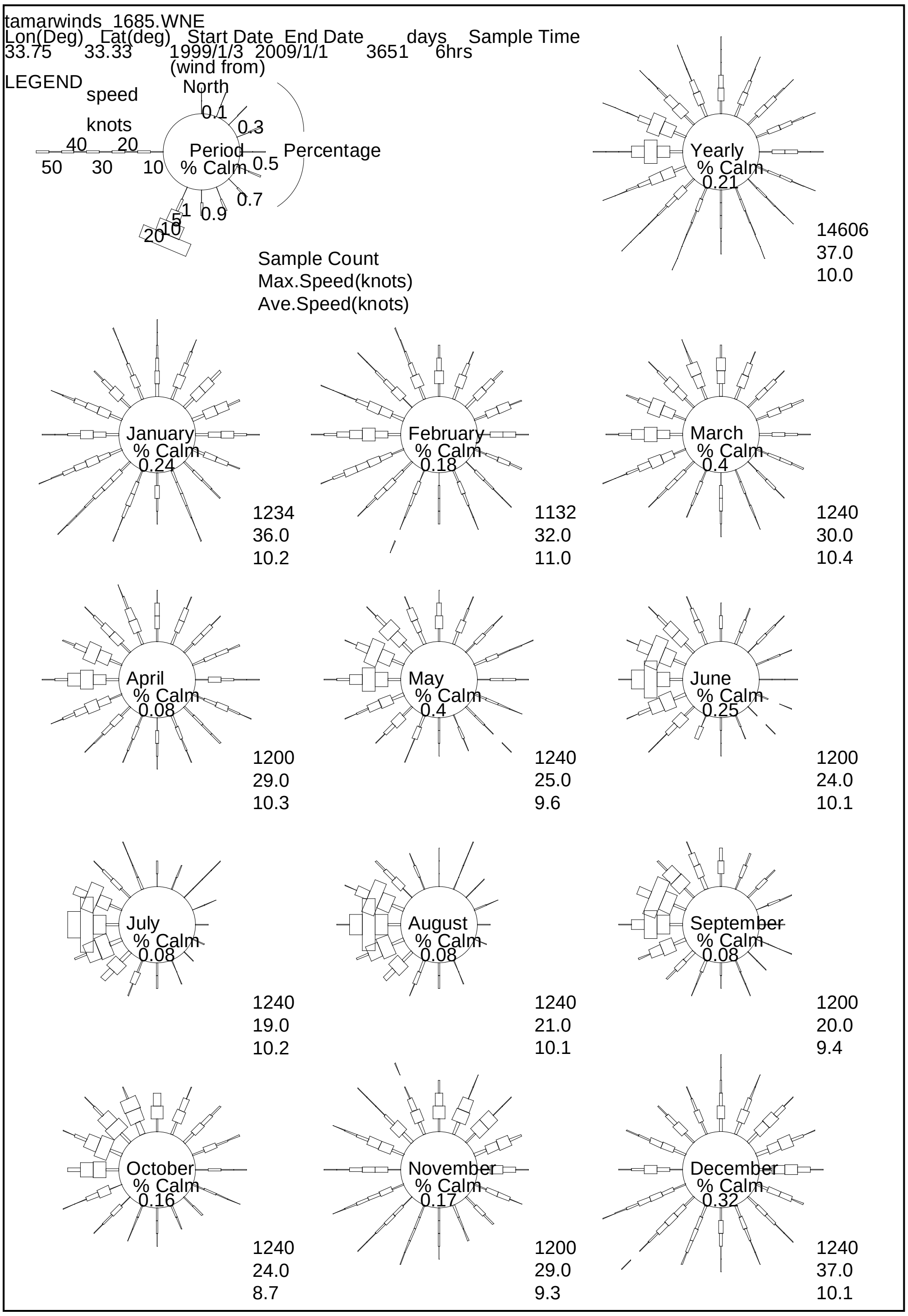


Figure 1-24. Monthly and yearly wind roses of National Center for Environmental Predictions Wind Station 1685, January 1999 through January 2009.

1.6 NATURE AND ECOLOGY

1.6.1 Benthic Communities

This area of the Levantine Basin is characterized by smooth, relatively flat soft bottoms. Sediments in the Leviathan Field generally are composed of clay and silt (see **Section 1.4.6**). Soft bottom assemblages are composed of biota (typically fauna in depths below the photic zone) living within the sediments (infauna) and on the sediment surface (epifauna). Several studies have documented the composition of these communities in the general area of the Leviathan Field (Kress et al., 1993; Galil and Goren, 1994; Kröncke et al., 2003; Galil, 2004). These studies, as well as other Noble Energy surveys, have shown that infauna and epifauna generally are in low abundance compared to nearshore environments.

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). A summary of the composition of major infaunal phyla within the Leviathan Field is presented in **Table 1–5**. The dominant phyla were Annelida and Arthropoda, which composed 63.59% and 25.87% of the total fauna, respectively. The phyla Mollusca and Platyhelminthes contributed 5.30% and 2.79%, respectively. The five most common taxonomic subgroups are presented in **Table 1-6**. These five subgroups make up 49.4% of the fauna within the Leviathan Field. The most abundant taxonomic subgroup was the arthropod *Typhlotanais* sp., accounting for 16.09% of the total infauna. The other four most dominant subgroups were within Annelida: *Notomastus* sp., Polycirrinae, *Scolelepis* sp., and *Prionospio* sp.

Table 1–5. Density and percent composition of major infauna phyla within the Leviathan Field sampling grids.

Taxonomic Subgroup	Density (individuals m^{-2})	Infauna (% composition)
Leviathan Field		
Annelida	68.24	73.78
Arthropoda	16.30	17.63
Cnidaria	0.03	0.03
Echinodermata	0.06	0.06
Mollusca	3.58	3.88
Nemertea	0.55	0.59
Platyhelminthes	1.19	1.28
Sipuncula	2.54	2.75
Total	**92.49**	**100**

Table 1–6. Total density and percent composition of total infauna for the five most abundant taxonomic subgroups within the Leviathan Field sampling grids.

Phylum	Taxonomic Subgroup	Density (individuals m^{-2})	Infauna (% composition)
Leviathan Field			
Annelid	*Prionospio* sp.	11.07	11.97
Annelid	Spionidae	10.43	11.28
Annelid	*Notomastus* sp.	9.51	10.28
Arthropod	*Typhlotanais* sp.	6.94	7.50
Annelid	*Glyphanostomum* sp.	6.41	7.06
Total			**48.09**

During the Leviathan Background Monitoring Survey, infaunal density was generally within the 99% confidence limit (CL) of the Levantine Basin Baseline, with the exception of the area immediately surrounding Leviathan-2 and at a location in the western portion of the grid

(**Figure 1-25**). The color scale in **Figure 1-25** represents the density of infauna within a grid cell and this correlates to the number of standard deviations above the Leviathan Basin Baseline for infaunal density. For example, the yellow color indicates infaunal densities above 462 individuals per m^2 and this is greater than 3.5 standard deviations above the Leviathan Basin Baseline.

Increased infaunal density around the Leviathan-2 wellsite was primarily due to the abundance of members of the phylum Annelida (namely *Prionospio* sp. and Spionidae). Density of all annelids, *Prionospio* sp., and Spionidae around the Leviathan-2 wellsite was 511, 169, and 184 individuals per m^2, respectively. Increased infaunal density around Leviathan-2 was likely due to the subsurface discharge of formation sands covering the seafloor within 200 m of the wellsite during an uncontrolled discharge event that occurred between July 2011 and August 2012. The depth of the formation sand layer ranged from more than 3 m thick within 50 m and 2 cm thick within 200 m of the wellsite. The formation sand was low in most metals and hydrocarbon concentrations, and therefore was not considered toxic to marine life. 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. Increased infaunal density in the western portion of the grid (the yellow circular area in **Figure 1-25**) was due to the arthropod *Typhlotanais* sp., which had a density of 653 individuals per m^2 within that grid cell. There has been no development within this area and it is likely that changes in density are due to natural variability.

Mollusk densities were generally low and uniform throughout the region and were not above the 99% CL of mollusk density of the Leviathan Field. The mean density of mollusks was 5.5 individuals per m^2. A family of the Platyhelminthes phylum (flatworm), Stylochidae, was found in patches of relatively high densities in the northern (centered on B03) and southern (centered on J11) areas of the Leviathan. The mean density of Stylochidae was low (3.19 individuals per m^2) and ranged between 0 and 40.8 individuals per m^2. Patches of relatively high densities of the phylum Sipuncula (peanut worm) were found in the western portion of the Leviathan Field centered on I14 and B10. The mean density of the phylum Sipuncula was 1.75 individuals per m^2, ranging between 0 and 32.7 individuals per m^2.

Diversity indices for the Leviathan Field are summarized in **Table 1-7**. The number of taxonomic subgroups throughout the region was low and below the 99% CL of the Leviathan Field mean, averaging 7 ± 3 taxa per grid cell (**Figure 1-26**). Taxonomic diversity, as calculated by the Shannon-Weiner Diversity Index, was low to moderate throughout the region (1.6 ± 0.5). There were no locations within the Leviathan Field where taxonomic diversity was greater than the 99% CL (**Figure 1-26**). This finding indicates that relatively few unique taxa were found throughout the Leviathan Field. Pielou's evenness was high indicating that all taxa within the region have comparable numerical equality (i.e., low densities for most infaunal organisms).

Except for high densities of the *Prionospio* sp. around the Leviathan-2 wellsite, there was no apparent visual pattern to organism density, composition, or diversity associated with the distribution of existing wellsites within the Leviathan Field. Therefore, multivariate analyses were run to identify any correlation between the environmental variables (trace metals, sediment grains size, total organic carbon, and total petroleum hydrocarbons) and infaunal taxonomic composition. The subset of environmental variables most highly correlated (Spearman's rho=0.435) with the infauna similarity matrix included % clay, barium, and copper (vanadium, nickel, and zinc). The permutation test for this match was significant (999, permutations p=0.1%). The result of this test should be viewed as an exploratory analysis identifying a subset of variables that correlated with the taxonomic composition (similarity patterns) in the infauna matrix. The correlation is relatively weak (Spearman's rho ranges from 0 [no correlation] to 1.0 [perfect correlation]) and does not indicate a particularly strong influence on the biotic assemblage.

Specific types of biological communities known as chemosynthetic communities have been documented in the eastern Mediterranean Sea (e.g., Dimitrov and Woodside, 2003) and other locations worldwide. However, chemosynthetic communities have not been encountered in any surveys conducted by Noble Energy in the Levantine Basin, including the Leviathan Field.

Several visual surveys were conducted for pre-drill studies within the Leviathan Field at the following proposed or drilled wellsites: ML-1X, Leviathan-2, Leviathan-3, Leviathan-4, Leviathan-5, and Leviathan Deep (CSA International, Inc., 2011, 2012; CSA Ocean Sciences Inc., 2013a,b). No hard bottom outcroppings were observed during the visual survey of sites located within the Leviathan Field. Hard bottom offshore Israel is most prevalent in shallower shelf waters at water depths of 5 to 30 m and includes naturally occurring sandstone outcrops (Alder, 1985) and artificial structures (Spanier, 2000). However, a deepwater hard bottom area was discovered in a water depth of approximately 650 m west of Tel Aviv during a cruise by the R/V *Nautilus* (Bell and Fuller, 2011).

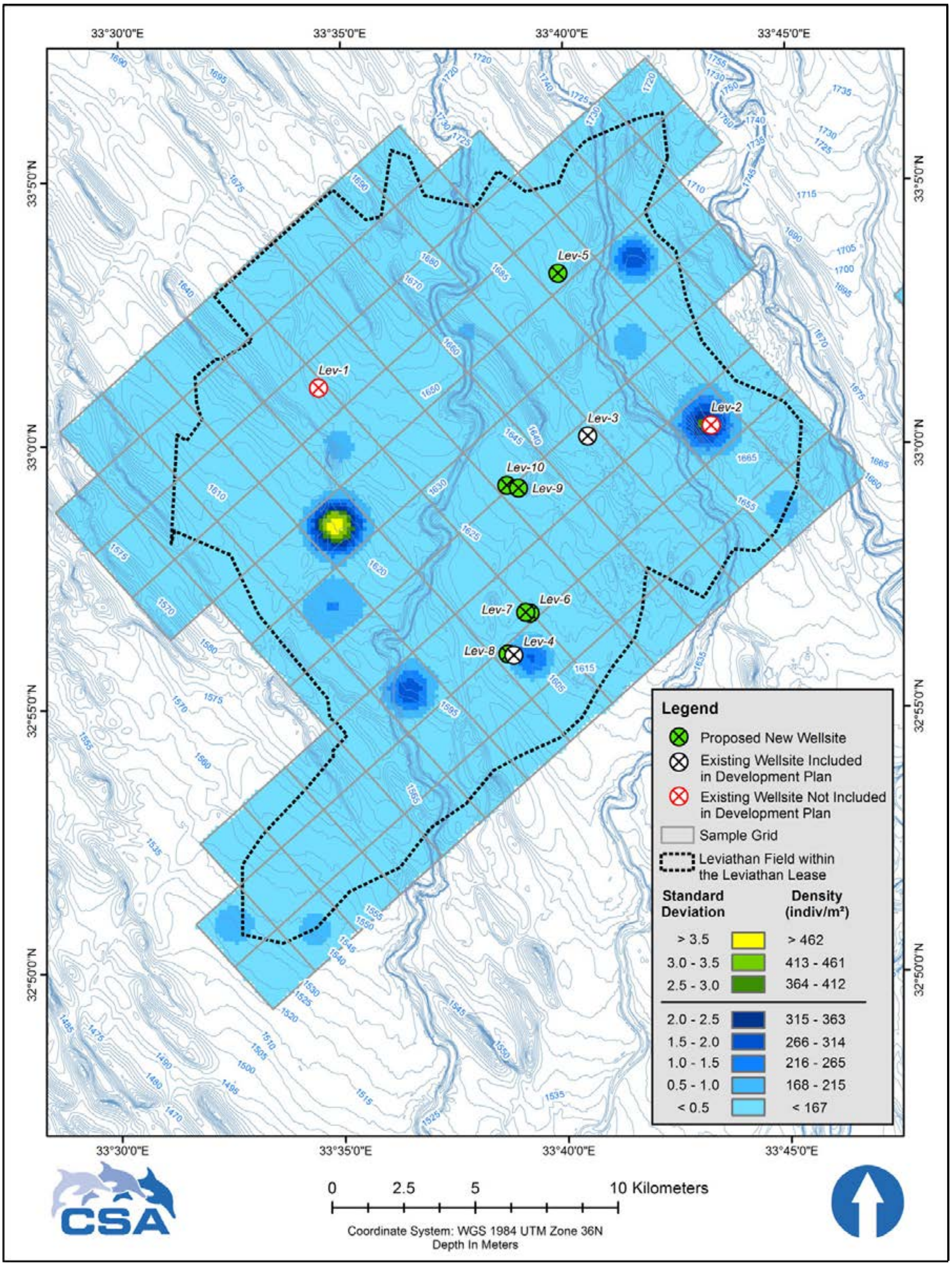


Figure 1–25. Kriged densities (individuals per m^2) of benthic infauna within the Leviathan Field. Blue represents values that are within the 99% confidence limit of the Levantine Basin Baseline (the mean of pre-drilling samples from the region). Two of the existing wells shown (Leviathan-1 and Leviathan-2) are not part of the activities in this Application. Proposed New Wellsite locations are preliminary; final well locations may vary slightly. Contours indicate water depth in meters.

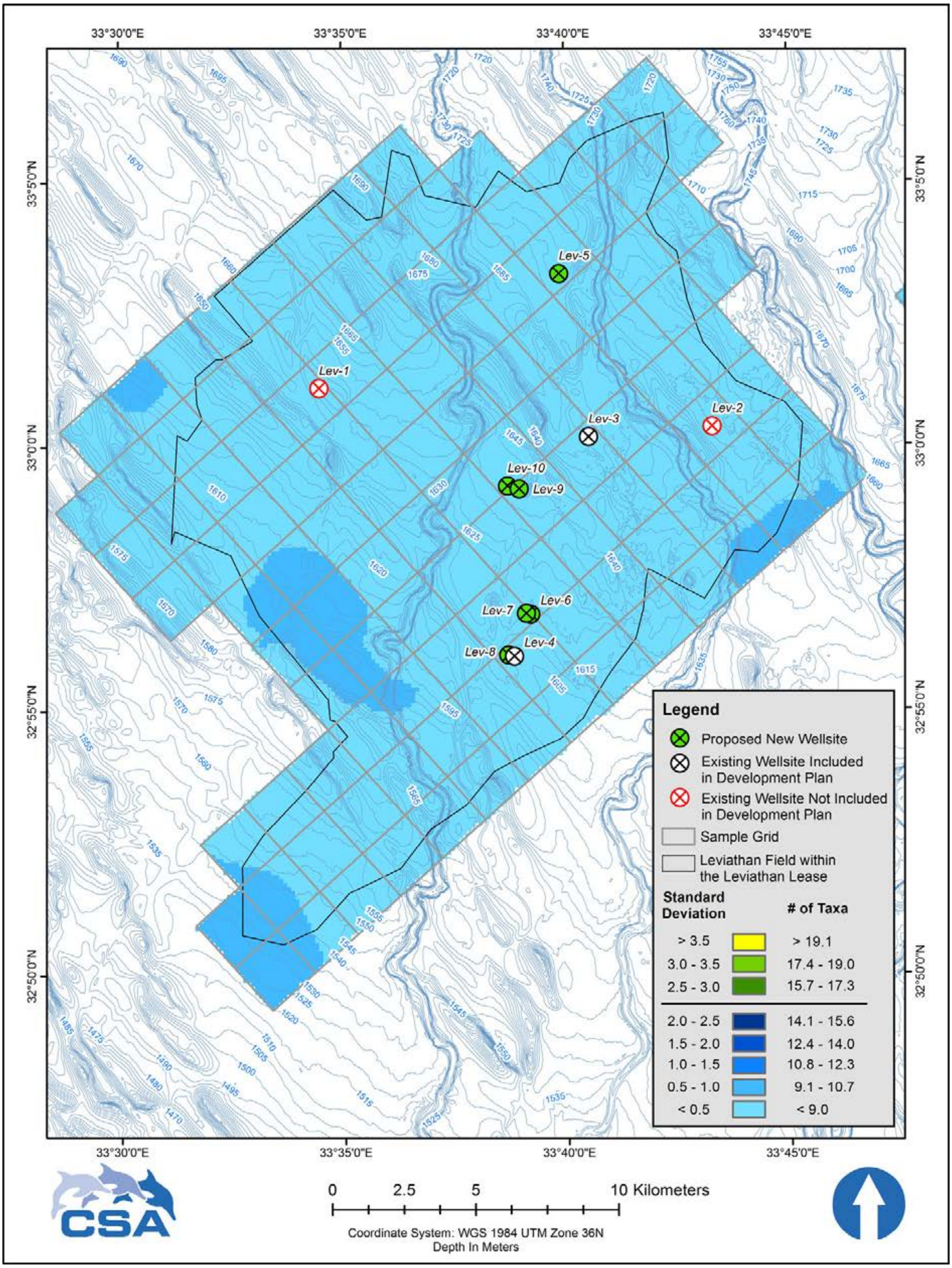


Figure 1–26. Taxonomic richness within the Leviathan Field. Map color scales are standardized to show the possible range of values; therefore, all colors in the scale may not be present on the map because concentrations at those levels may not be present. Note that not all taxa were identified to the species level.

Table 1–7. Mean (± standard deviation) diversity metrics within the Leviathan Field grid cells.

Location	Number of Taxonomic Subgroups	Shannon-Wiener Diversity (H′)	Pielou's Evenness (J′)
Leviathan Field	7 ± 3	1.663 ± 0.544	0.920

1.6.2 Marine Mammals, Sea Turtles, Birds, and Fishes

1.6.2.1 Marine Mammals

There are no site-specific marine mammal data from the Application Area. Regional sightings and strandings data for marine mammals in the Mediterranean Sea have been reviewed and summarized by Notarbartolo di Sciara and Birkun (2010) and Reeves and Notarbartolo di Sciara (2006). Kerem et al. (2012, 2014) reviewed the status of cetaceans in the Levantine Basin and Israeli waters, respectively. Based on these studies, **Table 1-8** lists marine mammal species that may be present in the Application Area.

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*	VU[2]	Yes
Visitor Species (Levantine Basin)			
Fin whale	*Balaenoptera physalus*	EN	Yes
Minke whale	*Balaenoptera acutorostrata*	LC	Yes
Sperm whale	*Physeter macrocephalus*	VU	Yes
False killer whale	*Pseudorca crassidens*	DD	Yes
Cuvier's beaked whale	*Ziphius cavirostris*	LC	Yes
Vagrant Species (Levantine Basin)			
Indo-Pacific humpback dolphin	*Sousa chinensis*	NT	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*	DD	No
Dwarf sperm whale	*Kogia sima*	DD	No
Sowerby's beaked whale	*Mesoplodon bidens*	DD	No
Blainville's beaked whale	*Mesoplodon densirostris*	DD	No
Gervais' beaked whale	*Mesoplodon europaeus*	DD	No
Harbor porpoise	*Phocoena phocoena*	LC	No
Mediterranean monk seal	*Monachus monachus*	CR	No

ACCOBAMS = Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area.
[1] International Union for the Conservation of Nature (IUCN) status: CR = critically endangered; DD = data deficient; EN = endangered; LC = least concern; VU = vulnerable.
[2] The VU designation for bottlenose dolphins applies to the Mediterranean subpopulation.

Small cetacean species that are considered regular species or visitors in the Levantine Basin include the common bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphus*), Risso's dolphin (*Grampus griseus*), rough-toothed dolphin (*Steno bredanensis*), striped dolphin (*Stenella coeruleoalba*), and false killer whale (*Pseudorca crassidens*). Large cetaceans that are considered regular residents or visitors in the Levantine Basin include the fin whale

(*Balaenoptera physalus*), minke whale (*Balaenoptera acutorostrata*), and sperm whale (*Physeter macrocephalus*). The humpback whale (*Megaptera novaeangliae*) and killer whale (*Orcinus orca*) are considered vagrants in the Levantine Basin, along with the Indo-Pacific humpback dolphin (*Sousa chinensis*), a Lessepsian migrant introduced through the Suez Canal. Several other marine mammal species are considered vagrants elsewhere in the Mediterranean and their presence is not confirmed in Israeli waters (**Table 1-8**). There is one report of a gray whale (*Eschrichtius robustus*) sighting offshore Israel, but it is considered an extreme example of a vagrant species (Kerem et al., 2012).

Six of the species in **Table 1-8** are listed by the International Union for Conservation of Nature (IUCN) as either critically endangered (Mediterranean monk seal), endangered (fin whale, sei whale, and north Atlantic right whale), or vulnerable (sperm whale and common bottlenose dolphin) (International Union for Conservation of Nature, 2014). Of these, the common bottlenose dolphin is the most abundant in the region and the only one that is a regular resident of the Levantine Basin (Kerem et al., 2012). The fin whale and sperm whale are visitors, whereas the sei whale and North Atlantic right whale are vagrants in the Mediterranean and are not reported from Israeli waters.

The Mediterranean monk seal (*Monachus monachus*), a critically endangered species, is the only pinniped found in the Mediterranean region. The Mediterranean monk seal population is estimated at approximately 350 to 450 surviving individuals, making it one of the world's most critically endangered mammals (International Union for Conservation of Nature, 2014). It is very unlikely that monk seals will be present in the Application Area because they are extremely rare within waters offshore Israel. A single monk seal was spotted off the coast of Herzliya in January 2010, the first such sighting in recent decades. The last sightings of Mediterranean monk seals off Israel's coast prior to this event were 50 and 60 years ago.

Kerem et al. (2014) assessed the status of small cetacean species offshore Israel, including bottlenose dolphin, short-beaked common dolphin, Risso's dolphin, rough-toothed dolphin, and Cuvier's beaked whale. Abundance was not estimated for any of these species. Based on strandings and sightings data, common bottlenose dolphin appears to be the most abundant. Rough-toothed dolphin is the only Mediterranean cetacean species for which the Levantine Basin may be the critical habitat for the subpopulation (Notarbartolo di Sciara and Birkun, 2010; Kerem et al., 2012).

According to Kerem et al. (2012), the common bottlenose dolphin accounts for 85% of all reported marine mammal sightings and 60% of strandings. Although most of the sightings are in shallow coastal waters, there have been sightings up to 30 km offshore, over water depths of approximately 1,300 m. As noted previously, the Mediterranean subpopulation has been listed by the IUCN (2014) as Vulnerable. The justification for this status includes evidence of substantial incidental mortality in fishing gear, overfishing of dolphin prey, habitat loss and degradation, disturbance by marine traffic, and high levels of contamination by pollutants (Bearzi et al., 2012).

CSA Ocean Sciences Inc. (2014c) 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.

1.6.2.2 Sea Turtles

There are no site-specific sea turtle data from the Application Area. However, tracking studies indicate that sea turtles could occur in the Application Area (Seaturtle.org, 2008). Three sea turtle species are known to occur in the Levantine Basin: green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), and loggerhead turtle (*Caretta caretta*) (**Table 1-9**). The IUCN (2014) lists loggerhead and green turtles as endangered, and leatherback turtles as vulnerable. The hawksbill turtle (*Eretmochelys imbricata*), a critically endangered species, also occurs occasionally in the Mediterranean Sea (Camiñas, 2004) but would not be expected within the Levantine Basin (Kot et al., 2013).

Table 1–9. Sea turtle species potentially occurring in the Application Area.

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

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

Loggerhead turtles and green turtles nest along the Israeli coast, with the loggerhead turtle being more common. While the primary nesting grounds for the Mediterranean loggerhead turtle population are located along the shores of Greece, Cyprus, and Turkey, the Israeli coast has historically provided habitat for hundreds of nests. Nesting starts at the end of May for loggerhead turtles and in mid-June for green turtles, continuing until the end of July and mid-August, respectively. According to data from the Israel National Parks Authority, the number of loggerhead turtle nests was 98 in 2009, 132 in 2010, and 139 in 2011; and the number of green turtle nests was 17 in 2009, 10 in 2010, and 25 in 2011 (Levy, 2011).

1.6.2.3 Seabirds and Migratory Birds

There are no site-specific bird data from the Application Area. However, the Mediterranean is home to several hundred bird species, many of which could occur in the area. This discussion includes seabirds as well as migratory birds that pass through the area.

Seabirds. At least 38 seabird species are native to Israeli waters (**Table 1-10**). This includes 36 seabird species listed by BirdLife International (2014a), plus two others based on additional information (International Union for Conservation of Nature, 2014; Palomares and Pauly, 2014). Because the Application Area is more than 100 km offshore, the avifauna is likely to consist mainly of pelagic seabirds – those that spend most of their life cycle in the marine environment, often far offshore over the open ocean. Examples of pelagic seabirds 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*). Other seabirds, including various species of gulls, terns, pelicans, and cormorants, could occur in the Application Area but are likely to be more abundant in near-coastal waters.

Two of the seabirds listed in **Table 1-10** are Vulnerable according to the IUCN (2014) Red List. The Yelkouan Shearwater is endemic to the Mediterranean basin, but its precise distribution is not well known and numbers are disputed (Bourgeois and Vidal, 2008). The main breeding colonies are in the central and eastern basins of the Mediterranean, from Corsica and Sardinia through the central Mediterranean and into the Adriatic and the Aegean (International Union for Conservation of Nature, 2014). There is no reported breeding in Israel. The Dalmatian Pelican (*Pelecanus crispus*) breeds in eastern Europe and east-central Asia; there is no reported breeding in Israel.

Several of the pelagic seabird species in **Table 1-10** are listed in Annex II of the Protocol Concerning Specially Protected Areas and Biological Diversity of the Mediterranean (United Nations Environment Programme, 2013) as endangered or threatened avifauna of the Mediterranean region. These include Cory's Shearwater, Slender-billed Gull (*Larus genei*), Mediterranean Gull (*Larus melanocephalus*), Dalmatian Pelican, Great White Pelican (*Pelecanus onocrotalus*), Pygmy Cormorant (*Phalacrocorax pygmeus*), Levantine Shearwater, Little Tern (*Sterna albifrons*), Lesser Crested Tern (*Sterna bengalensis*), Caspian Tern (*Sterna caspia*), Gull-billed Tern (*Sterna nilotica*), and Sandwich Tern (*Sterna sandvicensis*). Two of these, the Great White Pelican and Little Tern, breed in Israel; their IUCN status is "least concern."

Annex II also includes several shorebirds reported from Israel as listed in **Table 1-11**. The Slender-billed Curlew (*Numenius tenuirostris*), is listed by the IUCN as Critically Endangered but is considered a vagrant species in Israel and does not breed there. None of these species are likely to be present in the Application Area.

Table 1–10. Seabird species occurring in Israeli waters (Adapted from: BirdLife International, 2014a).

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*	NT	--	--
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*	LC	--	--
Dalmation Pelican[4]	*Pelecanus crispus*	VU	Yes	--
Great White Pelican	*Pelecanus onocrotalus*	LC	Yes	Yes
Great Cormorant	*Phalacrocorax carbo*	LC	--	--
Pygmy Cormorant[4]	*Phalacrocorax pygmeus*	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) 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 (2014a) map viewer showing range and breeding locations.

[4] Dalmation Pelican and Pygmy Cormorant are not listed as native to Israel by BirdLife International (2014a) but have been added based on IUCN (2014) and their individual species descriptions on the BirdLife International website.

Table 1–11. Shorebird species occurring in Israel that are on the Annex II list.

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 columbinus*	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) status: CR = critically endangered; LC = least concern.
[2] Occurrence in Israel based on IUCN (2014).
[3] Breeding in Israel based on BirdLife International (2014a) map viewer showing range and breeding locations.

Migratory Birds. Israel is well known as one of two major migratory pathways in the Mediterranean region, with the other being Gibraltar. Research over the past decade has shown that approximately 500 million migrating birds fly over Israel's narrow airspace (Leshem and Atrash, 1998). The location is a "bottleneck" of the migration route for approximately 85% of the world's White Stork (*Ciconia ciconia*) population, many species of birds of prey, and most of the Paleartic population of White Pelicans.

The Mediterranean lies along seasonal migratory pathways for several European and African species; several species that breed in Europe over-winter in the Mediterranean basin. Autumn and spring are the busiest times of the year for migrating birds. Many of the migratory species seasonally traverse the expanses of Europe and Asia from the high Arctic to Africa and the Indian subcontinent. Migrating shorebirds feed and reside in coastal areas along sandy beaches, embayments, shallow tidal flats, and brackish ponds. Mudflats are the often the last refueling stopover for migratory birds traveling from their Northern Hemisphere breeding grounds (Siberia, Russia) on their way to the Southern Hemisphere wintering grounds before crossing the thousands kilometers of Arabian desert. They also provide a respite for these flying migrants on their way back.

BirdLife International (2014b) lists 315 migratory bird species as occurring in Israel. Of these, species listed by the IUCN (2014) as Endangered, Critically Endangered, or Vulnerable are: Basra Reed-warbler (*Acrocephalus griseldis*), Greater Spotted Eagle (*Aquila clanga*), Eastern Imperial Eagle (*Aquila heliaca*), Houbara Bustard (*Chlamydotis undulata*), Saker Falcon (*Falco cherrug*), Northern Bald Ibis (*Geronticus eremita*), Marbled Teal (*Marmaronetta angustirostris*), Egyptian Vulture (*Neophron percnopterus*), White-headed Duck (*Oxyura leucocephala*), Dalmatian Pelican, Yelkouan Shearwater, Syrian Serin (*Serinus syriacus*), and Sociable Lapwing (*Vanellus gregarius*).

Of the 15 Important Bird Areas (IBAs) designated in Israel, two include coastal habitats (BirdLife International, 2014c). The Zevulun Valley IBA within the coastal plain north of Haifa is largely developed or agricultural, with fish ponds and some other small wetlands, including the marsh at Ein Afeq (a nature reserve and Ramsar wetlands site), approximately 8 km south of Akko. The Carmel Coast IBA is 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), a large complex of fish ponds at Ma'agan Mikhael and Ma'ayan Zvi (25 km north of Netanya), and some small islands off Ma'agan Mikhael.

1.6.2.4 Fishes

The Mediterranean Sea supports more than 700 fish species (Froese and Pauly, 2014). There are 636 marine fish species reported from Israeli waters, including 582 natives and 54 introduced species (Froese and Pauly, 2014). The distribution of these species varies in relation to hydrography, physiography, and environmental factors over multiple basins and ridges that shape the

Mediterranean. A broad pattern within the Mediterranean is that the number of species decreases from west to east. This gradient of richness is thought to be correlated with gradients of increasing temperature and salinity and decreasing productivity. The waters of the Levantine Basin are considered oligotrophic (nutrient-starved) and do not support particularly rich fisheries.

The ichthyofauna is generally composed of species with Atlantic (75%) and cosmopolitan (20%) origins (Golani, 2005). Important additions to this ichthyofauna are the numerous Indo-Pacific species introduced through the Suez Canal (e.g., 54 introduced species in Israel, as noted previously). This invasion 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 (bottom dwelling) or pelagic (water column dwelling). Demersal species can be further subdivided into soft bottom and hard bottom species, depending on the type of substrate.

The regional ichthyofauna can be summarized based on surveys conducted by Galil (2004). A series of 12 cruises were conducted between 1988 and 1991 to study the bathyal environment off the coast of Israel (i.e., along the 1,500-m depth contour west of Dor). A total of 566 specimens from 31 fish species was collected. Mediterranean spiderfish (*Bathypterois mediterraneus*) and roughtip grenadier (*Nezumia sclerorhynchus*) were the most common, representing 38% and 27% of the specimens, respectively. Cusk eels (*Cataetyx laticeps*), Sloane's viperfish (*Chauliodus sloani*), and the ubiquitous Mediterranean spiderfish were photographed at a depth of 2,900 m. Other fishes 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). 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 also.

A recent set of cruises by the R/V *Nautilus* was performed at depths of 650 to 1,600 m in 2010 (Bell and Fuller, 2011). Several species emerged as dominant, namely the wreckfish *Polyprion americanus* and the tripodfish *Bathypterois mediterraneus*, which was the most common fish species observed near the Application Area. Other fishes included shark (*Centrophorus* spp.) and skate (*Dipturus oxyrhinchus*), the anglerfish *Lophius piscatorius,* the forkbeards *Phycis phycis* and *Phycis blennoides,* the ghost shark *Chimaera monstrosa,* the dragonfish *Stomias boa,* and several unidentified hatchetfish, scorpionfishes, triglids, and flatfishes.

The pelagic offshore environment includes both small and large pelagic fish species. Whereas small pelagics tend to be more concentrated in shallow waters, larger pelagics may be found farther offshore in blue water as well. Of the large pelagics, special note is warranted for Atlantic bluefin tuna (*Thunnus thynnus*). Considered one of the most valuable fish species, if not the most valuable, it is undergoing a commercial collapse. Bluefin tuna enter the Mediterranean Sea to spawn in spring. Specimens caught in Israeli waters are almost always observed with ripe gonads. Other large offshore pelagic fishes in the Levantine Basin include albacore tuna (*Thunnus alalunga*) and other scombrids (e.g., *Euthynnus alletteratus*), dolphinfish, swordfish, sailfish, and pelagic sharks (e.g., hammerhead shark, and blue shark, *Prionace glauca*).

Of the deepwater ichthyofauna, hake (*Merluccius merluccius)* is worthy of special mention. This species, once caught by Israeli trawlers on the slope in hundreds of tons (Shapiro, 2007) has all but disappeared in recent years either due to higher sea water temperatures or overfishing (Edelist et al., 2010). Other deepwater species that show significant declines include the wreckfish (*P. americanus*) and the Haifa grouper (*Hyporthodus haifensis*).

1.6.3 Fishing Areas and Landings

No fishing areas are known within the Application Area due to water depth and distance from shore. A brief summary of the regional fishing activities and areas is presented in the following subsections.

1.6.3.1 Commercial Fishing

The Mediterranean coastline of Israel has three main fishing ports – Ashdod, Jaffa, and Kishon (Haifa), although many other landing sites, docking points, and marinas exist for inshore vessels. Fishing is concentrated along the narrow continental shelf, which is 50 km wide along the southern portions of the country and narrows to only approximately 15 km in the north. Fishing takes place year-round over almost the entire continental shelf. Approximately 40% of fishing activity is concentrated between Ashkelon and Jaffa, while another 40% is concentrated in waters between Hadera and Akko.

Table 1-12 presents the composition of the Israeli fishing fleet, based on number of fishing licenses; the table includes ports of origin, fishing method used, and vessel size. It is estimated that 300 inshore vessels, 40 purse seiners, and 20 trawlers exist in Gaza. However, the number of active boats is actually about a one third of this total for inshore and purse seine (i.e., pelagic) fishermen, and two thirds of this total for trawl fishermen (Shapiro, 2007).

Table 1–12. Characteristics of the Israel fishing fleet, including composition by port (anchorage), gear, and vessel size (From: Shapiro, 2007).

Anchorage	Gear Type				Vessel Size (length)		
	Trawl	Pelagic	Inshore	Total	<7 m	7-11 m	>11 m
North of Akko	--	--	7	7	7	--	--
Akko	--	4	53	57	42	9	6
Haifa – Kishon	12	7	94	113	56	38	19
Haifa – Dor	--	--	38	38	37	1	--
Hadera – Tel Aviv	--	--	26	26	14	10	2
Jaffo	9	7	87	103	63	28	12
Ashdod and Ashkelon	10	1	61	72	43	17	12
South of Ashkelon	--	--	22	22	18	4	--
Total Mediterranean Sea	**31**	**19**	**388**	**438**	**280**	**107**	**51**

The Israeli commercial fishing industry generates approximately US$100 million per annum in revenue and employs approximately 1,500 workers (Shapiro, 2007). The Mediterranean fish catch is roughly 3,000 tons, generating approximately US$40 million annually. Most of the fishing in the Mediterranean is in shallow water, in water depths up to 110 m. Fishing in both shallow and deep waters has resulted in depletion of fish, fishing down the food web, elimination of predators, and growth overfishing (species are becoming smaller). In an attempt to reduce the depletion of fish stocks, fishing is controlled by the government, mostly through reduction of effort by freezing the size of the fishing fleet and not allowing any new participants to join.

The catch profile of Mediterranean fishes landed in Israel is mixed, reflecting its multi-species nature. Several species stand out as the most important for each fishing method. The trawl catch comprises more than a dozen species groups, including shrimp, groupers, cephalopods and cartilaginous fishes, and bony fishes (Sparidae, Carangidae). The most important inshore gillnet and trammel net species are sharks and rays, mullets, and sparids (mostly marmoras and *Diplodus* spp.). *Trachurus* spp. and sardines are the principal pelagic species (Food and Agriculture Organization of the United Nations, 2007) and groupers, amberjacks, scombrids, and sparids are the main target species of bottom long-liners.

Bottom Trawling

The otter trawl is a type of bottom trawler used by the Israeli fishing fleet. The mouth of the otter trawl's net consists of a ground-rope, often rigged with heavy steel chains, which drags along the bottom, and headline-bearing floats to keep it as high as possible in the water. The mouth is pulled open by large steel plates, called doors or otter boards, which push laterally as they are hauled through the water, thus pulling the net mouth open. These doors are typically 50 to 70 m apart and can be many meters in front of the net. These weigh up to 300 kg and almost always gouge plough marks in the seafloor. Heavy ropes connect the doors to the net and create clouds of mud which help herd fish into the net.

Trawling is responsible for more than half of the Israeli fishery yields in the Mediterranean. While 31 trawlers are registered and licensed in Israel, only 23 to 25 currently work regularly. The trawl fleet, with vessels characteristically 14 to 25 m in length and displacing 30 to 300 gross tons, is equipped with radar, global positioning system (GPS) devices, echo sounders, and hydraulic winches. Many vessels in the trawling fleet are more than 30 years old (Shapiro, 2007).

Bottom trawlers fish within the territorial waters at depths ranging from 15 to 400 m, but most of the fishing effort is concentrated in waters shallower than 50 m. Typical towing speeds are approximately 3 knots and haul duration is approximately 3 hours in the daytime and 5 hours at night. The entire fleet trawls approximately 120 to 150 km^2 of sandy and muddy bottom daily. Trawling is practiced on a daily basis year-round.

The area south of Hadera is covered mostly by trawlers based in Ashdod and Jaffa ports, and more than 95% of this fishing ground is concentrated on the continental shelf shallower than 110 m. Vessels fish deeper in this area only in late winter when trawling for hake. Southern trawling is always in a north-south orientation, parallel to shore.

Northern trawlers based in the Kishon tend to fish deeper, as the shelf is narrower. This fleet often trawls in circular patterns over several depth strata. Greater depths of up to 400 m, especially north of Shiqmona, are reached when trawling for hake or red shrimp (*Aristeomorpha foliacea*). Fishing regulations forbid the trawl fleet from fishing in depths less than 15 m and other regulations concern minimum landing size of the commonest species but are rarely enforced.

Trawling is a multi-species fishery, with more than 40 species significantly contributing to catches. The prominent commercial trawl fish species include shrimp (most notably the Lessepsian migrant Kuruma prawn [*Marsupenaeus japonicus*]), goatfishes (Mullidae), and white grouper (*Epinephelus aeneus*), which has become rare in recent years, all of which may be sold for US$35/kg. Cephalopods and cartilaginous fishes (i.e., sharks, skates, rays) make up a significant portion of the catch, as do bony fishes from the families Sparidae and Carangidae.

Trawlers usually fish for bottom fishes and cephalopods in the deeper strata during the daytime and then approach shore to trawl for shrimps in shallow waters at night. Until 2005, there was a well-established deepwater trawling fishery for hake and red and rose shrimps in depths between 150 and 500 m; however, recent declines in the hake stock caused this fishery to cease almost completely and trawlers seldom venture beyond 150 m.

Pelagic Fishery

Purse seiners for pelagic fishes range in length from 10 to 12 m and are equipped with power blocks and depth sounders. Twenty-eight purse seiners were registered in 2007, but many boats fished only sporadically. The boats are berthed in the major ports of Jaffa, Kishon, and Akko (Food and Agriculture Organization of the United Nations, 2007). The pelagic fishery reported a catch of 303 tons in 2007, valued at US$1.8 million, which is approximately 1.6% of the total catch (Shapiro, 2007). The predominant species caught via this method are carangid jacks (*Seriola dumerili, Alepes djadaba, Caranx* spp.), tuna and mackerels (*Scomber japonicus,* *Scomberomorus commerson, Euthynnus aletteratus, Trachurus* sp.), sardines (*Sardinella aurita, Sardina pilchardus, Dussumieria elopsoides*), and anchovies (*Engraulis encrasicolus*).

Pelagic fishing has been declining since 2000. Pelagic stocks have undergone significant changes in recent decades which have caused pelagic species such as sardines, anchovies, and mackerels to decline sharply along the Israeli coast (Food and Agriculture Organization of the United Nations, 2007). The main reason for the decline in pelagic fishery landings is the installation of the Aswan High Dam on the Nile in 1969. The presence of the dam, while controlling flooding in the lower Nile River delta, also ended the annual floods that enriched coastal waters of the Eastern Mediterranean region with nutrients and supported a large pelagic fishery in Egypt and Israel. This fishery subsequently collapsed to its current level.

Inshore Fishery

It is estimated that 700 families earn their living directly and 500 families indirectly from the inshore fishery. In 2007, the fleet of licensed fishing boats numbered 519 small vessels. It is estimated, nevertheless, that less than 300 of these vessels fish on a full-time basis (Kerem and Edelist, 2008). The inshore catch in 2007 was 760 tons (3.0% of the total catch) worth US$8.815 million (Shapiro, 2007).

Boats used in the inshore fishery land along the entire Israeli coast, either drawn up on the beaches or in small-protected inlets, or in the major ports and marinas. The fishermen can switch between gillnets and bottom or floating long-lines, depending on the availability of fish and the season (Food and Agriculture Organization of the United Nations, 2007). Kerem and Edelist (2008) estimated inshore fishery activity levels, noting that 50 long-liners deployed more than 50,000 hooks, and 200 trammel and gillnetters deployed 50 to 100 km of nets while engaging in stationary gear fishing. In recent decades, many bottom long-liners ceased fishing due to sharp declines in yield of high-priced target species such as groupers (*Epinephelus marginatus, Epinephelus aeneus*) and sparids (*Pagrus* spp.), which represent a main portion of revenues. Other species missing from catches recently are deepwater demersal groupers and wreckfish, which were once very common. The inshore fishery sector is more or less evenly spread along the Israeli coastline with aggregates occurring around complex rocky bathymetry, such as sandstone ridges or sunken vessels. Inshore fishermen dock (from south to north) at Zikim, Ashkelon, Ashdod, Palmachim, Jaffa, Herzliya, Natanya, Olga, Caesarea, Jasser-A-Zarka, Dor, Shiqmona, Kishon, Acco, and Naharyia.

1.6.3.2 Recreational (Sport) Fishing

Due to the distance from shore, recreational fishing is not expected in the Application Area. However, recreational (sport) fishing does occur in coastal waters. Along with the increase in population, as well as affluence, sport fishing in Israel has risen sharply in recent years (Kerem and Edelist, 2008). Many amateur noncommercial fishermen fish along the Mediterranean coast of Israel in a variety of manners:

- Scuba spear-fishing: Despite recent regulations banning this method and enforcement efforts, it is estimated that several hundred divers still engage in scuba fishing.
- Free dive spear-fishing: Approximately 1,000 free divers engage in the sport of spear-fishing;
- Rod and line fishing: On a sunny day, up to 20,000 Israelis fish with rods from beaches. Estimates for the total number of such anglers range between 50,000 and 300,000;
- Kayak fishing: Roughly 1,000 kayak owners fish along the Israeli coast; and
- Yacht and small craft fishing: Several hundred small boats engage in fishing along the coast.

1.6.4 Coastal Habitats and Infrastructure

The Leviathan Field is located approximately 120 km from the nearest shoreline and therefore, coastal habitats are not within or near the Application area. However, coastal habitats are relevant to the extent that they could be contacted by an accidental spill (see **Section 4.3**).

Table 1-13 summarizes the coastal habitats and infrastructure along the shoreline of Israel. The shoreline is divided into 24 segments according to Noble Energy's Environmental Sensitivity Index (ESI) Atlas. 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 beach (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.

The shorelines of Israel include a variety of 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 ports within the region are Haifa and Ashdod, and there are smaller ports at Acre, Ashkelon, Jaffa, and Tel Aviv.

In addition to cities such as Haifa, Tel Aviv, Acre, Ashdod, Ashkelon, and Netanya, 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.

Table 1–13. Coastal habitats and infrastructure along the Israel coast. The coastline is divided into 24 segments as indicated in Noble Energy's Environmental Sensitivity Index (ESI) Atlas.

Coastal Segment No.	Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Other Important Features
1	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	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	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	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	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
6	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

Table 1-13. (Continued).

Coastal Segment No.	Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Other Important Features
7	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	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	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	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
11	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

Table 1-13. (Continued).

Coastal Segment No.	Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Other Important Features
12	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	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	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	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
16	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	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	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 Le-Zion; Resorts, hotels, and seaside residence; Restricted military area (highly undisturbed area); Sea turtles nesting observed

Table 1-13. (Continued).

Coastal Segment No.	Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Other Important Features
19	Gan Soreq 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	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	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
22	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	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	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.

1.7 SEAWATER AND SEDIMENT QUALITY

1.7.1 Water Quality

1.7.1.1 Hydrography

The deepwater environment of the eastern Mediterranean Sea is characterized by relatively high salinity, low turbidity, low nutrients, and high dissolved oxygen (DO). The yearly ranges for surface salinity and temperature in the eastern Mediterranean Sea are approximately 39.0 to 39.5 and 17°C to 28°C, respectively. Salinity remains fairly constant with depth, while temperature decreases with depth to the range of 14°C to 17°C (Zodiatis et al., 2001). The entire water column is well oxygenated; even the deep waters (e.g., 1,000 m depth) have saturation values greater than 70% to 80%. DO concentrations generally range from approximately 4.8 mg/L at the surface, increasing to 5.4 mg/L through the surface-mixed layer before gradually stabilizing to 4.1 mg/L for the remainder of the water column to the seafloor (Krom et al., 2005).

CSA has conducted several environmental baseline surveys in the Levantine Basin offshore Israel since mid-2011. **Figure 1-27** shows seasonal hydrographic profiles for one station at the Leviathan-2 wellsite in 2011-2012. These are typical hydrographic profiles for the region, and Leviathan-2 is the only station that provides seasonal data.

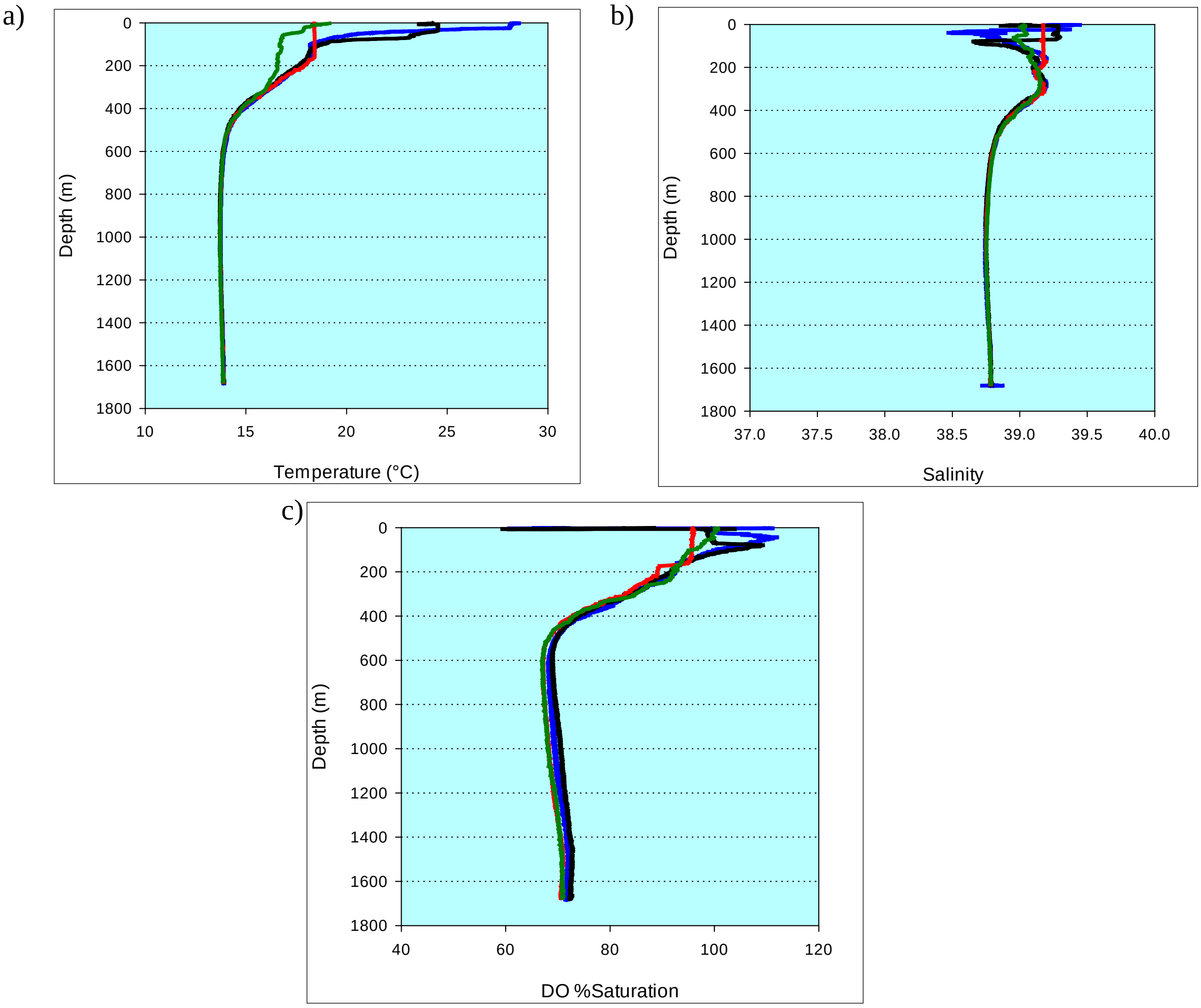


Figure 1-27. Seasonal hydrographic profiles from the Leviathan-2 wellsite for a) temperature, b) salinity, and c) dissolved oxygen. Comparison of autumn (black), summer (blue), winter (red), and spring (green).

During the Background Monitoring Survey, hydrographic data were acquired on 2 May 2014 at five stations in the Leviathan Field in water depths between 1,550 and 1,730 m. Detailed methods and results are provided in **Appendix D**. The results were typical of deepwater conditions in the eastern Mediterranean Sea during early to mid-spring. As no significant differences were noted between stations, Station F05 (located near the center of the Leviathan Field), was selected as representative. Hydrographic profiles from this station are shown in **Figures 1-28** through **1-31**.

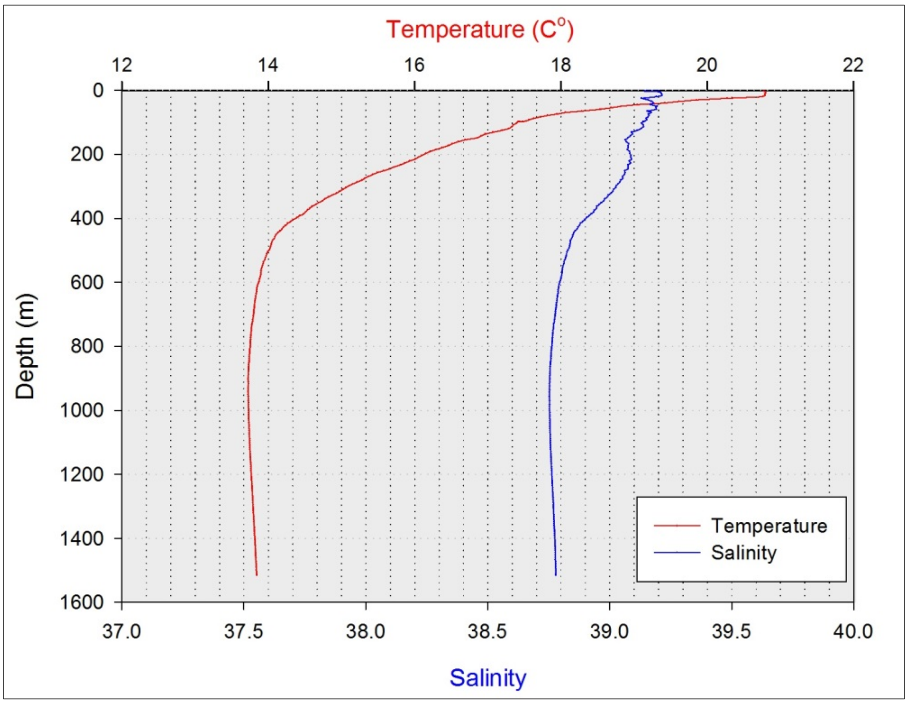


Figure 1-28. Representative temperature and salinity profiles for Station F05 in the Leviathan Field survey area, collected on 2 May 2014.

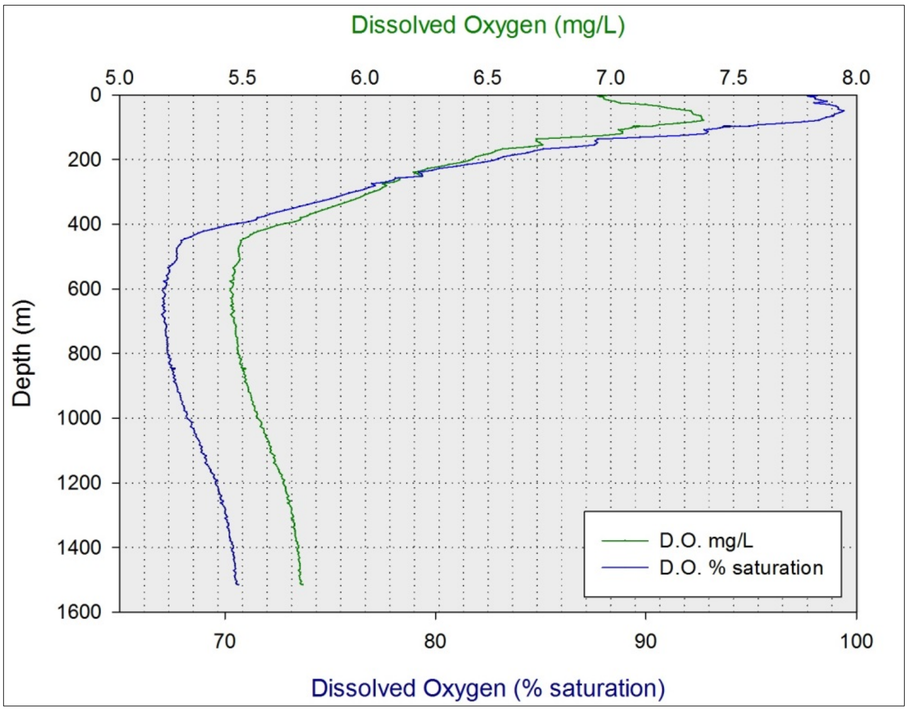


Figure 1–29. Representative dissolved oxygen profiles for Station F05 in the Leviathan Field survey area, collected on 2 May 2014.

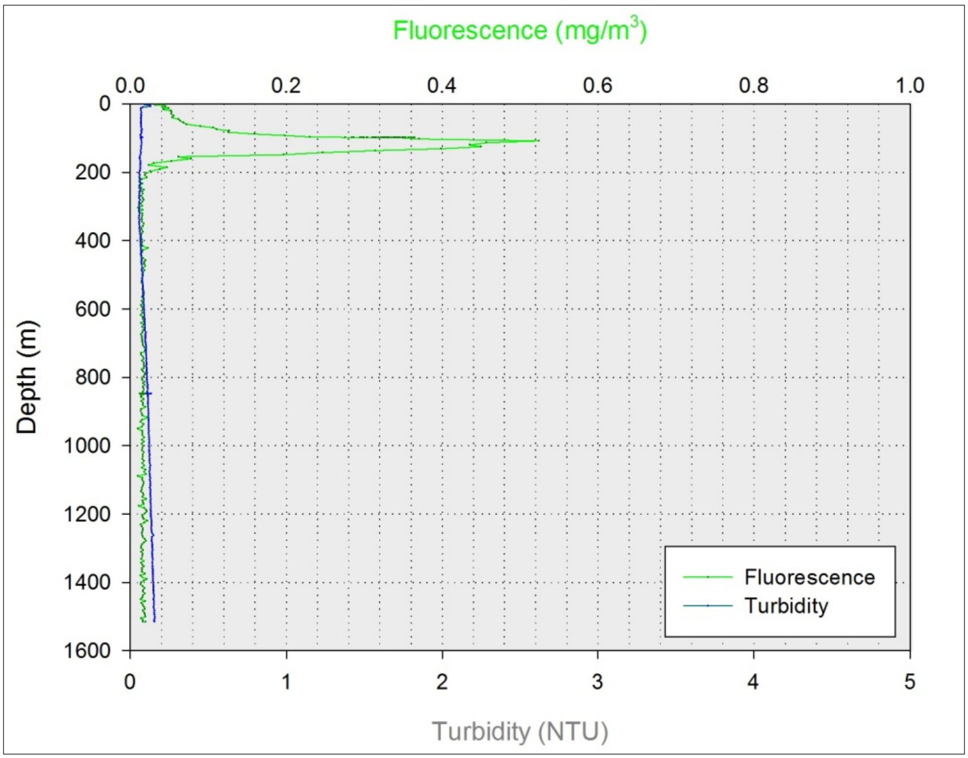


Figure 1–30. Representative fluorescence and turbidity water column profiles for Station F05 in the Leviathan Field survey area, collected on 2 May 2014.

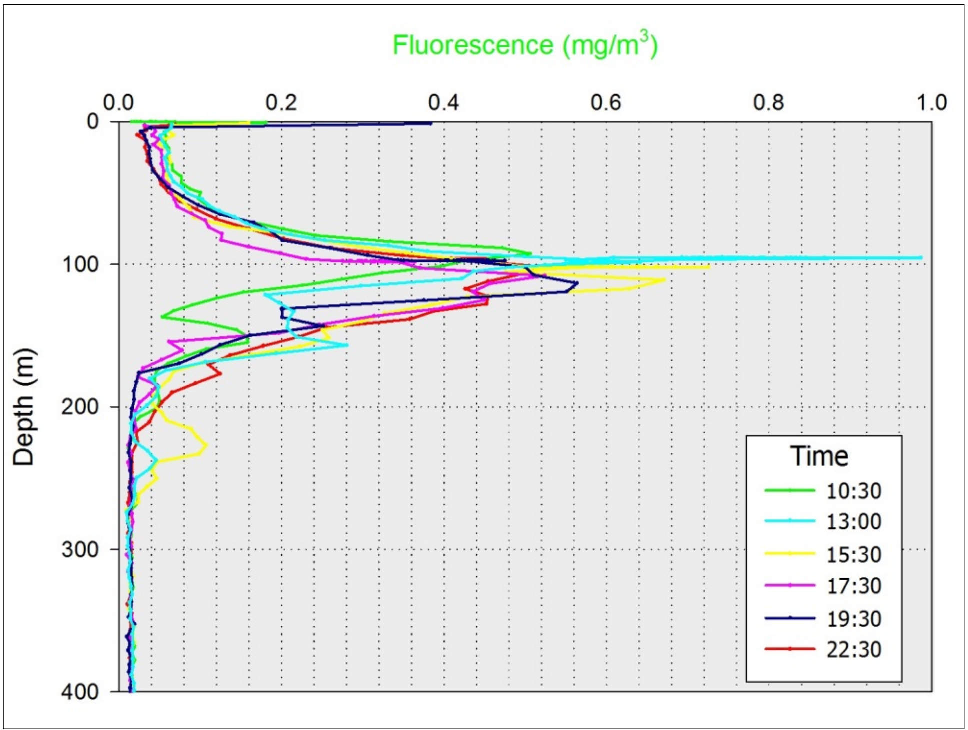


Figure 1–31. Fluorescence water column profile for Station F05 in the Leviathan Field survey area collected on 2 May 2014. Each colored line represents a different time in day for the survey area. Fluorescence, providing an estimate of phytoplankton biomass, was high at shallow depths around midday (light blue line), followed by a deepening and weakening later in the day.

Temperature and Salinity

The hydrographic profiles conducted during the Background Monitoring Survey showed the first signs of seasonal stratification in the upper surface waters (less than 200 m) (**Figure 1-28**). Water temperature reached a maximum of 21.03°C at the surface, decreasing steeply through the permanent thermocline, then slowly stabilizing and reaching a minimum of 13.72°C at a depth of 915 m, and slightly increasing near the bottom to 13.85°C. Salinity was highest (39.32) at the surface and decreased to a stable reading of 38.77 from the base of the permanent halocline to the bottom of the water column.

The findings of the Background Monitoring Survey are consistent with CSA's previous hydrographic profiles from the region, which show that environmental conditions at depths below 200 m are fairly uniform with temperatures of approximately 13.8°C, salinities of approximately 38.8, and DO saturation at approximately 70%. At depths shallower than 200 m, differences in conditions are due to seasonal effects such as warmer temperatures (28°C) and salinity stratification (39.5) during the summer and cooler temperatures (17.5°C) and wind-induced mixing during the winter months.

Dissolved Oxygen

During the Background Monitoring Survey, DO concentrations were highest in the upper mixed layer, with a maximum concentration of 6.98 mg/L and 98% saturation (**Figure 1-29**). Below the deep chlorophyll maximum (DCM) at 95 m depth, due to the lack of photosynthetic activity, oxygen followed seawater temperature, decreasing through the water column with a minimum of 5.45 mg/L and 67% saturation at 576 m and a slight increase near the bottom to 5.74 mg/L and 70.6% saturation.

The findings of the Background Monitoring Survey are consistent with CSA's previous hydrographic profiles from the region, which show that environmental conditions at depths below 200 m are fairly uniform, with DO saturation at approximately 70%. At depths shallower than 200 m, DO concentrations are strongly affected by photosynthetic activity and vary diurnally and seasonally.

Turbidity

During the Background Monitoring Survey, turbidity was consistently low throughout the water column ranging from 0.03 nephelometric turbidity units (NTU) at the surface to 0.19 NTU near the bottom (**Figure 1-30**). These findings are consistent with CSA's previous hydrographic profiles from the region.

Fluorescence

During the Background Monitoring Survey, fluorescence (an indicator of phytoplankton biomass) was highest in the photic zone (less than 200 m), with a DCM at 95 m (**Figure 1-30**). Data collected at different times throughout the day showed a pattern of diel vertical migration of phytoplankton in response to changing light intensities (**Figure 1-31**). Fluorescence was high in shallow depths at midday, reaching a maximum value of 0.98 mg/m^3 at the DCM, where the combination of nutrients and light are sufficient for photosynthesis. Later in the day, fluorescence values declined and the highest values were deeper in the water column.

The findings of the Background Monitoring Survey are consistent with CSA's previous hydrographic profiles from the region. At depths shallower than 200 m, fluorescence is strongly affected by light intensities, varying diurnally and seasonally.

1.7.1.2 Seawater Quality

CSA has conducted several environmental baseline surveys in the Levantine Basin offshore Israel since mid-2011. Based on these surveys and peer-reviewed literature, seawater in the region has the following characteristics:

- Very low nutrient concentrations;
- Metal concentrations that are below detection limits and/or below the relevant criteria and standards;
- Concentrations of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) that are below detection limits; and
- Radionuclide concentrations that are below the U.S. Environmental Protection Agency (USEPA) established maximum contaminant level.

During the Background Monitoring Survey, water quality sampling was conducted at five stations in the Leviathan Field, and an additional near-bottom water sample was collected at the proposed floating production storage and offloading (FPSO) location. Detailed methods and results are provided in **Appendix D**. The following subsections present values by station for each of the examined parameters and a calculated mean and SD for each depth. The tables in each subsection also list the mean and SD for the Levantine Basin Baseline, which is calculated from all baseline and pre-drilling sampling conducted by CSA offshore Israel.

Total Organic Carbon

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 Background Monitoring Survey, TOC concentrations near the surface averaged 0.86 ± 0.13 mg/L, decreasing at mid-depth to 0.58 ± 0.13 mg/L and stabilizing near the bottom at 0.53 ± 0.08 mg/L. 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 1-14**).

Nutrients

The eastern Levantine Basin is considered "ultra-oligotrophic" with extremely low levels of nutrients (Krom et al., 2005). Concentrations of nitrogen bound within nitrate and ammonium in surface waters in the eastern Mediterranean Sea are one-half their concentrations in the western basin (Bethoux et al., 1992). The nitrogen:phosphorus (N:P) ratio in the southeastern Levantine Basin deep water ranges from 25:1 to 28:1, suggesting that the basin is phosphorus limited (Krom et al., 2005). This severe nutrient deficit is apparently due to a combination of high N:P values in all the external nutrient inputs and low denitrification rates in the Eastern Mediterranean Sea (Krom et al., 2010). Additionally, the Atlantic inflow brings in nutrient-depleted surface waters, and there is very little nutrient input from rivers in the eastern Levantine Basin (Krom, 1995; Tanhua et al., 2013), especially after the construction of the Aswan Dam across the Nile River.

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 (**Table 1-14**). 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.

Concentrations of nitrogen bound within the nitrogen species (ammonium, nitrate, and nitrite) averaged 12% of TN in near-surface water, and 55% in near-bottom water (**Table 1-14**). This suggests that organic forms of nitrogen and phosphorus dominate the near-surface water due to increased biological productivity and primary production. The organic forms are then recycled within the water column by excretion and microbial breakdown of organic particulate matter (detritus), which in turn changes the proportion in favor of inorganic species. Overall, nutrient concentrations were consistent with previous studies from the Levantine Basin (Azov, 1986; Herut et al., 1999; Kress et al., 2005) and were below the proposed MEWQS mean and/or maximum permissible levels, where applicable.

Table 1-14. Mean concentrations of total organic carbon, total phosphorus, phosphate, total nitrogen, nitrate, nitrite, and ammonium in seawater samples collected at the Leviathan Field.

Depth Stratum	Station	Total Organic Carbon (mg L^{-1})	Total Phosphorus (mg P L^{-1})	Phosphate (mg P L^{-1})	Total Nitrogen (mg N L^{-1})	Nitrate (mg N L^{-1})	Nitrite (mg N L^{-1})	Ammonium (mg N L^{-1})
Near-Surface	C01/89	0.95	0.0052	0.0019	0.06	0.0062	0.0007	0.003
	B10/91	0.95	0.0070	0.0017	0.10	0.0022	0.0007	0.003
	F05/91	0.95	0.0048	0.0018	0.10	0.0048	0.0007	0.004
	J01/95	0.80	0.0041	0.0019	0.08	0.0143	0.0007	0.003
	J14/90	0.67	0.0045	0.0019	0.09	0.0033	0.0007	0.004
Mean ± Standard Deviation		0.86 ± 0.13	0.0051 ± 0.0011	0.0018 ± 0.0001	0.09 ± 0.02	0.0062 ± 0.0048	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	--[3]	0.442 ± 0.487; 1.70	--[3]	--[3]	--[3]
Mid-Depth	C01/866	0.64	0.0097	0.0071	0.13	0.0940	0.0007	0.002
	B10/832	0.69	0.0122	0.0068	0.16	0.0828	0.0007	0.003
	F05/839	0.56	0.0121	0.0075	0.17	0.0945	0.0007	0.002
	J01/821	0.64	0.0135	0.0086	0.15	0.0888	0.0007	0.003
	J14/775	0.37	0.0107	0.0082	0.15	0.0955	0.0007	0.005
Mean ± Standard Deviation		0.58 ± 0.13	0.0116 ± 0.0015	0.0076 ± 0.0008	0.15 ± 0.01	0.0911 ± 0.0053	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	--[3]	0.482 ± 0.465; 1.69	--[3]	--[3]	--[3]
Near-Bottom	C01/1554	0.45	0.0113	0.0063	0.12	0.0875	0.0007	0.002
	B10/1495	0.60	0.0103	0.0058	0.13	0.0711	0.0007	0.005
	F05/1505	0.61	0.0120	0.0059	0.15	0.0701	0.0007	0.003
	J01/1470	0.58	0.0137	0.0059	0.17	0.0832	0.0007	0.003
	J14/1390	0.41	0.0101	0.0066	0.16	0.0691	0.0007	0.006
Mean ± Standard Deviation		0.53 ± 0.09	0.0115 ± 0.001	0.0061 ± 0.0003	0.15 ± 0.02	0.0762 ± 0.0085	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	--[3]	0.476 ± 0.477; 1.71	--[3]	--[3]	--[3]
Proposed MEWQS in Israel[2]		N/A	0.1 ; --	N/A	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 National Infrastructures, Energy and Water Resources; therefore, the Levantine Basin Baseline mean cannot be calculated.
CL = confidence limit; MEWQS = Mediterranean Environmental Water Quality Standards; N/A = not applicable.

Total Suspended Solids and Discrete Turbidity

The eastern Mediterranean Sea is a highly oligotrophic body of water with high water column transparency. The low total suspended solids (TSS) levels and high underwater transparency expected in the eastern Mediterranean Sea are attributed to low water column productivity and low terrestrial inputs from riverine discharges. In the deep sea, near-bottom waters generally have few suspended solids due to few disturbances that stir up the sediment on the seafloor; small particles transported from the surface usually are entrained in subsurface currents or pycnoclines (i.e., density gradient).

Mean TSS concentrations observed in the Leviathan Field were below the Levantine Basin Baseline mean and in agreement with results from recent studies conducted in the northeastern Mediterranean (Yilmaz et al., 1998; Uysal and Köksalan, 2006, 2010). 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 1-15**). 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.

Table 1-15. Mean concentrations of total suspended solids, chlorophyll *a*, and discrete turbidity as well as pH levels in seawater samples collected in the Leviathan Field for the Leviathan Field Development Background Monitoring Survey.

Depth Stratum	Station / Depth (m)	Total Suspended Solids (mg L^{-1})	Discrete Turbidity – onboard reading (NTU)	pH	Chlorophyll *a* (µg L^{-1})
Near-Surface	C01/89	5.3	0.39	8.08	0.56
	B10/91	4.9	0.31	8.09	0.35
	F05/91	4.3	0.43	8.09	0.41
	J01/95	4.9	0.46	8.10	0.53
	J14/90	4.1	0.27	8.10	0.23
Mean ± Standard Deviation		4.7 ± 0.49	0.37 ± 0.08	8.09 ± 0.01	0.42 ± 0.13
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		9.79 ± 7.73; 29.7	--[3]	--[3]	--[3]
Mid-Depth	C01/866	5.4	0.37	8.05	Not sampled
	B10/832	5.3	0.38	8.05	
	F05/839	6.1	0.36	8.06	
	J01/821	7.2	0.34	8.06	
	J14/775	3.8	0.25	8.05	
Mean ± Standard Deviation		5.56 ± 1.24	0.34 ± 0.05	8.05 ± 0.01	Not sampled
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		9.92 ± 7.13; 28.3	--[3]	--[3]	--[3]
Near-Bottom	C01/1554	3.6	0.33	8.05	Not sampled
	B10/1495	5.1	0.30	8.06	
	F05/1505	8.6	0.39	8.06	
	J01/1470	7.0	0.40	8.08	
	J14/1390	2.4	0.30	8.02	
Mean ± Standard Deviation		5.3 ± 2.51	0.34 ± 0.05	8.05 ± 0.02	Not sampled
Levantine Basin Baseline Data[1] (Mean ± Standard Deviation; Upper 99% CL)		9.63 ± 8.21; 30.8	--[3]	--[3]	--[3]
Proposed MEWQS in Israel[2]		-- ; seasonal mean +10% or 10 mg L^{-1}	-- ; seasonal mean +10%	[4] 7.9 – 8.5 ; ±0.2	N/A

[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 National Infrastructures, Energy and Water Resources; therefore, the Levantine Basin Baseline mean cannot be calculated.
[4] Acceptable pH range; permissible deviation.
CL = confidence limit; MEWQS = Mediterranean Environmental Water Quality Standards; N/A = not applicable.

pH and Chlorophyll a

pH is an important property of aqueous solutions, including seawater, because it affects chemical and biochemical properties such as chemical reactions, equilibrium conditions, and biological toxicity (Bates, 1982; Dickson, 1984, 1993; Millero, 2001). The pH 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 pCO_2 (higher carbon dioxide [CO_2] would yield lower pH) (Millero, 2005). Onboard pH measurements of seawater samples resulted in normal readings, consistent among depths and stations and averaging 8.09 ± 0.01 at near-surface, 8.05 ± 0.01 at mid-depth, and 8.07 ± 0.03 at near-bottom. These results are well within the given mean range provided in the proposed MEWQS.

Very low nutrient concentrations are the key factor in limiting the biological activity and primary production in the area. Chlorophyll *a* concentrations ranged from 0.23 to 0.56 µg/L (**Table 1-15).** Chlorophyll *a* concentrations coincide with fluorescence results and profiles shown in **Section 1.7.1.1**, exhibiting highest concentrations at approximately noon (0.56 µg/L). However, while *in situ* fluorescence and extracted chlorophyll *a* measurement show similar daily trends, the relation between them is somewhat variable (Kiefer et al., 1989) as fluorescence in living cells depends on the ongoing rate of photosynthesis (Mauzerall, 1990) and the physiological status of cells (Morales et al., 1994). Following winter mixing and the injection of nutrients into the upper layers, in early to mid-spring concentrations are expected to be higher than observed for the euphotic zone (0 to 100 m) off the coast of Israel (0.06 to 0.12 µg/L) as recorded by Berman et al. (1986), and the 0.1 to 0.30 µg/L observed by Kress et al. (2014). Near-surface water samples were collected between 90 and 95 m, in close proximity to the observed DCM presented in **Section 1.7.1.1**.

Cations and Anions

Major ions compose the bulk of most abundant dissolved constituents (approximately 99.9%; Cl^-, SO_4^{2-}, K^+, Na^+, Mg^{2+}, Ca^{+2}, and Sr^{2+}) present in constant proportions to each other and to the total salt content of seawater. These proportions are constant because of the rate at which water is moved through and within the ocean is much faster than any of the chemical processes that act to remove or supply the major ions (i.e., freezing of seawater and dissolved riverine input). In turn, major ions are removed from seawater by a variety of biogeochemical processes which collectively operate at slower rates than those acting on the biolimited and particulate-scavenged elements, such as phosphorus and iron. Overall, the total amount of major dissolved ions can vary from place to place in the oceans, but the relative proportions remain virtually constant (Libes, 2011).

As an aqueous solution is always electrically neutral, the sum (in milliequivalents/liter) of the anions and the cations should always balance, approximately reaching a ratio of 1.0. Thus, a balanced sample would serve as an indication for steady, undisturbed seawater and as a good quality control for laboratory procedures. Certain natural variation does occur among different water samples, and hence it is accepted to consider an error of ion balance, or percent difference (criteria of acceptance by American Public Health Association [APHA] for ion balance purposes). Based on ionic charge, ions concentrations are converted into electrical charge and put into the following equation to produce an error of ion balance value:

$$Error\ of\ ion\ balance\ (\%) = \left(\frac{\sum Cations\ -\ \sum Anions}{\sum Cations + \sum Anions}\right) \times 100$$

Ion 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 1-16)**. According to ASTM Standard D 596-83, a clean water sample with an anion sum between 10 and 800 milliequivalents/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 and typical of the eastern Mediterranean Sea (**Table 1-16**).

Table 1-16. Ion composition in the Leviathan Field compared with average standard seawater and eastern Mediterranean seawater.

Depth Stratum	Station	Cations (mg/L)					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)	Anions (meq/L)	% 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	5.0
	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.

Dissolved Metals

Previous regional sampling indicates that metal concentrations in seawater are below detection limits and/or below the relevant criteria and standards. The results from the Background Monitoring Survey (**Table 1-17**) are consistent with previous findings. The results are compared with Israel's MEWQS (Ministry of Environmental Protection, 2002), European Union Commission Environmental Quality Standard (EUCEQS) for priority substances in the field of water policy (Directive 2008/105/EC and proposed amendment COM (2011)876), and toxicity reference values (marine Criterion Continuous Concentrations [CCCs] from Buchman, 2008). Where the USEPA's National Recommended Water Quality Criteria (NRWQC) (Buchman, 2008) are not available for some metals, criteria from other countries (e.g., Canada, New Zealand) are provided for reference.

All seawater dissolved metals concentrations were either below the laboratory's quantification limit or within the Levantine Basin Baseline SD and 99% confidence interval. Furthermore, all metals at all depths (near-surface, mid-depth, and near-bottom) were well below Israel's MEWQS, EUCEQS, and CCC reference values. No unusual and or exceptional observations were made.

Hydrocarbons

Previous regional sampling indicates that TPH concentrations are below detection limits. Results from the Background Monitoring Survey are consistent with previous findings. TPH was not detected in any of the seawater samples collected for the Leviathan Field (**Appendix D**). In accordance with the described methodology for hydrocarbons analysis and the approved Scope of Work, samples were not analyzed further.

Radionuclides

Previous regional sampling indicates that radionuclide concentrations are below the relevant criteria and standards. Results from the Background Monitoring Survey are consistent with previous findings.

During the Background Monitoring Survey, approximately 15% of the seawater samples from the Leviathan Field were sampled for Ra 226 and Ra 228 (n = 4). Station J01 was the only sampled station for the Leviathan Field area that was sampled at all water depths. Results of the seawater analysis of radionuclides (radium [Ra] 226 and Ra 228) are presented in **Table 1-18**. 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. All Ra 226 and Ra 228 concentrations were within the Levantine Basin Baseline SD and 99% confidence interval. Combined Ra 226 and Ra 228 values for seawater were well below the USEPA's (1976) established maximum contaminant level of 5 pCi/L.

Table 1-17. Metal concentrations in seawater samples from the Leviathan Field survey area during 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.

Depth Stratum	Station / Depth (m)	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	C01/89	<0.02	1.40	9.80	<0.03	<0.03	0.30	0.31	0.0010	0.30	0.04	<1.0	<1.0	0.04	4.30	0.70
	B10/91	<0.02	1.40	9.10	<0.03	<0.03	<0.3	0.3	0.0005	0.30	0.03	<1.0	<1.0	<0.03	<8.0	0.70
	F05/91	<0.02	1.50	8.60	<0.02	<0.02	0.20	1.99	<0.0005	0.30	0.03	<1.0	<1.0	<0.02	4.30	0.60
	J01/95	<0.02	1.40	9.20	<0.02	<0.02	0.30	0.22	<0.0005	0.30	0.03	<1.0	<1.0	<0.02	4.60	1.00
	J14/90	<0.02	1.40	9.20	<0.02	<0.02	0.30	0.2	<0.0005	0.40	0.02	<1.0	<1.0	<0.02	4.00	<0.6
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	C01/866	<0.02	1.50	12.30	<0.03	<0.03	0.30	0.19	<0.0005	0.40	0.03	<1.0	<1.0	<0.03	4.40	<0.60
	B10/832	<0.02	1.50	12.20	<0.02	<0.02	0.30	0.17	<0.0005	0.40	0.03	<1.0	<1.0	<0.02	4.90	<0.60
	F05/839	<0.02	1.50	12.20	<0.03	<0.03	0.30	0.19	<0.0005	0.30	<0.03	<1.0	<1.0	<0.03	<4.0	<0.60
	J01/821	<0.02	1.50	12.50	<0.02	<0.02	0.30	0.48	<0.0005	0.30	0.03	<1.0	<1.0	<0.02	4.00	0.70
	J14/775	<0.02	1.50	12.60	<0.02	<0.02	0.30	0.16	<0.0005	0.40	0.04	<1.0	<1.0	<0.02	4.00	<0.60
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
Near-Bottom	C01/1554	<0.02	1.50	12.60	<0.02	<0.02	0.30	0.22	<0.0005	0.30	0.03	<1.0	<1.0	<0.02	<4.0	1.10
	B10/1495	<0.02	1.50	12.20	<0.02	<0.02	0.30	0.25	<0.0005	0.30	0.03	<1.0	<1.0	<0.02	4.30	<0.6
	F05/1505	<0.02	1.50	12.40	<0.02	<0.02	0.30	0.18	<0.0005	0.30	<0.02	<1.0	<1.0	<0.02	4.40	0.70
	J01/1470	<0.02	1.50	12.40	<0.02	<0.02	0.30	0.24	<0.0005	0.30	0.04	<1.0	<1.0	<0.02	<4.0	0.90
	J14/1390	<0.02	1.50	13.10	<0.02	<0.02	0.30	0.21	<0.0005	0.30	0.03	<1.0	<1.0	<0.02	4.30	<0.6
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

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.
[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.

Table 1-18. Mean and combined mean concentrations (pCi L^{-1}) of radionuclides (radium [Ra] 226 and Ra 228) in seawater from the Leviathan Field, 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	0.310
	Mid-depth / 821	0.015	0.00	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.

1.7.2 Sediment Quality

Sediment sampling has been conducted at 117 grid cells in the Leviathan Field (**Appendix D**). This includes 79 stations sampled during the Background Monitoring Survey, as well as stations previously sampled near the Leviathan-2, Leviathan-3, and Leviathan-4 wellsites and near the ML-1X, Leviathan-5, and Leviathan Deep proposed wellsites. The Leviathan-2 and Leviathan-4 samples included post-drilling surveys. Sediment samples were analyzed for grain size, TOC, metals, hydrocarbons (TPH and PAHs), radionuclides, and polychlorinated biphenyls (PCBs). Sediment grain size was discussed in **Section 1.4.6**.

1.7.2.1 Sediment Total Organic Carbon

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 Levantine Basin Baseline for TOC concentration.

1.7.2.2 Sediment Metals

Means and standard deviations of sediment metal concentrations from the Leviathan Field are summarized in **Table 1-19**. Concentrations of all metals were below effects range low (ERL) values with the exception of arsenic, copper, and nickel, and only nickel exceeded the effects range median. However, these three metals are within the upper 99% CL of the Levantine Basin Baseline and are naturally found in high concentrations throughout the Levantine Basin (**Table 1-19**). Thus, ambient concentrations of arsenic and copper are above the ERL, and ambient concentrations of nickel are above the effects range median (ERM) (**Table 1-19**).

Selenium and silver concentrations generally were not detectable within the Leviathan Field (more than 84% were non-detects). Additionally, most of the other metals with concentrations above detection limits were within the 99% CL of the Levantine Basin Baseline (e.g., Al, As, Be, Cr, Cu, Fe, Hg, Ni, V, and Zn). The metals that were found to have some concentrations above the 99% CL of the Levantine Basin Baseline were antimony, barium, cadmium, lead, and thallium.

Antimony concentrations ranged from 0.2 to 1.8 parts per million (ppm), the majority were below the Levantine Basin Baseline (0.62 ± 0.25 ppm) (**Table 1-19**). Antimony concentrations near the Leviathan-4 wellsite were elevated above the upper 99% CL for the Levantine Basin Baseline (1.27 ppm), while concentrations surrounding the Leviathan-2 wellsite were not. Antimony concentrations in drilling mud (from Tamar Field samples) are about twice the Levantine Basin Baseline, and therefore elevated concentrations near a wellsite is not surprising. However, the T_{50}

concentration (the chemical concentration that corresponded to the 50% probability of observing sediment toxicity) for antimony is 2.4 ppm (Buchman, 2008). This indicates that elevated concentrations of antimony (less than 1.8 ppm) within the field were low and do not pose a threat to the environment.

Barium concentrations within the Leviathan Field were highly elevated in grid cells containing the Leviathan-2 (12,263 ppm) and Leviathan-4 (8,218 ppm) wellsites. This was not unexpected because barite is a major constituent of drilling mud and barium concentrations in drilling mud are much higher than the Levantine Basin Baseline (173.4 ± 30.1 ppm) (**Table 1-19**). The elevated barium concentrations were primarily within 500 m of these wellsites, which is consistent with the dispersion modeling that predicted that there could be bottom deposition of particles from the discharge plume out to 676 - 775 m from the well site. Barium concentrations elsewhere within the Leviathan Field ranged from 113 to 375 ppm. Barium is not considered to be toxic to marine organisms and there is no established ERL/ERM concentration for this metal; therefore, the high concentrations of barium reported around the wellsites are not expected to negatively affect the environment.

Cadmium concentrations ranged from below the detection limit (0.16 ppm) to 1.04 ppm. Cadmium concentrations were slightly elevated at various locations throughout the field when compared to the upper 99% CL of the Levantine Basin Baseline (0.36 ppm). Relatively high concentrations of cadmium were found in close proximity to the Leviathan-2 and Leviathan-4 wellsites. Cadmium concentrations ranged between 0.26 and 0.74 in proximity to the Leviathan-4 wellsite, and between below the detection limit of 0.16 to 0.64 in proximity to the Leviathan-2 wellsite. These concentrations may be due to drilling muds, as cadmium is a component of drilling mud barite. However, other areas of elevated cadmium concentrations, relative to the Levantine Basin Baseline, were located far from drilling activities and were relatively patchy in distribution. This finding indicates that the distribution of cadmium concentrations above the upper 99% CL of the Levantine Basin Baseline within the Leviathan Field may be due to natural variation of this metal within seafloor sediments of the region. Cadmium concentrations within the Leviathan Field (**Table 1-19**) were well below the ERM value (9.6 ppm) and ERL value (1.2 ppm) for cadmium (Long and Morgan, 1990), and therefore do not pose a threat to the environment. A concentration below an ERL represents a minimal effects range where biological effects are very rarely observed, while a concentration above an ERM represents a range where biological effects are likely to be observed (Long and Morgan, 1990). Moreover, studies have shown that cadmium in barite has very low solubility, leaches only slightly into the seawater, and has very limited availability to marine organisms (Trefry and Smith, 2003; Neff, 2008).

Lead concentrations were generally below the upper 99% CL of the Levantine Basin Baseline (49.1 ppm), with the exception of locations near the Leviathan-2 and Leviathan-4 wellsites. Lead is a component of drilling mud and barite and has been found in cuttings, so its presence in the field near the existing wellsites is unsurprising. A single high lead concentration (48.3 ppm), located in the grid cell containing Leviathan-2, was just above the ERL concentration (46.7 ppm), but well below the T_{50} concentration (94 ppm) and ERM concentration (218 ppm) for this metal. Lead concentrations elsewhere in the Leviathan Field ranged from 11.9 to 39.3 ppm. These results indicate that lead concentrations within the Leviathan Field are not expected to negatively affect the environment.

Some thallium concentrations were elevated above the upper 99% CL of the Levantine Basin Baseline (0.86 ppm) in the northern portion of the Leviathan Field. Thallium concentrations reached a maximum of 2.8 ppm in this region. This location is more than 10 km from any known areas of previous drilling or anthropogenic activity; therefore, elevated concentrations of this metal within this region likely reflect natural concentration variations within seafloor sediments. There are no ERL/ERM values for thallium concentrations in marine sediments.

Table 1–19. Mean (± standard deviation) total metals concentrations (ppm unless noted otherwise) in sediments collected from the Leviathan Field. 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
Leviathan Field	5.7 ± 0.74	16.82 ± 2.63	337.82 ± 1338.81	0.63 ± 0.17	0.21 ± 0.14*	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 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 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
Drilling Mud	1.3 ± 1.5	3 ± 2.3	1,202 ± 409	1.0 ± 1.1	1.0 ± 1.1	3.0 ± 3.1	7.0 ± 2.8	2.3 ± 1.7	2.0 ± 1.9	123.0 ± 85.6	3.0 ± 2.7	N/A	2.0 ± 2.5	13.0 ± 6.6	1 ± 1.2
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 (>70%) of non-detects in the relevant data sets.

1.7.2.3 Sediment Hydrocarbons

Sediment TPH concentrations within the Leviathan Field ranged from 4.0 to 27.1 ppm, and had a mean (± SD) of 13.2 ± 4.8 ppm. TPH concentrations throughout the entire survey area were within the 99% CL of the Levantine Basin Baseline of 21.85 ppm. TPH concentrations in the middle of the Leviathan Field were sampled prior to this survey and were analyzed by ALS Kelso. ALS Kelso had a method reporting limit of approximately 50 ppm, which is substantially higher than the method detection limit of 1.4 ppm for the analytical laboratory, TDI-Brooks. While all TPH concentrations in these grid cells were below ALS Kelso's method reporting limit, the usual substitution of half the method reporting limit was not utilized because this value was above the 99% CL of the Levantine Basin Baseline. Its inclusion in the interpretation would have grossly overestimated TPH concentrations in the middle of the field.

Studies done in the Arabian Gulf have shown ambient background TPH concentrations of 10 to 15 ppm (Massoud et al., 1996; Tehrani et al., 2012), which are similar to those of the eastern Levantine Basin. These studies have characterized TPH concentrations between 15 and 50 ppm as "slightly polluted" and concentrations greater than 200 ppm as "heavily polluted." Mean (± SD) TPH concentrations within the Leviathan Field (13.2 ± 4.8 ppm) were comparable with Tamar Reservoir mean (13.3 ± 10.6 ppm) (CSA Ocean Sciences Inc., 2014d). Using the classification scheme above, TPH concentrations within the Leviathan Field would be classified as either ambient or slightly polluted because several grid cells have TPH concentrations above 15 ppm. However, these terms are highly qualitative and there are no official established toxicity thresholds for TPH concentrations. The results indicate that TPH concentrations, even in the slightly elevated grid cells, were consistent with the region and are at concentrations that do not pose a threat to the environment.

Hydrocarbons were analyzed further to determine concentrations of the 16 USEPA priority PAHs. Mean (± SD) PAH concentrations in strata sampled during the Leviathan Field Development Survey are summarized in **Table 1-20**. PAHs were analyzed only in samples that had a TPH concentration above the 95% CL of the Levantine Basin Baseline 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). Few individual PAHs had concentrations that were higher than the Levantine Basin Baseline (**Table 1**–**20**). A 99% CL for the Levantine Basin Baseline of individual PAHs is not provided because many of the Levantine Basin Baseline samples had individual PAH concentrations below detection limits. The total PAH concentration within the Leviathan Field (72.9 ± 45.4 parts per billion [ppb]) was above the Levantine Basin Baseline (55.4 ± 23.4 ppb) and the Tamar Reservoir mean (48.9 ± 45.3 ppb) (CSA Ocean Sciences Inc., 2014d). Total PAHs concentration was below the 99% CL for the Levantine Basin Baseline (115.8 ppb) and was well below the ERL (4,022 ppb) and ERM (44,702 ppb) values for total PAHs in marine sediment.

The Fossil Fuel Pollution Index (FFPI) was calculated to determine the percentage of fossil fuel PAHs relative to total PAHs (Boehm and Farrington, 1984). The FFPI is based on the knowledge that combustion-derived (pyrogenic) PAH assemblages are rich in three- to five-ringed PAH compounds while fossil fuels (petrogenic) are rich in polynuclear organosulfur compounds (e.g., dibenzothiophene) and two- to three-ringed PAH assemblages (Steinhauer and Boehm, 1992). The FFPI is calculated from the following equation (Boehm and Farrington, 1984):

$$\frac{\left[\Sigma\, naphthalenes(C_o - C_4) + \Sigma\, dibenzothiophenes(C_o - C_3) + \frac{1}{2}\Sigma\, phenanthrenes(C_o - C_1) + \Sigma\, phenanthrenes(C_2 - C_4)\right]}{\Sigma\, PAH}$$

An FFPI ratio of 0 to 0.25 indicates PAH assemblages dominated by pyrogenic sources, a ratio of approximately 0.25 to 0.49 is indicative of intermediate PAH assemblages containing a mix of pyrogenic and petrogenic sources, and a ratio of 0.5 to 1.0 is indicative of PAH assemblages dominated by petrogenic sources (Boehm and Farrington, 1984).

The FFPI ratios for the Leviathan Field are summarized in **Figure 1**–**32**. 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.

Table 1–20. Mean (± standard deviation) U.S. Environmental Protection Agency priority and total polycyclic aromatic hydrocarbons (PAHs) concentrations (ppb) 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.

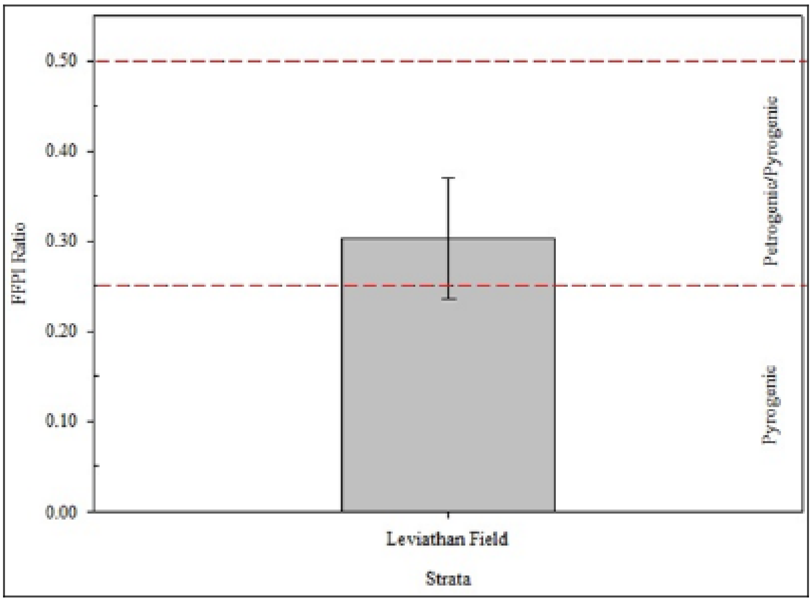


Figure 1–32. Mean (± standard deviation) Fossil Fuel Pollution Index (FFPI) ratios from samples with high total petroleum hydrocarbons (TPH) concentrations within the Leviathan Field sampling grid. The red dashed lines indicate the boundary between sediments that are of pyrogenic (0 to 0.24) or a mix of petrogenic and pyrogenic (0.25 to 0.5) origins.

1.7.2.4 Sediment Radionuclides

A total of 10% of all sampled sediment stations in the Leviathan Development Program (Field and proposed FPSO location; Pipeline; and nearshore) were sampled for radionuclides (Ra 226, Ra 228, and thorium [Th] 228). Of that representative sample, eight stations were in the Leviathan Field. Analytical results for each individual sampling station within the Leviathan Field and Levantine Basin Baseline data are provided in **Table 1-21**.

Table 1–21. Concentrations (pCi/g) and mean concentrations of radionuclides (radium [Ra] 226, Ra 228, and thorium [Th] 228) in sediment from the Leviathan Field and mean Levantine Basin Baseline data.

Station	Ra 226	Ra 228	Th 228
A01	0.41	0.75	0.50
C11	0.22	0.84	0.58
E05	0.29	1.15	0.58
F01	0.30	0.42	0.54
G08	0.36	0.46	0.48
H13	0.37	0.43	0.48
I04	0.47	0.92	0.62
J11	0.38	0.43	0.47
Mean ± SD	0.35 ± 0.08	0.68 ± 0.28	0.53 ± 0.06
Levantine Basin Baseline[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; SD = standard deviation.

Ambient radium concentrations in most soils and rocks are approximately 0.5 to 5.0 pCi/g of total radium (U.S. Geological Survey, 1999). Ambient concentrations of Th 228 in sediments range from 0.36 to 1.93 pCi/g (Agency for Toxic Substances and Disease Registry, 1990). The USEPA (1998) established a protective health based level for radium and thorium of 5 pCi/g at the sediment surface as a threshold for the clean up of the top 15 cm of soil from contaminated U.S. Superfund sites. Mean radium and thorium concentrations within the Leviathan Field survey area were well below this threshold. Mean radium and thorium concentrations generally were similar to the Levantine Basin Baseline concentrations, and all samples (except for one) were within the 99% CL of the Levantine Basin Baseline. The Ra 228 concentration from the E05 sampling station was 1.15 pCi/g, just above the 99% CL of 1.14 pCi/g. This minor deviation from the Levantine Basin Baseline is unlikely to be biologically significant.

1.7.2.5 Sediment Polychlorinated Biphenyls

A representative 10% of all sampled sediment stations in the Leviathan Development Program (Field and proposed FPSO location; Pipeline; and nearshore) 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.

1.8 CULTURE AND HERITAGE SITES

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

Noble Energy contracted Geoscience Earth & Marine Services (GEMS) to conduct seafloor, shallow geologic, and archaeological assessments in the Leviathan Field. GEMS used high-resolution subbottom profiler, side-scan sonar, and multibeam bathymetry and backscatter data collected by an autonomous underwater vehicle (AUV) for this assessment. An archaeological assessment was prepared (Geoscience Earth & Marine Services, 2014). The survey encompassed 795 km^2 of seafloor. High-resolution digital side-scan sonar, subbottom profiler, multibeam backscatter, and multibeam bathymetry 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.

The archaeological assessment delineated 397 unidentified side-scan sonar contacts. While most of these contacts met the size parameters mentioned above, a number of contacts were selected based on other criteria such as object shape, side-scan sonar shadow (if present), or other distinguishable characteristics. The multibeam bathymetry and backscatter data as well as the subbottom profiler data were used to further analyze contacts noted in the side-scan sonar data.

Of the 397 unidentified sonar contacts, 38 were interpreted to represent possible cultural resources with potential archaeological significance. **Figure 1-33** shows a polygon surrounding the general location of the sonar contacts. This map is also provided in **Appendix F** at a 1:100,000 scale, as required in the Guidelines.

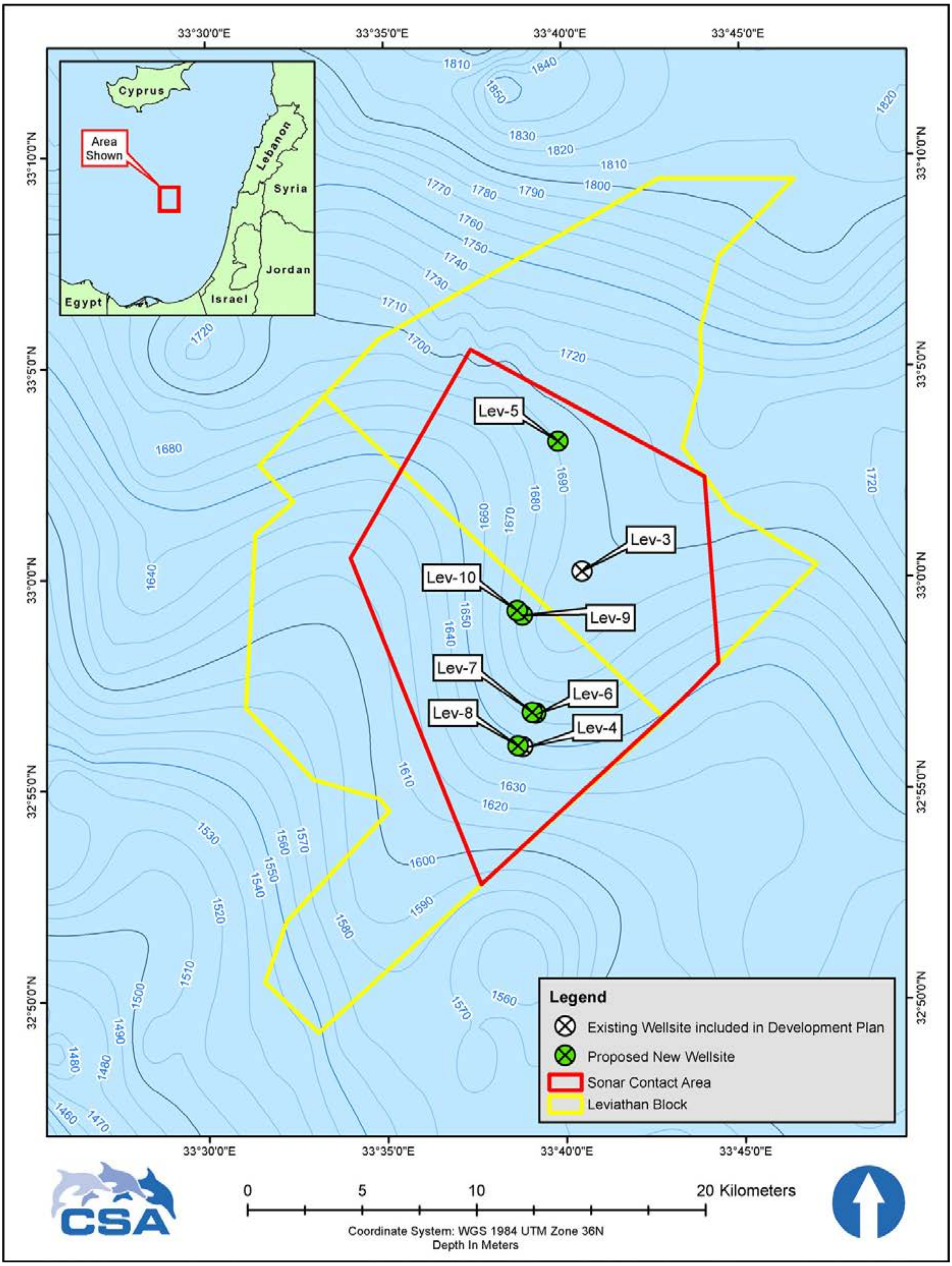


Figure 1–33. General locations of side-scan sonar contacts interpreted to represent possible cultural resources with potential archaeological significance.

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 (for Marine Archaeology Unit approval, see **Appendix F**).

During operations, should any object be determined to likely represent an antiquity, Israel's Antiquities Authority will be notified. In addition, a 305-m archaeological avoidance zone will be kept as instructed by the U.S. Minerals Management Service, Gulf of Mexico Region NTL No. 2005-G07.

1.9 METEOROLOGY AND AIR QUALITY

1.9.1 Existing Meteorological Conditions

There are no site-specific meteorological data from the Application Area. However, regional data are available to describe representative conditions. Israel's subtropical location between 29° and 33° north of the Equator generally brings long, hot, dry summers and short, cool, rainy winters, as modified locally by altitude and latitude. Israel experiences a climate between the subtropical aridity characteristic of Egypt and the subtropical humidity of the Eastern Mediterranean.

The climate conditions of the Eastern Mediterranean region can be divided into cold and warm periods. The cold period (December to March) is characterized by the low circulation associated with intense cyclogenetic activity. The anticyclonic type of circulation during this period is associated with cold core anticyclones laying over the central Europe or Balkan region. 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 (Kallos et al., 1993; Kassomenos et al., 1995). 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 (that extends toward the Mediterranean) 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.

An oppressive hot, dry desert wind called the sharav or khamsin "east wind" blows from the Arabian Desert from May to mid-June and from September to October. The sharav or khamsin can be triggered by depressions that move eastward along the southern parts of the Mediterranean or along the North African coast from February to June and lasts for 2 to 5 days at a time.

Meteorological data from 2007 to 2012 recorded at Haifa are available for reference (Israel Meteorological Service, 2014; Weatherspark, 2014). Highest daily air temperatures range from approximately 25°C in January to 42°C in April, May, and June. Lowest daily air temperatures range from approximately 0.7°C in January to 16.6°C in August. The mean and extreme temperatures are moderated by Haifa's coastal location. 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).

1.9.2 Air Quality

No site-specific air quality data are available for the Application Area (as required in Guidelines section 1.9.3). However, in the offshore environment of the Application Area, more than 100 km from the coastline and urban areas, air quality is expected to be good. The major pollutant sources of anthropogenic origin in the Mediterranean region are located in central and southern Europe, with minor contribution from North Africa and the Middle East (Asaf et al., 2008). Because the Application Area is approximately 120 km from the nearest shoreline, a description of coastal air quality is not presented.

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. In a general sense, there are three major synoptic weather types that are conducive to short-term air quality problems in coastal Israel (Dayan and Levy, 2002):

- Red Sea Trough – occurs 29% of the time, mainly during autumn, brings regimes of light winds transporting hot and dry air from eastern origins;
- Anticyclone – occurs 25% of the time, mainly during spring and is often accompanied by an upper-air ridge, which usually leads to stagnation caused by the very weak pressure gradient formed over Israel; and
- Shallow Persian Trough – occurs 20% of the time, typically during summer whenever the extensive North-African upper-air subtropic anticyclone advances to the region leading to subsidence and stabilization of the atmosphere.

Other weather types associated with air pollution periods (e.g., high-ozone days), and their frequency of occurrence, include Turkish high (8%), Persian trough (7%), Col (4%), Egyptian low (4%), a western axis Red Sea Trough (1%), and undefined (2%) (Dayan and Levy, 2002).

1.10 NOISE

There are no site-specific measurements of underwater noise in the Application Area. The most likely dominant source of ambient noise is shipping. Shipping noise 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). The Eastern Mediterranean region is one of the busiest sea routes in the world, with a number of high-volume port facilities and crowded shipping lanes. The opening of the Suez Canal significantly increased the volume of shipping traffic, particularly in the Eastern Mediterranean region.

Broadband source levels for ships typically increase with increasing vessel size, with source levels of 160 to 175 dB re 1μPa for smaller vessels (less than 50 m), 165 to 180 dB re 1μPa for medium-size vessels (50 to 100 m), and 180 to 190 dB re 1μPa for large vessels (more than 100 m) such as supertankers, large bulk carriers, container ships (Richardson et al., 1995; OSPAR Commission, 2009). The main noise sources from shipping include propellers and thrusters, machinery, sea-connected systems (e.g., pumps), and hydrodynamic noise caused by the movement of the hull through the water (Spence et al., 2007). Propeller cavitation is usually the dominant source for large commercial vessels (Brown, 2007).

Potter et al. (1997) measured ambient noise levels in shallow water (i.e., 4 to 5 m depth) offshore Haifa. At low frequencies (a few hundred hertz or less), the ambient noise spectra exhibited characteristics of medium to heavy shipping noise. Biological sound sources (i.e., snapping shrimp) dominated the spectrum for frequencies above a few hundred hertz.

1.11 MARINE TRANSPORTATION SYSTEM AND INFRASTRUCTURE

Existing maritime infrastructure within the Application Area includes four previously drilled wells (Leviathan-1 through Leviathan-4) and one telecommunications cable. Shipping lanes are present in coastal waters inshore of the Application Area.

1.11.1 Telecommunications Cables

A MedNautilus submarine telecommunications cable passes through the middle of the Leviathan Field in a west-northwest to east-southeast direction (**Figure 1-34**) and is part of a regional fiber optic network connecting the Mediterranean region to Western Europe and the United States (MedNautilus, 2014a). The north-south oriented MINERVA cable shown in the figure is a subsystem of MedNautilus (MedNautilus, 2014b). All of the drillsites are more than 1 km away from the nearest cable (**Table 1-22**).

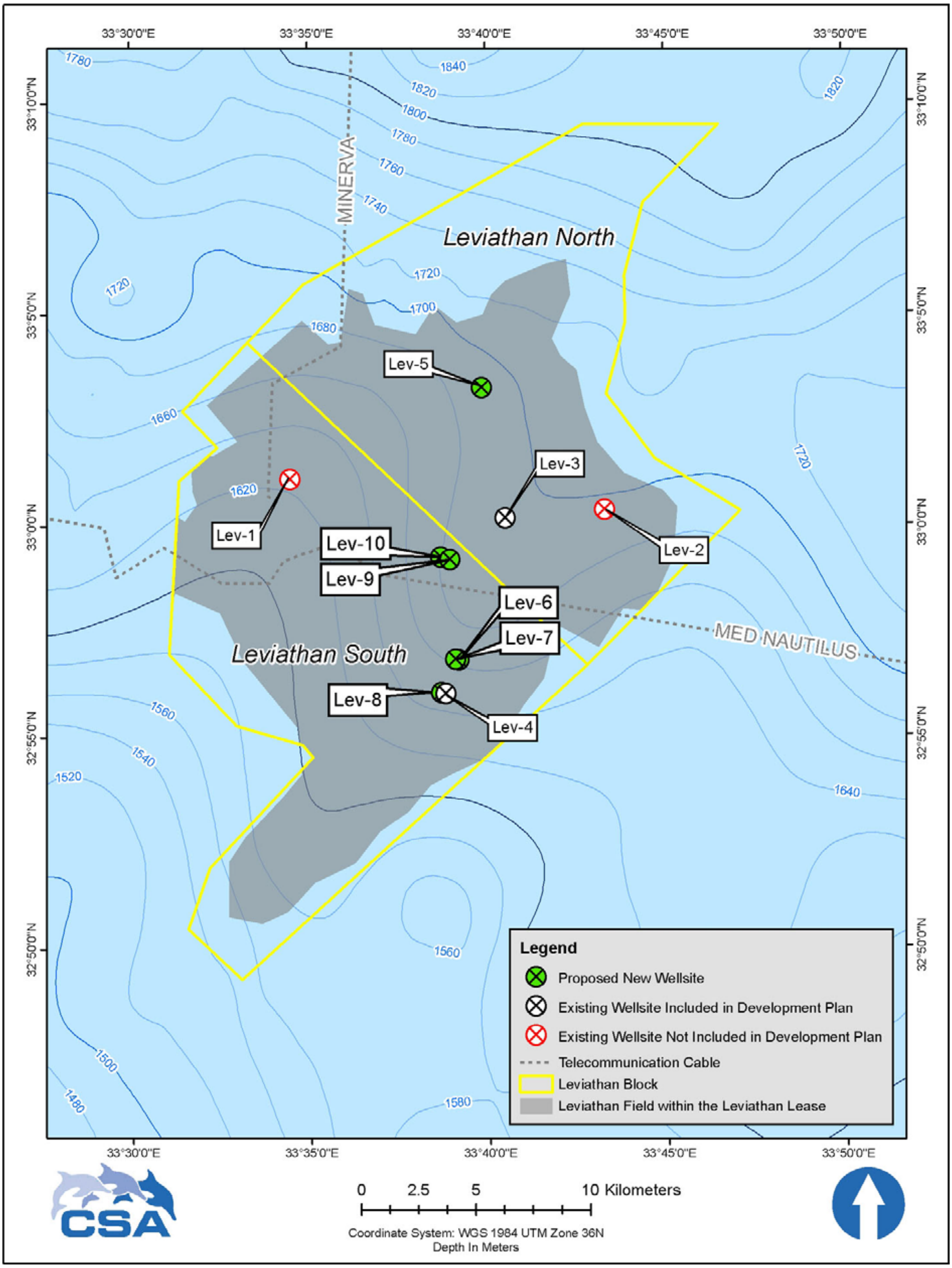


Figure 1–34. Locations of existing marine infrastructure (telecommunications cable and previous drillsites) within the Leviathan Field in relation to the initial wellsites included in the Leviathan Field Development Plan. Proposed New Wellsite locations are preliminary; final well locations may vary slightly. Contours indicate water depth in meters.

Table 1–22. Minimum distances to the nearest telecommunications cable and existing wellsite for each drillsite.

Drillsite	Proximity to Telecommunication Cables		Proximity to Existing Wellsites	
	Nearest Cable	Minimum Distance (km)	Nearest Existing Wellsite	Minimum Distance (km)
Leviathan-3	MedNautilus	3.36	Leviathan-3	0
Leviathan-4	MedNautilus	4.64	Leviathan-4	0
Leviathan-5	MedNautilus	8.81	Leviathan-3	5.79
Leviathan-6	MedNautilus	3.09	Leviathan-4	1.58
Leviathan-7	MedNautilus	3.12	Leviathan-4	1.60
Leviathan-8	MedNautilus	4.67	Leviathan-4	0.13
Leviathan-9	MedNautilus	1.04	Leviathan-3	3.24
Leviathan-10	MedNautilus	1.09	Leviathan-3	3.17

1.11.2 Existing Wellsites

There are four existing wellsites (Leviathan-1 through Leviathan-4) in the Leviathan Field (**Figure 1-34**). Two of the proposed drillsites in this Application are existing wellsites (Leviathan-3 and Leviathan-4). These reservoir control points provide part of the basis for locating subsequent wells in the proposed early stage of Leviathan development. The proposed Leviathan-6, Leviathan-7, and Leviathan-8 surface locations are clustered around Leviathan-4. The proposed Leviathan-9 and Leviathan-10 surface locations are near Leviathan-3. The lateral distances between these are shown in **Table 1-22,** the lateral distance with other future (notional) Leviathan wells are tabulated in **Section 3.2**. The proposed Leviathan-5 surface location is located on the northern flank of the reservoir.

1.11.3 Shipping Lanes

The Leviathan Field is not located within a shipping lane as shown in **Figure 1-3**. The nearest shipping lanes are those approaching the port of Haifa. Numerous shipping lanes cross 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.

1.12 MARINE FARMING

Fish farming locations are shown in **Figure 1-35**. No mariculture or fish farming operations are known to exist within 30 km of the Application Area. Fish farming usually takes place in secure bays to avoid damage to the cages, although there are exceptions. Using a special patented technique developed in Israel, a submergible open water fish farm was developed and has become operational approximately 5 nmi west of Palmachim. Total capacity is approximately 1,500 tons per annum when fully operational. A second farm is located inside Ashdod port with a capacity of 300 tons and was built as a temporary solution for the fish farms of Eilat. A third, experimental farm, located approximately 1.6 nmi west of Michmoret, was established recently (2011) to support the rapidly growing demand and uprising market. Mariculture production accounts for only 3% (approximately 2,300 tons) of total fish consumption in Israel valued at US$16.5 million (Shapiro, 2007). The main cultured fish species grown is gilthead sea-bream (*Sparus aurata*), with some European sea-bass (*Dicentrarchus labrax*). All fishes are inspected at the farm gate by a veterinary service for pathogens and heavy metals; so far, no threats have been detected.

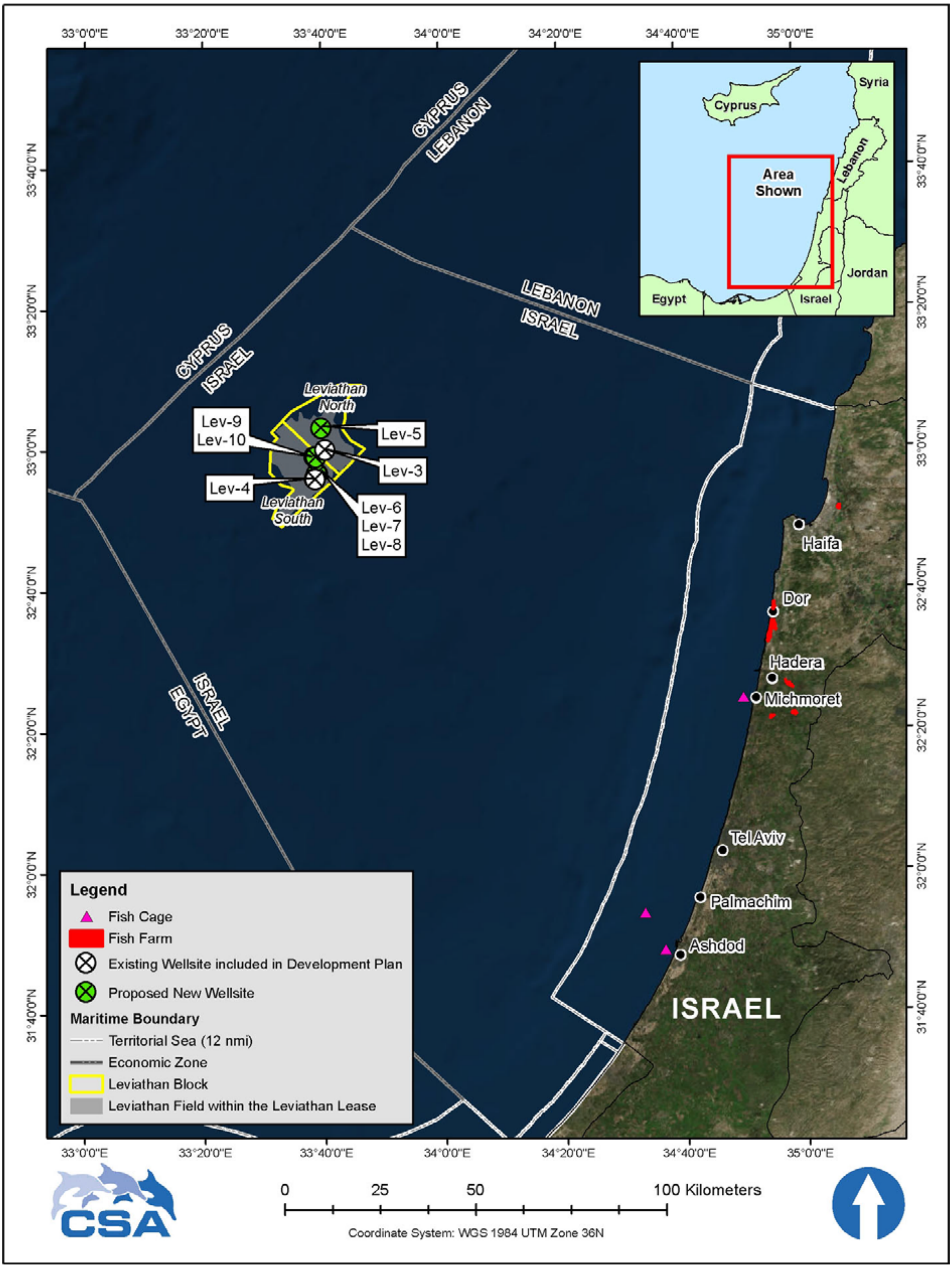


Figure 1–35. Map of fish farming locations in Israel (Data from: Ministry of Agriculture and Rural Development – Fish Ponds and Offshore Cages Geospatial Data, 2014).

The Israeli market consumes approximately 80,000 tons of fish per year, relying heavily on the import of frozen fish (approximately 60,000 tons) but also obtaining approximately 20,000 tons from local produce through fisheries and aquaculture (Shapiro, 2007). Along the coastal plain of Israel, mainly north of Kibbutz Ma'agan Michael and south Ha'bonim village, are fish ponds where several species of freshwater and brackish water fish are cultivated, including the commercially important flathead gray mullet (*Mugil cephalus*) and red drum (*Sciaenops ocellatus*). Not all ponds are operational as some were abandoned and left as dry pits while others, such as the "Diple" at the Dalia stream estuary, serve as a reservoir for the fish ponds, as agreed between the Israel National Parks Authority and fish pond operators, and act as a natural marshland consisting of species of fish and marine invertebrates unique to brackish water. The fish ponds attract many seabirds that pass through the area while migrating south during the winter, while some stay to nest at designated sites. Excess water from the fish ponds are routinely discharged into the Dalia stream estuary and the Mediterranean Sea (Israel National Parks Authority, 2011).

1.13 LEVIATHAN-2 WELLSITE MONITORING SUMMARY

During drilling of the Leviathan-2 well in May 2011, wellbore integrity issues occurred prior to drilling of the well's reservoir section. Due to these issues, the drilling rig was removed from the well. Following cessation of drilling operations (May 2011) and prior to the successful plugging (plug-and-abandonment) of the well in September 2012, there was a flow of formation water and subsurface sediments from the well. During the flow, formation sand and water settled in the area surrounding the Leviathan-2 well. A brine pool formed immediately around the wellhead in a caldera (approximately 15m across and 1 meter deep) created by the jetting of water immediately after plugging operations to allow for a visual inspection of the wellhead. Similar brine pools, but much smaller in size (1 – 3 m in length; < 10 cm deep), occurred in natural depressions in the seafloor. All of these smaller brine pools were found within a 200 m radius of the wellsite.

Noble Energy immediately implemented a monitoring program of the Leviathan-2 wellsite to document the environmental conditions and provide a baseline for evaluating future changes and recovery. After plugging activities were completed, six full surveys (November 2012, April 2013, September 2013, February 2014, June 2014, and January 2015) and one hydrographic survey (June 2013) were conducted at the Leviathan-2 wellsite and surrounding region. Each full survey included the collection of a combination of the following data: video, water column and near-bottom hydrographic profiles, and physical collection of sediment and near-bottom water samples. Samples were collected within 200 m of the wellhead, at two reference stations, and along three fault lines in close proximity to the wellsite. The hydrographic survey was inclusive only of video data and near-bottom hydrographic profiling at those same locations.

Findings from all post-plugging surveys conducted to date (November 2012 to January 2015) suggest that the plugging was effective (i.e., no evidence of a leak), and that conditions are gradually approaching normal conditions (i.e., decrease in size and salinity of caldera brine pool). It has been repeatedly shown in previous reports that all environmental impacts are minimal and highly localized within 200 m of the wellhead, and the area is showing signs of recovery. The effects of water and sand discharges appear to be minimal, having no indicators of toxic levels of contamination from compounds of concern.

CHAPTER 2: REASONS FOR PREFERENCE OF THE LOCATION OF THE PROPOSED PLAN AND POSSIBLE ALTERNATIVES

2.1 GENERAL

Noble Energy proposes to conduct well drilling and completion activities in the Leviathan Field. This chapter explains the options that Noble Energy evaluated in selecting the initial well locations and drilling technology.

2.2 WELL LOCATION ALTERNATIVES

2.2.1 Overview and Application Rationale

Noble Energy's development plan for the Leviathan Field includes the drilling and completion of up to 29 wells for full field depletion. The final number of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, and future appraisal. Specific locations of the wells will take into account these factors as well as shallow hazard evaluation and avoidance of potential archeological contacts. Eight initial development drillsites in this report were selected based on the interpretation of seismic data acquired in the Leviathan North and South Leases as well as results from previous exploratory and appraisal wells completed in the Leviathan Field. Details regarding the selection of the drillsite locations were explained in the development plan and are outlined in the following sections. The detailed plans presented in this report include the drilling of Leviathan-3 ST02 and Leviathan-5 through Leviathan-10 as well as the completion of the previously drilled Leviathan-4 ST01.

2.2.2 Proposed Development Program

Reservoir simulation studies indicate that an initial group of eight well locations will satisfy early production needs and can provide important reservoir surveillance for Leviathan Field. The planned distribution, by reservoir zone, is as follows:

[redacted]

This initial development phase includes two well clusters generally centered around the existing Leviathan-3 and Leviathan-4 appraisal locations. These are structurally high areas of the field, with a concentration of gas-in-place that will ultimately require high well concentrations. Staying close to these existing control points where high quality seismic data are available reduces uncertainty with structure, sand deposition, and reservoir quality. Anchoring the initial development phase around two clusters of four wells each also optimizes field facilities/infrastructure.

In order to optimimize gas production and minimize water influx, the following philosophy is used:

[redacted]

In general, completions in the lower sand zones will be done early in the field life. This will help minimize the risk associated with drilling through sands that, based on reservoir simulation modeling, are expected to show pressure depletion over the life of the field. It also will provide improved stratigraphic control on the shallower gas pay zones early in the field life and facilitate their subsequent completion.

2.2.3 Completion Philosophy and Details of Well Planning

Early completions in the Leviathan Field are designed to efficiently drain the gas reservoir through wells in the two key reservoir sands. Through careful monitoring, these initial wells will provide key data relative to deliverability as well as vertical and lateral reservoir connectivity. Reservoir modeling indicates that subsequent wells will likely be concentrated in the "A" Sand, wherein the majority of the Leviathan Field resources occur. However, early well performance data will be used to optimize subsequent completions relative to lateral position in the reservoir and specific sand zone for completion.

Because the wells are located in different sectors (south, central, and northeast), production rates and pressures can be collected and analyzed to provide a basis for understanding the reservoir performance and connectivity. Analysis of production data from the initial producers will help fine-tune later well locations to optimize gas production and minimize water influx.

[redacted]

[redacted]

Figure 2-1. Schematic section through the northern well cluster. Black lines represent appraisal legs and red lines are completions. Because wells are projected onto a common plane, the diagram is somewhat distorted.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Figure 2-2. Schematic section through the southern well cluster. Black lines represent appraisal legs and red lines are completions. Because wells are projected onto a common plane, the diagram is somewhat distorted.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Table 2-1 summarizes the planned activities, water depth, true vertical depth subsea, and the planned completion zone for the initial proposed wells.

Table 2-1. Planned activities, water depth, true vertical depth subsea, and the planned completion zone for the initial proposed wells.

[redacted]

[a] Where two values are listed, the second is for the sidetrack (ST) well.
[b] The Leviathan-5 well is planned as an "A" Sand completion; however, a "B" Sand completion is a fall-back option for this well. Noble Energy will make the best completion possible based on the data obtained during drilling.

2.2.4 Well Clearance and Environmental Sensitivity

The proposed location and borehole trajectory of each individual Leviathan Field development well was selected and the well drilling program designed to include considerations minimizing the risk of encountering the following shallow hazards:

- Seafloor instability – The selected locations are in relatively flat areas away from any seafloor channel or fault scarp;
- Shallow faulting – The locations avoid all areas of shallow faulting at or near the seafloor; and
- Anomalies within salt – The proposed locations have been screened, using seismic interpretation, to avoid areas of significant intra-salt deformation.

Casing and drilling program engineering were considered in the proposed development program as well. Specifically, the 20-inch casing shoe has been designed to be set in a clean halite interval that is free of clastic interbeds. In addition, the well locations were selected within an area of undulating seafloor. The locations were chosen to avoid high dip magnitudes of the seafloor and any faults in the area.

Geohazards and environmental sensitivities were considered during selection of the drillsite locations. Gardline Surveys Inc. (2010, 2014) conducted a geohazards survey of the Leviathan Field and subsequently performed individual geohazard assessments for each proposed drillsite and an area surrounding it with a 2,000-m radius, based on 3D seismic data. Site-specific well clearance letters will be prepared and submitted as part of the application for a marine discharge permit for each individual well. The drillsites are located in water depths ranging from 1,619 to 1,709 m. The seafloor at the proposed drillsites is smooth and featureless. There are no significant seafloor features (such as hard bottom areas or deepwater coral formations), and there are no high seafloor amplitude signatures indicative of fluid expulsion within 500 m of each proposed well location. The seafloor sediments are believed to be composed of silts and clays with interbedded sands, which become firmer with increasing water depth.

Within the broader area, the Leviathan Field development drillsites were selected with respect to seafloor characteristics, shallow subsurface intervals of possible concern, and the optimal penetration point of the gas reservoir. An enlarged area encompassing the entire Leviathan Field was studied to define the original drillsite locations, from which the proposed locations were set to avoid potential gas hazards. The Leviathan Field drillsites 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 drillsite was adjusted to avoid deeper faults proximal to the original wellbore. The choice of drillsites effectively avoids intersection with small faults in the shallow, post-salt section and allows for the setting of two successive casing points in relatively clean salt that is expected to be clean of clastic interbeds. All of these considerations help to minimize the safety, environmental, and drilling risks at each of the proposed drillsite locations.

The following additional specific criteria cited in the “Guidelines for Preparation of Environmental Impact Document” were taken into account by Noble Energy:

- 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 are 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 are present in the Application area (see benthic communities discussion in **Section 1.6.1**).
- “[P]roximity to towns and residential areas, visibility and appearance from the coastline” – not relevant due to the distance from shore (122 km for the nearest well).
- “[H]abitats of animals in danger of extinction” – there are no specific “critical” habitats for endangered or threatened species in the Application area. Endangered or threatened species that may be present in the region are discussed in **Section 1.6** and are included in the impact analysis in **Chapter 4**.
- Shipping lanes – There are no shipping lanes in the Leviathan Field; the nearest shipping lanes are those approaching the port of Haifa (see **Section 1.11**). Therefore, shipping lanes did not factor into the selection of drillsites.
- Infrastructure, communications and energy lines – known regional infrastructure proximal to the drillsites includes 1) a Med Nautilus telecommunications cable, which runs through the middle of the field; and 2) the currently “as drilled” Leviathan subsea wells (Leviathan-1 through Leviathan-4) (see **Section 1.11**). The drillsites have been selected to avoid any physical impacts to the telecommunications cable; all of the drillsites are more than 1 km away from the nearest cable. No seafloor-disturbing activities will be conducted near the telecommunications cable and no impacts are expected (see **Chapter 4**).
- Current regime – the current regime was considered in the design criteria for drilling rigs and support vessels, but there are no significant spatial differences in current regime within the Leviathan Field. Therefore, it was not a factor in selecting individual drillsites.

- Fish reproduction zones and times; fishing areas and marine farming zones – there are no fish reproduction zones or fishing areas in the Leviathan Field, and the nearest marine farming zones are along the coast (see **Sections 1.6.3** and **1.12**).

Table 2-2 presents a summary of the technical and environmental factors considered by Noble Energy in selecting the initial drillsites for the proposed drilling and completion program.

Table 2-2. Summary of technical and environmental factors evaluated in the selection of drillsite locations. Because no formal location alternatives were evaluated, the proposed drillsite locations (as a group) are rated as acceptable or not acceptable for each criterion.

Criteria	Evaluation	Reference	Rating
Structure and target layers	Initial well locations were selected based on the interpretation of seismic and geophysical survey data acquired in the Leviathan North and South Leases, as well as results from previous exploratory and appraisal wells at Leviathan and in nearby fields.	Section 2.2	Acceptable
Geohazards	Noble Energy commissioned a 3D geohazards survey of the Leviathan Field by Gardline Surveys Inc., and the findings were taken into account in the siting of the proposed drillsites. Noble Energy will prepare a site-specific geohazard assessment for each drillsite to be submitted with the application for a discharge permit. The geohazards assessment evaluated the seafloor and sub-seafloor conditions including shallow hazards that may affect drilling and completion activities out to a radius of 2,000 m. No significant geohazards were identified at the seafloor; there is no known risk of gas in the area of the proposed drillsites; and there is little or no shallow water flow risk based on offset wells in the area. Noble Energy used the information from the geohazards assessment to design the drilling program to mitigate risks from geohazards. The subsurface team considered numerous alternative locations for each well to avoid seafloor anomalies and to avoid interpreted shallow sand accumulations and possible fault intersections in the shallow section.	Geohazards reports (Gardline Surveys Inc., 2010, 2014).	Acceptable
Marine reserves	None are present in or near the Leviathan Field.	Chapter 1	Acceptable
Special regions	No ridges, canyons or deep coral reefs, sponges, or other hard bottom communities are present in the Application area.	Section 1.6.1; Appendix D	Acceptable
Habitats of endangered animals	No critical habitats for endangered species are present in or near the Leviathan Field.	Section 1.6.2	Acceptable
Proximity to villages and residential areas	Not a factor in drillsite selection due to the distance from shore (122 km for the nearest well).	N/A	Acceptable
Shipping lanes	Not a factor in drillsite selection because there are no shipping lanes in the Leviathan Field (the nearest shipping lanes are those approaching the port of Haifa).	Section 1.11	Acceptable
Infrastructure including communications cables and energy pipelines	A Med Nautilus telecommunications cable runs through the middle of the Leviathan Field. The drillsites have been selected to avoid any physical impacts to the telecommunications cable, and all of the initial drillsites are more than 1 km away from the nearest cable. No seafloor-disturbing activities will be conducted near the cable.	Section 1.11	Acceptable
Fishing and marine agriculture	Not a factor in drillsite selection due to the distance from shore (122 km for the nearest well). There are no fish reproduction zones or fishing areas in the Leviathan Field, and the nearest marine farming zones are along the coast.	Section 1.6.3 Section 1.12	Acceptable
Current regime	The current regime was considered in the design criteria for drilling rigs and support vessels, but there are no significant spatial differences in current regime within the Leviathan Field. Therefore, it was not a factor in selecting drillsites.	Section 1.5	Acceptable

2.3 TECHNOLOGICAL ALTERNATIVES

Noble Energy evaluated technological alternatives including types of drilling rigs, drilling technology, the drilling mud program, and cuttings treatment technology.

2.3.1 Type of Drilling Rig

Two drilling rigs, which have not yet been identified, will be needed to conduct the drilling and completion operations as described in **Chapter 3**. One rig will conduct the drilling operations, and the second rig will perform the well completions. Based on the technical requirements for the drilling program, Noble Energy determined that a dynamically positioned (DP) drillship or DP semisubmersible is preferred with the following minimum general specifications:

- Minimum drilling depth capability in excess of 6,000 m;
- Minimum working water depth in excess of 1,700 m;
- Well control equipment rated at 10,000 psi capacity;
- 18¾-inch blowout preventer (BOP) system with dual annulars and 4 ram-type preventers;
- Minimum hook load of 1,500 kilopounds and 60.5-inch rotary table;
- Top drive to deliver 50,000 ft-lb of torque at drilling rpm of 130;
- Three mud pumps rated at 7,500 psi;
- Bulk storage for 10,000 sacks of cement and 6,000 sacks of barite;
- Fluid storage of 17,000 barrels (bbl) for active and reserve pits and additional storage for 6,000 bbl of brine;
- Zero-discharge capability;
- Pipe and tubular handling for all drill pipe, casing, and tubing required for the project;
- Completion and well-testing capabilities;
- Drill pipe: 6⅝-inch designed for 7,500 m (approximately 25,000 ft) with 50,000 ft-lb of torque; and
- Minimum personnel capacity of 180 persons.

Noble Energy is in the process of evaluating rig tenders that meet these requirements. The selection will be affected by rig availability and Noble Energy's additional rig operations in the Eastern Mediterranean region. After the drilling rigs are selected, the specific rig detail will be submitted to the ministries in the discharge permit application.

2.3.2 Drilling Technology

The new Leviathan wells (Leviathan-5 through Leviathan-10) are planned as vertical where possible, but directional where required to avoid shallow hazards. A directional pilot hole will be drilled to total depth, the reservoir will be evaluated, and the wellbore will be sidetracked back to vertical, offsetting the original wellbore, down to the top of the reservoir ("A" or "C" Sand), as required. The wells are planned with a generous target tolerance. Control drilling or sliding to maintain wellbore vertical is not a requirement; however, care will be taken to minimize "dog legs." Rotary steerable technology will be used. A summary of the key drilling technologies are as follows:

- **Rotary steerable systems** are 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 drillstring or orient the bit in the desired direction while continuously rotating at the same number of rotations per minute as the drillstring. 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** are 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. Some MWD tools have the ability to store the measurements for later retrieval with wireline or when the tool is tripped out of the hole if the data transmission link fails. MWD tools that measure formation parameters (resistivity, porosity, sonic velocity, gamma ray) are referred to as logging while drilling (LWD) tools. 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.

2.3.3 Drilling Mud Selection and Cuttings Treatment Technology

To date, all but one of Noble Energy's wells offshore Israel have been drilled using water-based mud (WBM). A deep hole portion of Leviathan-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 (National Research Council, 1983) and is adequate for many drilling programs. However, 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, Noble Energy has 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.

In November 2013, Noble Energy drilled Tamar SW-1, a Miocene well from 3,620 to 5,377 m measured depth (MD) in 157.3 rotating hours (on bottom) with WBM. Previously, between June and August 2013, Noble Energy drilled Cyprus A-2a, a similar Miocene well, [redacted] This was 83.2 hours (3.5 days) less, or a 53%

reduction in total drilling hours, due to increased rates of penetration with MOBM. This does not include other potential reductions in time that could be achieved from reduced hole-stability issues.

These factors have led Noble Energy to pursue the alternatives of non-aqueous drilling fluids (NADF) such as MOBM to maintain proper well control, rheological control, inhibition capability, and lubricity. With the infrastructure currently being installed for use of MOBM for the deep drilling test (ML-1X), Noble Energy is proposing to use MOBM for the drilling program in the Leviathan Field as well. 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.

When wells are drilled exclusively with WBM, all of the cuttings (and some of the drilling mud) are typically discharged to the ocean (National Research Council, 1983; Neff, 1987, 2005, 2010). Discharges of WBM and cuttings are routinely permitted offshore Israel and in nearly all countries that have an offshore oil and gas industry. However, when NADF are used, the muds are recycled rather than discharged, and cuttings discharges are subject to restrictions that vary from country to country (International Association of Oil & Gas Producers, 2003). Under the Offshore Protocol of the Barcelona Convention (which Israel has signed but not ratified), NADF cuttings discharges are allowed, subject to a retention limit of 10% base oil content (by dry weight) on cuttings. A well-established regulatory framework exists in the North Sea (Norway, United Kingdom, etc.) through the Convention for the Protection of Marine Environment in the Northeast Atlantic (OSPAR), which provides the basis for the option being considered by Noble Energy. In the OSPAR region, NADF systems are widely used and include both MOBM and synthetic-based mud. Although NADF cuttings can be discharged, the residual NADF on cuttings is limited to 1% (dry weight) under OSPAR Resolution 2000/3 (OSPAR Convention for the Protection of Marine Environment in the Northeast Atlantic, 2000).

Noble Energy's preferred option is to use MOBM for the Leviathan Field Drilling Program due to increased operational efficiency, shale inhibition, wellbore stability, and lubricity while reducing drilling time and chemical usage. The initial well intervals still would be drilled with WBM as explained in **Section 3.7.2**. The cuttings from MOBM well intervals would be processed to less than l% base oil content (by dry weight) on cuttings and disposed of on site, as is currently permitted by OSPAR. This objective would be achieved by installing a thermomechanical cuttings cleaner (TCC) on the drilling rig which would process the cuttings prior to discharge. Further details of the selected MOBM and TCC are presented in the following sections.

2.3.3.1 Mineral Oil Based Drilling Mud System

[redacted]

[redacted]

[redacted]

2.3.3.2 Thermomechanical Cuttings Cleaner

Noble Energy plans to use a TCC (or equivalent system) to process the cuttings to less than 1% oil on cuttings for on-site disposal (see **Appendix I** for specifications). **Figure 2-3** shows a flow diagram for processing drilling mud and cuttings on the drilling rig. Drilling mud is circulated down the drill pipe continuously during drilling and returns to the surface through the annular space between the drill pipe and casing, carrying drill cuttings in suspension. On the drilling rig, the mud and cuttings are passed through solids control equipment designed to separate the drill cuttings so that the mud can be pumped back down the hole. The cuttings are initially separated using mesh screens on shale shakers and then transferred to a process plant that uses mechanical action applied directly to the drill cuttings to create temperatures (260°C to 280°C) that rise above the boiling points of water and oil. Reaching these temperatures removes the hydrocarbons from the solids to less than less than 1% oil on cuttings. The remaining water and oil vapor is then condensed into the relevant streams and recovered separately. The recovered oil is pumped back into the mud system and the water is disposed overboard if it meets the offshore disposal guidelines. Water that does not meet the discharge limits is transferred to a holding tank and disposed of onshore. Typical oil in water content of the recovered water is less than 30 ppm.

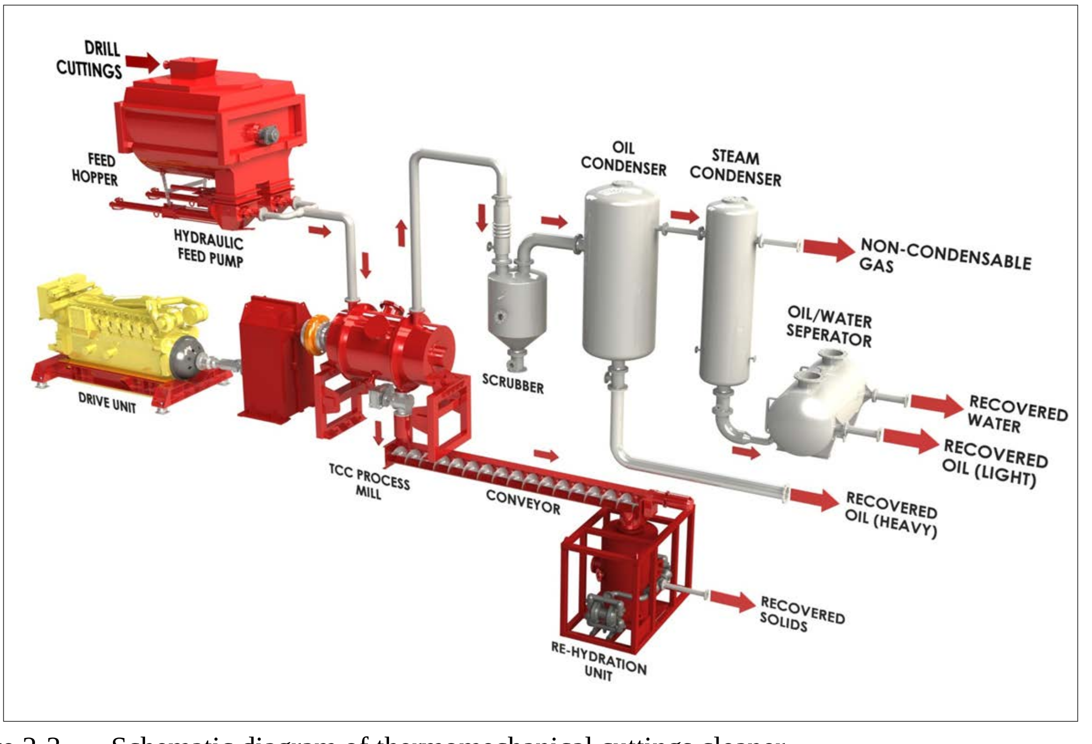


Figure 2-3. Schematic diagram of thermomechanical cuttings cleaner.

The process mill is the heart of the TCC process. Its main function is to generate friction heat to force the evaporation of water and oils present in the feed material. The rotor operates with the rotational speed of 600 to 700 rpm, which creates a ring-shaped bed of material along the stator wall. Due to the intense agitation of the rotor, motor energy is transferred as heat to the material bed, allowing water and oil in the material to be efficiently flash evaporated. The condenser module is broken into four stages with the oil scrubber being the primary vessel that removes the final solids from the recovered vapor. From there, the vapor travels through an oil condenser, water condenser, and oil/water separator (OWS).

Key advantages of the system are as follows:

- Direct heating of the waste stream resulting in maximum energy efficiency;
- Recovered base oil which can be directly recycled;
- Dried solids that are clean and can be disposed of on site;
- An easily relocated unit that is ideal for offshore use; and
- Rapid start-up and shutdown, which facilitates simple maintenance tasks.

Data collected from previous operations where the proposed TCC technology has been used in the U.K. North Sea show that the average oil content on cuttings is much lower than than 1% OSPAR limit (Aquateam COWI AS, 2014). Noble Energy received information from the U.K. Department of Energy and Climate Change that performance levels achieved from this technology achieved oil removal to levels as low as 0.015% in 2011 and 2012 and 0.1% in 2013.

2.3.3.3 Riserless Mud Recovery System

Noble Energy is actively engaged in the investigation of the use of riserless mud recovery systems for the Leviathan Development. Preliminary investigation with the world's leading supplier of this recovery system has been initiated. The initial investigation has discovered that the water depths in the Leviathan Field are 250 to 300 m greater than the maximum depth of use of this system. Some preliminary calculations have been made and have determined that the subsea pumps available are capable of delivering the performance necessary for this project; however, new return piping and deployment systems would have to be investigated to determine actual feasibility in these water depths. Such a feasibility study would have to be performed prior to the economic benefit analysis. It is estimated that this study and the ensuing analysis could be accomplished in a 6-month time frame. Once the project is officially sanctioned, it will be submitted for budget.

2.3.3.4 Cuttings Disposal Alternatives

Noble Energy evaluated the alternative of transporting MOBM cuttings to shore for disposal (Noble Energy, 2014). This would entail an energy cost to transport the cuttings by ship from the drillsite to a processing facility in Haifa with further transport of residual materials to the Ramat Havav hazardous waste disposal facility. The additional energy cost and air pollutant emissions (from vessels and trucks) would add to the total environmental footprint of the project. In addition, the cuttings would need to be disposed at the Ramat Havav hazardous waste facility (rather than a conventional landfill) due to the probable high total dissolved solids (TDS) content. The expected TDS content of the cuttings is less than that of seawater and will consist of salts of sodium, calcium and magnesium, which would have minimal to no impacts if disposed offshore. The cuttings would contribute to filling up the Ramat Havav facility, thereby accelerating the need for expansion of this facility before its time. Therefore, the onshore disposal alternative is ranked as less suitable than Noble Energy's preferred alternative (offshore disposal of TCC-treated cuttings).

Noble Energy also considered reinjection of cuttings. However, reinjection requires a dedicated well that has the ability to absorb the residual slurry. During drilling, such wells are not generally available because they need a continuous flow of materials to make them feasible. Additionally, high solids content of injected material makes it difficult to keep such wells operational. The reinjection alternative is evaluated as not feasible for this drilling program.

2.3.4 Blowout Preventer Technology

Detailed BOP specifications vary depending on the drilling rig. However, Noble Energy's rig tender included the following specifications: 1) minimum well control equipment rated at 10,000 psi capacity; and 2) 18¾-inch BOP system with dual annulars and four ram-type preventers. Details and a diagram of the BOP stack are provided in **Section 3.2.5**. Noble Energy and the rig's owner will engage in a comprehensive inspection and testing of the rig'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.

There are no alternatives to the use of a BOP for well control, although different configurations were evaluated (see **Section 3.2.5**). The BOP specifications which were selected are based on best industry practice and reflect Noble Energy's commitment to safety throughout the drilling program.

2.4 SUMMARY

Table 2-3 summarizes the location and technology alternatives evaluated in this chapter.

Table 2-3. Summary of location and technological alternatives evaluated for the Leviathan Field drilling and completion activities.

<table>
<tr><th>Subject</th><th>Proposed Action</th><th colspan="2">Alternatives Evaluated and Ratings</th><th>Reference</th></tr>
<tr><td>Well locations</td><td>Noble Energy's development plan includes the drilling and completion of up to 29 wells in the Leviathan Field. Eight well locations are proposed for the initial development. The final number and locations of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and futur7e appraisal.</td><td colspan="2">RATING: Acceptable
Noble Energy considered alternate placement of wells and larger and smaller total numbers of wells to develop the field. The number and location of initial wells were selected to satisfy early production needs, provide optimal drainage of gas, and provide reservoir surveillance. Table 2-2 summarizes the factors considered. Initial well locations were 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.</td><td>Section 2.2
Section 3.2</td></tr>
<tr><td>Type of drilling rig</td><td>Two drilling rigs are required (one for drilling and one for well completions). Due to the water depths in the Leviathan Field, Noble Energy plans to use a dynamically positioned (DP) drillship or semisubmersible. Drilling rigs have not been selected but Noble Energy has issued detailed specifications.</td><td>DP Drillship or DP Semisubmersible
RATING: Acceptable
A DP drillship or semisubmersible can meet Noble Energy's specifications.</td><td>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.</td><td>Section 3.2.2</td></tr>
<tr><td>Drilling technology</td><td>The initial drilling plan includes vertical and sidetrack (directional) wells. The new wells (Leviathan-5 through Leviathan-10) 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.</td><td colspan="2">RATING: Acceptable
The design of individual wells was based on Noble Energy's evaluation of reservoirs and is intended to satisfy early production needs, result in optimal drainage of gas, and provide reservoir surveillance. Drilling technologies were selected based on Noble Energy's experience as most suitable for the safety and efficiency of the drilling program.</td><td>Section 3.2</td></tr>
<tr><td>Drilling mud selection</td><td>Noble Energy plans to use a combination of water-based mud (WBM) and mineral oil-based mud (MOBM). The MOBM system that Noble Energy is planning to use is [redacted] would be the base fluid for this mud system.</td><td>WBM and MOBM Combination: RATING: Acceptable
This alternative will allow Noble Energy 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. [redacted] is a highly refined product with low toxicity and very low aromatic content; it is readily biodegradable and not expected to exhibit chronic toxicity to marine organisms.</td><td>WBM Only: RATING: Less Suitable
Using WBM exclusively would be less efficient, extend drilling time, and would require the use of numerous specialty chemicals.</td><td>Section 2.3.3
Section 3.7.2
Appendix G</td></tr>
</table>

Table 2-3. (Continued).

Subject	Proposed Action	Alternatives Evaluated and Ratings			Reference
Cuttings treatment and disposal	Noble Energy proposes to discharge cuttings to the ocean at the drillsites. Cuttings from MOBM well intervals will be treated in a thermomechanical cuttings cleaner (TCC) on board the drilling rig to reduce the MOBM retention on cuttings to less than 1% by dry weight in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3).	**Offshore Disposal RATING: Acceptable** The proposed offshore disposal of TCC-treated MOBM cuttings to the ocean at the drillsites, subject to MNIEWR approval, is the most efficient alternative and meets Noble Energy's environmental goals by reducing the retention on cuttings to less than 1% in accordance with OSPAR guidelines.	**Onshore Disposal RATING: Less Suitable** This would entail an energy cost that would add to the environmental footprint of the project. The cuttings would need to be disposed at the Ramat Havav. The cuttings would contribute to filling up the Ramat Havav facility.	**Cuttings Reinjection: RATING: Not Feasible** Reinjection requires a dedicated well that has the ability to absorb the residual slurry. During drilling, such wells generally are not available because they need a continuous flow of materials to make them feasible. Additionally, high solids content of injected material makes it difficult to keep such wells operational.	Section 2.3.3 Section 3.7.2 Appendix F
Blowout preventer (BOP) technology	Detailed BOP specifications will depend on the drilling rig. Noble Energy's rig tender included the following specifications: 1) well control equipment rated at 10,000 psi capacity; and 2) 18¾-inch BOP system with dual annulars and four ram-type preventers. Noble Energy and the rig's owner will engage in a comprehensive inspection and testing of the rig's subsea BOP system to ensure compliance with the U.S. Bureau of Safety and Environmental Enforcement (BSEE).	**RATING: Acceptable** The BOP specifications which were selected are based on best industry practice and reflect Noble Energy's commitment to safety throughout the drilling program.			Section 3.2.5

CHAPTER 3: PROJECT DESCRIPTION

3.1 GENERAL

This chapter describes Noble Energy's plans to conduct well drilling and completion activities for gas production and development in the Leviathan Field offshore Israel. Noble Energy's development plan includes the drilling and completion of up to 29 wells for full field depletion. The final number and locations of wells will be selected based on factors such as reservoir performance, reservoir connectivity, development phases, production profile, shallow hazards, and future appraisal. Although eight initial development drillsites were selected and are discussed in detail (see **Chapter 2**), the Application covers the entire Leviathan Field and is intended to anticipate additional future drilling in the field.

3.2 DESCRIPTION OF THE APPLICATION

3.2.1 General

Noble Energy plans to drill and complete six new wells (Leviathan-5 through Leviathan-10); drill a second sidetrack (ST02) of the existing Leviathan-3 well; and complete the existing Leviathan-4 ST01 sidetrack well, for a total of eight early producers. The locations are shown in **Figure 3-1** and the planned activities, water depth, and true vertical depth subsea for each well are summarized in **Table 3-1**.

Table 3-1. Planned activities, water depth, and true vertical depth subsea of initial wellsites for drilling and completion activities.

[redacted]

[a] Where two values are listed, the second is for the sidetrack (ST) well.

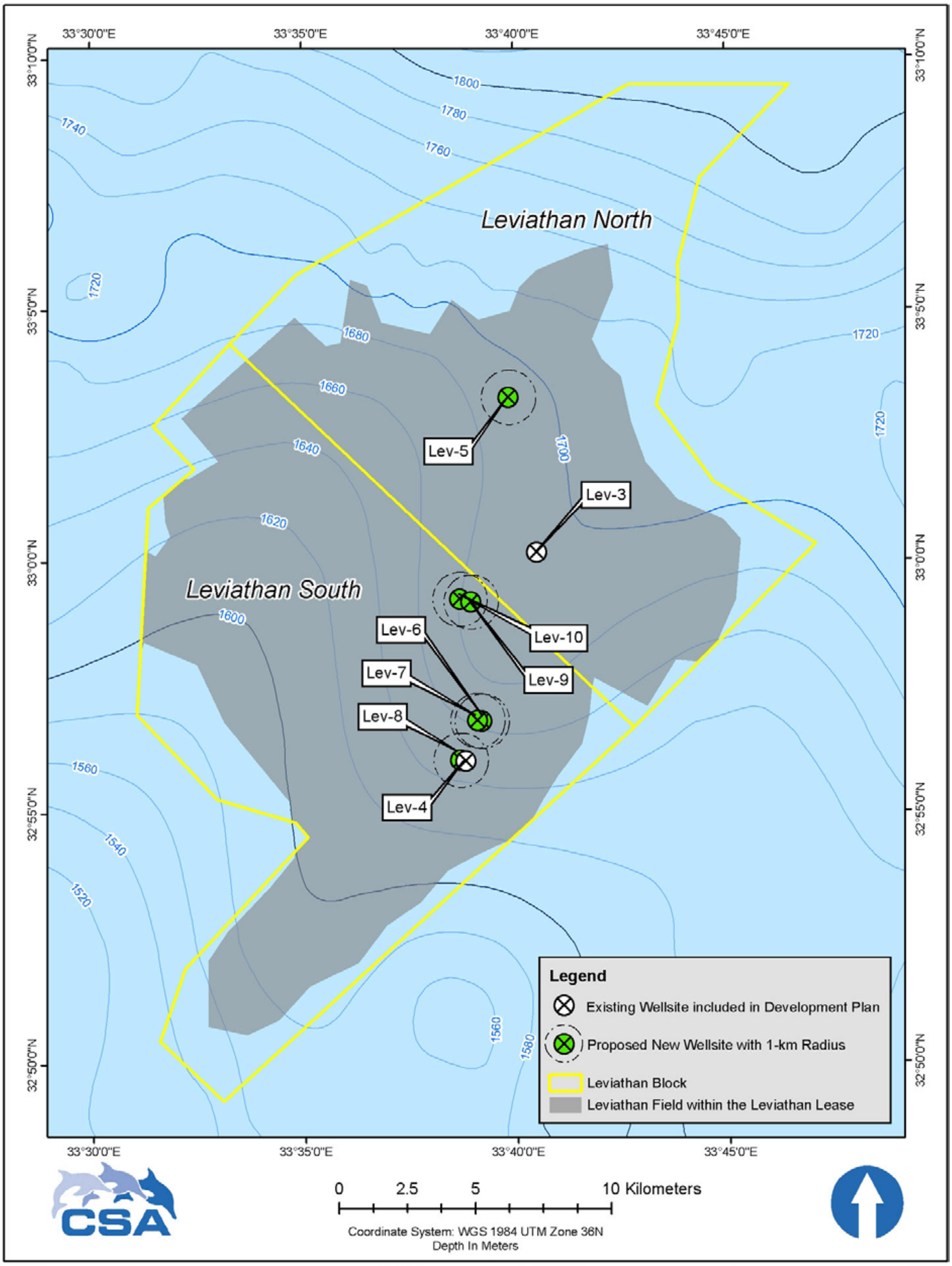


Figure 3–1. Locations of eight initial wellsites included in the Leviathan Field Development Plan. Leviathan-3 and Leviathan-4 are existing wells and locations are shown "as drilled." Leviathan-5 through Leviathan-10 are "new" proposed drillsites and the final surface locations may change within a 1-km radius, as shown. Contours show seabed depth.

The full development of the Leviathan Field is currently modeled to require approximately 29 producing wells, including two phases of construction. Phase 1 will include Leviathan-5 through Leviathan-10 as well as the completion of the Leviathan-3 and Leviathan-4 wells. It is also expected to require replacements for several of the initial wells. In Phase 2, additional wells will be drilled. The total number and locations for wells required in Phase 2 will change as production data are incorporated into the reservoir model and demand for the gas is detailed. Reservoir modeling and simulation have been run in order to forecast production performance and to help optimize possible future well needs and their locations. **Table 3-2** shows the distances between the well locations. Distances to the nearest shoreline and to Rosh Hacarmel and Hadera for the initial wellsites are listed in **Table 1-1**.

Table 3–2. Well spacing (distances in meters) between all current, planned, and possible future Leviathan Field wells (surface locations). Minimum distance to a neighboring well is highlighted in red; read along each row to the right from the starting well in the left column. Distances calculated from preliminary well locations; final distances may vary slightly.

Well Name	Distance (m) to Specified Well																															Min. Distance	Nearest Well
	Lev-1	Lev-2	Lev-3	Lev-4	Lev-5	Lev-6	Lev-7	Lev-8	Lev-9	Lev-10	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	L26	L27	L28	L29	L30	L31		
Lev-1	0	13805	9570	11592	9297	10820	10804	11661	7706	7681	7369	10520	10997	4867	5280	10873	743	9169	3968	7004	11462	8009	10151	12387	11914	9075	2708	2993	6113	15808	8397	743	L17
Lev-2	13805	0	4338	10623	7556	9142	9128	10534	7301	7250	7040	8559	6565	9364	10198	10606	13356	5193	9837	12092	4508	6571	10000	13657	2784	9646	13823	11358	7694	18558	13321	2784	L25
Lev-3	9570	4338	0	8113	5795	6530	6511	8065	3239	3165	2776	5877	4361	5026	5939	7829	9079	1249	5618	9257	3023	3636	8505	10908	3479	7716	9920	7366	3493	15841	9594	1249	L18
Lev-4	11592	10623	8113	0	13479	1586	1604	128	5768	5864	6646	2238	4086	7698	6464	730	10850	6906	9399	15425	6139	11013	16034	3044	11333	15043	13592	11453	8724	7942	4730	128	Lev-8
Lev-5	9297	7556	5795	13479	0	11952	11931	13456	7781	7682	6915	11317	10089	7263	8925	13049	9232	6767	6279	4773	8778	2481	2716	15952	4780	2102	7998	6304	5234	20707	13557	2102	L26
Lev-6	10820	9142	6530	1586	11952	0	20	1536	4331	4423	5199	653	2577	6555	5555	1468	10089	5328	8230	14106	4635	9499	14536	4534	9755	13568	12609	10339	7335	9476	5131	20	Lev-7
Lev-7	10804	9128	6511	1604	11931	20	0	1555	4310	4403	5178	634	2563	6536	5539	1481	10074	5309	8211	14086	4621	9479	14516	4549	9737	13547	12591	10320	7315	9492	5131	20	Lev-6
Lev-8	11661	10534	8065	128	13456	1536	1555	0	5761	5857	6639	2189	4006	7732	6517	822	10920	6863	9431	15441	6055	10994	16019	3143	11269	15033	13644	11492	8727	8027	4851	128	Lev-4
Lev-9	7706	7301	3239	5768	7781	4331	4310	5761	0	99	879	3754	3405	2855	2995	5286	7066	2123	4281	9813	3839	5300	10280	8179	6699	9278	8891	6412	3015	13000	6378	99	Lev-10
Lev-10	7681	7250	3165	5864	7682	4423	4403	5857	99	0	782	3843	3460	2823	3020	5384	7046	2065	4224	9727	3841	5202	10182	8278	6620	9180	8839	6353	2927	13098	6462	99	Lev-9
L11	7369	7040	2776	6646	6915	5199	5178	6639	879	782	0	4610	4060	2526	3168	6164	6776	1904	3703	8988	4099	4434	9402	9037	6133	8398	8322	5792	2186	13833	7046	782	Lev-10
L12	10520	8559	5877	2238	11317	653	634	2189	3754	3843	4610	0	2010	6112	5240	2057	9799	4677	7764	13557	4051	8871	13913	5154	9111	12953	12210	9889	6768	10103	5391	634	Lev-7
L13	10997	6565	4361	4086	10089	2577	2563	4006	3405	3460	4060	2010	0	6220	5881	4042	10321	3330	7684	12932	2060	7751	12770	7100	7322	11898	12295	9811	6200	12026	7213	2010	L12
L14	4867	9364	5026	7698	7263	6555	6536	7732	2855	2823	2526	6112	6220	0	1695	7060	4255	4394	1702	7858	6601	5020	9295	9429	7997	8182	6129	3784	2164	13831	6391	1695	L15
L15	5280	10198	5939	6464	8925	5555	5539	6517	2995	3020	3168	5240	5881	1695	0	5775	4560	5018	3228	9434	6782	6615	10990	7881	9202	9876	7128	5086	3731	12168	4696	1695	L14
L16	10873	10606	7829	730	13049	1468	1481	822	5286	5384	6164	2057	4042	7060	5775	0	10131	6597	8762	14834	6098	10573	15565	3106	11136	14555	12900	10795	8188	8058	4100	730	Lev-4
L17	743	13356	9079	10850	9232	10089	10074	10920	7066	7046	6776	9799	10321	4255	4560	10131	0	8610	3547	7323	10854	7768	10279	11659	11569	9179	3287	2995	5671	15141	7691	743	Lev-10
L18	9169	5193	1249	6906	6767	5328	5309	6863	2123	2065	1904	4677	3330	4394	5018	6597	8610	0	5334	9782	2508	4427	9440	9668	4706	8573	9859	7288	3377	14596	8398	1249	Lev-3
L19	3968	9837	5618	9399	6279	8230	8211	9431	4281	4224	3703	7764	7684	1702	3228	8762	3547	5334	0	6207	7753	4394	7989	11085	8032	6855	4623	2140	2144	15381	7841	1702	L14
L20	7004	12092	9257	15425	4773	14106	14086	15441	9813	9727	8988	13557	12932	7858	9434	14834	7323	9782	6207	0	12209	5723	3825	17285	9391	3138	4651	4647	6803	21553	13969	3138	L26
L21	11462	4508	3023	6139	8778	4635	4621	6055	3839	3841	4099	4051	2060	6601	6782	6098	10854	2508	7753	12209	0	6656	11494	9160	5425	10733	12329	9765	5875	14081	9021	2060	L13
L22	8009	6571	3636	11013	2481	9499	9479	10994	5300	5202	4434	8871	7751	5020	6615	10573	7768	4427	4394	5723	6656	0	5048	13471	4124	4146	7423	5165	2884	18238	11170	2481	Lev-5
L23	10151	10000	8505	16034	2716	14536	14516	16019	10280	10182	9402	13913	12770	9295	10990	15565	10279	9440	7989	3825	11494	5048	0	18381	7227	1136	8204	7299	7493	23031	15685	1136	L26
L24	12387	13657	10908	3044	15952	4534	4549	3143	8179	8278	9037	5154	7100	9429	7881	3106	11659	9668	11085	17285	9160	13471	18381	0	14240	17332	14740	12945	10903	4953	4143	3044	Lev-4
L25	11914	2784	3479	11333	4780	9755	9737	11269	6699	6620	6133	9111	7322	7997	9202	11136	11569	4706	8032	9391	5425	4124	7227	14240	0	6864	11543	9214	5992	19191	13070	2784	Lev-2
L26	9075	9646	7716	15043	2102	13568	13547	15033	9278	9180	8398	12953	11898	8182	9876	14555	9179	8573	6855	3138	10733	4146	1136	17332	6864	0	7238	6190	6430	21948	14572	1136	L22
L27	2708	13823	9920	13592	7998	12609	12591	13644	8891	8839	8322	12210	12295	6129	7128	12900	3287	9859	4623	4651	12329	7423	8204	14740	11543	7238	0	2572	6497	18403	10890	2572	L28
L28	2993	11358	7366	11453	6304	10339	10320	11492	6412	6353	5792	9889	9811	3784	5086	10795	2995	7288	2140	4647	9765	5165	7299	12945	9214	6190	2572	0	3925	17005	9404	2140	L19
L29	6113	7694	3493	8724	5234	7335	7315	8727	3015	2927	2186	6768	6200	2164	3731	8188	5671	3377	2144	6803	5875	2884	7493	10903	5992	6430	6497	3925	0	15545	8324	2144	L19
L30	15808	18558	15841	7942	20707	9476	9492	8027	13000	13098	13833	10103	12026	13831	12168	8058	15141	14596	15381	21553	14081	18238	23031	4953	19191	21948	18403	17005	15545	0	7601	4953	L24
L31	8397	13321	9594	4730	13557	5131	5131	4851	6378	6462	7046	5391	7213	6391	4696	4100	7691	8398	7841	13969	9021	11170	15685	4143	13070	14572	10890	9404	8324	7601	0	4100	L16

The six new drillsites form two clusters. Leviathan-6, Leviathan-7, and Leviathan-8 are near the existing Leviathan-4 drillsite; distances to Leviathan-4 are approximately 1,586 m for Leviathan-6; 1,604 m for Leviathan-7; and 128 m for Leviathan-8. The other cluster, consisting of Leviathan-5, Leviathan-9, and Leviathan-10, is near the existing Leviathan-3 drillsite; distances to Leviathan-3 are approximately 5,792 m for Leviathan-5; 3,239 m for Leviathan-9; and 3,165 m for Leviathan-10 (**Table 3-2**).

3.2.2 Drilling Rigs and Strategy

Two drilling rigs will be needed to conduct the drilling and completion operations. One rig will drill the wells, and the second rig will perform the well completions. Noble Energy has not selected specific drilling rigs but plans to use a DP drillship or DP semisubmersible (**Figure 3-2**) with the following minimum general specifications:

- Minimum drilling depth capability in excess of 6,000 m;
- Minimum working water depth in excess of 1,700 m;
- Well control equipment rated at 10,000 psi capacity;
- 18¾-inch BOP system with dual annulars and 4 ram-type preventers;
- Minimum hook load of 1,500 kilopounds and 60½-inch rotary table;
- Top drive to deliver 50,000 ft-lb of torque at drilling rpm of 130;
- Three mud pumps rated at 7,500 psi;
- Bulk storage for 10,000 sacks of cement and 6,000 sacks of barite;
- Fluid storage of 17,000 bbl for active and reserve pits and additional storage for 6,000 bbl of brine;
- Zero-discharge capability;
- Pipe and tubular handling for all drill pipe, casing, and tubing required for the project;
- Completion and well-testing capabilities;
- Drill pipe: 6⅝-inch designed for 7,500 m (approximately 25,000 ft) with 50,000 ft-lb of torque; and
- Minimum personnel capacity of 180 persons.

Figure 3-2. Example of a dynamically positioned (DP) drillship (left) and DP semisubmersible (right).

A DP drillship would mobilize to the Leviathan Field under its own power. A DP semisubmersible would be towed to the site by platform supply vessels.

3.2.3 Support Vessels and Helicopters

The drilling program will be supported by two MMC 87 Class platform supply vessels operating out of the port of Haifa. The vessels have an overall length of 87 m, a design draft of 5.9 m, and accommodations for 47 people. Helicopter support will be provided by a Bell 412SP owned by PHI, Inc. and operated by LAHAK out of Haifa Airport. Specifications for the project vessels and aircrafts are provided in **Appendix J**.

3.2.4 Drilling Schedule

Figure 3-3 shows the sequence of proposed drilling and completion activities. This schedule may be modified based on project delivery or Noble Energy drilling commitments.

The wells will be drilled in two clusters, a southern cluster consisting of Leviathan-6 through Leviathan-8 and a northern cluster consisting of Leviathan-9 and Leviathan-10 (both clusters are in the Leviathan South lease area), plus one satellite well, Leviathan-5, on the northern flank of the reservoir (in the Leviathan North lease area). The satellite well will be the first well drilled. Well drilling of the northern cluster will finish next to allow completion operations to start while drilling is being performed on the southern cluster. The first drilling rig will drill Leviathan-5, on the northern flank of the reservoir (approximately 75 days), then the northern cluster wells (Leviathan-9 and Leviathan-10) in sequence (approximately 75 days each) and then the Leviathan-3 sidetrack (approximately 30 days). Each well will be temporarily abandoned pending completion (see **Section 3.9**). The second drilling rig will begin completion operations on the northern cluster wells (approximately 40 days per well) while the first drilling rig proceeds to drill the southern cluster wells (Leviathan-6 through Leviathan-8) in sequence (approximately 75 days each, including sidetracks where applicable).

The total time for drilling and completing all of the wells is estimated to be 556 days. Drilling operations by the first drilling rig will require an estimated 480 days. The completion operations by the second drilling rig will require an estimated 320 days. There will be a period of approximately 236 days during which both drilling rigs will be operating in the Leviathan Field.

Task Name	Start	Duration
New Rig One	**0 days**	**480 days**
Lev 5 Drill	0 days	75 days
Lev 9 Drill	75 days	75 days
Lev 10 Drill	150 days	75 days
Lev 3 Drill	225 days	30 days
Lev 6 Drill	255 days	75 days
Lev 7 Drill	330 days	75 days
Lev 8 Drill	405 days	75 days
New Rig Two	**244 days**	**320 days**
Lev 5 Compete	244 days	40 days
Lev 3 Complete	284 days	40 days
Lev 9 Complete	324 days	40 days
Lev 10 Complete	364 days	40 days
Lev 6 Complete	404 days	40 days
Lev 7 Complete	444 days	40 days
Lev 8 Complete	484 days	40 days
Lev 4 Complete	524 days	40 days

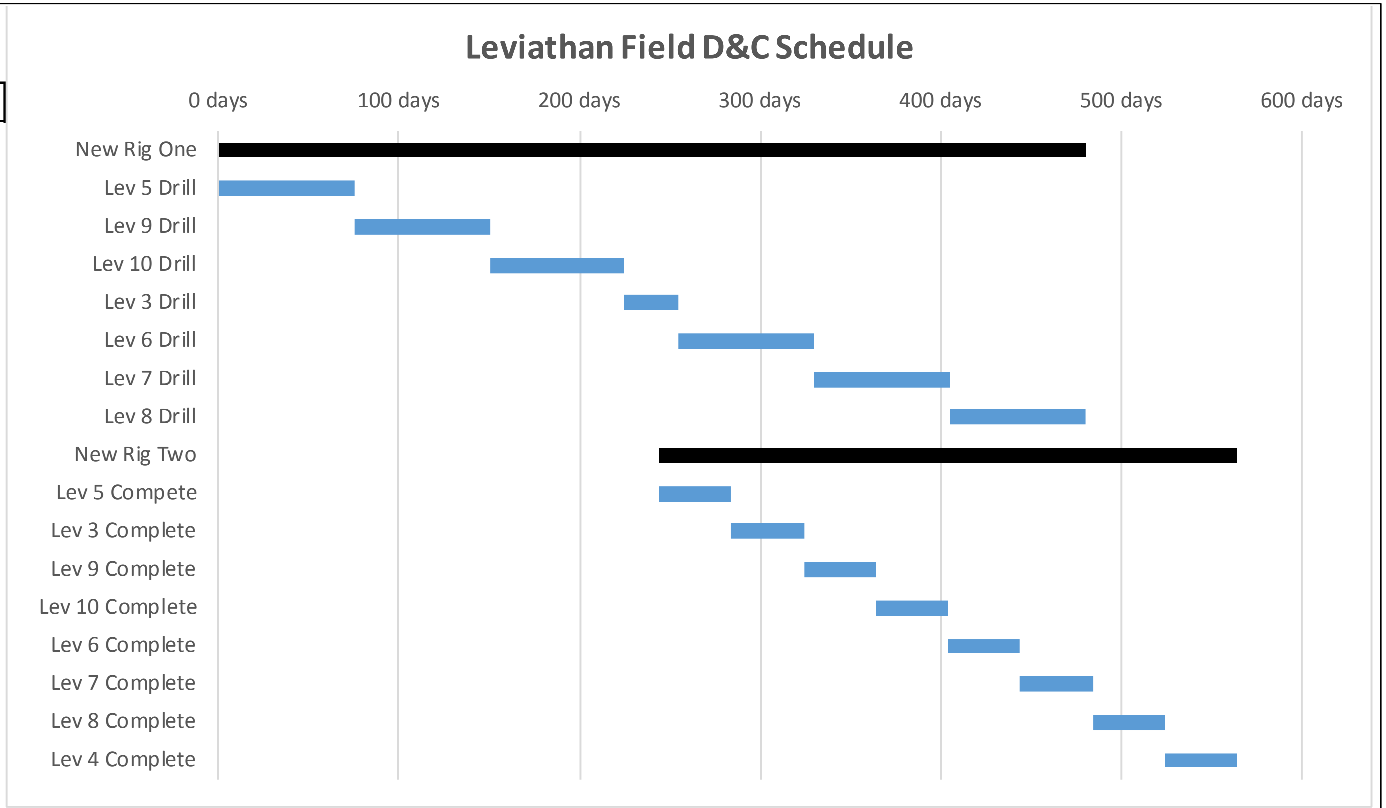


Figure 3-3. Schedule for drilling and completion activities in the Leviathan Field.

Figure 3-4 shows the depth of drilling as a function of time for the Leviathan-3 ST02 sidetrack well. The total duration is expected to be approximately 30 days. **Figure 3-5** shows a similar sketch for the Leviathan-5 through Leviathan-10 wells, which are expected to require approximately 75 days each. (No sketch is presented for the Leviathan-4 well because there will be no additional drilling, only completion.) The general steps for drilling each of the new wells (Leviathan-5 through Leviathan-10) are as follows:

[redacted]

[redacted]

Figure 3-4. Time vs. depth plot for drilling the Leviathan-3 ST02 sidetrack well.

[redacted]

Figure 3-5. Time vs. depth plot for drilling the Leviathan-5 through Leviathan-10 wells.

3.2.5 Blowout Preventer

Noble Energy 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). Noble Energy has not selected specific drilling rigs, and detailed BOP specifications vary depending on the drilling rig. A typical blowout preventor (BOP) stack is shown in **Figure 3-6**. A number of blowout preventer stacks have been evaluated and all were found to be fit-for-purpose for the Tamar Field Development, as shown in **Table 3-3**. Final BOP selection will depend on the drilling rig. Noble Energy's rig tender included 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**).

Table 3-3. Blowout preventer (BOP) stack manufacture, size and working pressure comparison by rig.

BOP Conponent	BOP Manufacture, Size and Working Pressure				
	ENSCO 5006	Noble Homer Ferrington	Sedco Express	GSF Development Driller II	Atwood Advantage
Annular	Hydril 18¾ in.x 10,000 psi WP	Shaffer Spherical 18-3/4 in x 5,000 psi WP (upper), 10,000 psi WP (lower)	Cameron DL 18¾ in. x 5,000 psi WP	Hydril GX 18¾ in. 10,000 psi WP	Hydril 18¾ in. x 10,000 psi WP
Pipe Rams	Cameron TL 18¾ in. x 15,000 psi WP	Shaffer SLX 18-3/4 in x 15,000 psi WP	Cameron TL 18¾ in. x 15,000 psi WP	Hydril Compact18¾ in x 15,000 psi WP	Hydril 18¾ in. x 15,000 psi WP

Noble Energy and the rig's owner will engage in a comprehensive inspection and testing of the rig'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 the BOP can be controlled:

- Electrocal 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.

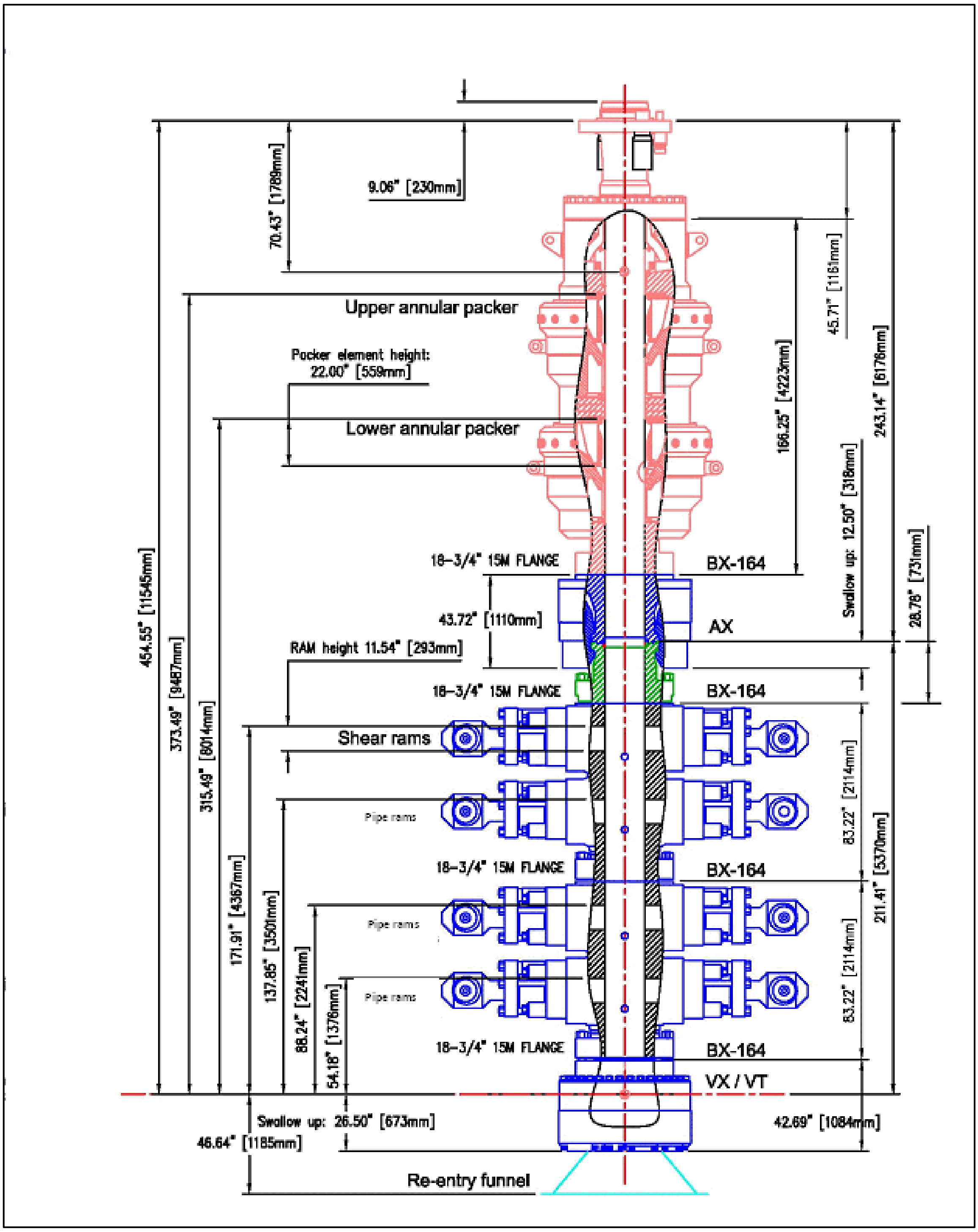


Figure 3-6. Typical blowout preventer (BOP) stack.

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 rig from the well in case of emergency. The EDS is intended to automatically trigger the deadman 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 rig 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 rig.

Noble Energy and the rig's owner will engage in a comprehensive inspection and testing of the rig's subsea BOP system to ensure compliance with BSEE regulations. The inspection and testing will be witnessed and certified by a third-party surveyor.

Noble Energy has committed to operating in Israel per BSEE regulations, unless superseded by MNIEWR 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 prvious shoe difference at the wellhead, casing top or shoe, whichever is less. For production casing stirngs, 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.

3.2.6 Protective Casing and Cementing

3.2.6.1 Casing Design

The basis of the well and casing design for the future Leviathan development wells is as follows:

- Water depths range from approximately 1,619 to 1,709 m with an estimated Rotary Kelly Bushing (RKB) elevation of 30 m above mean sea level;
- 36-inch structural casing set approximately [redacted] below the seafloor;

[redacted] 20-inch surface casing set at approximately [redacted]

- 16-inch drilling liner set at approximately 100 m above the base of salt;

- 13⅝-inch intermediate casing string set into the Serravallian; and
- 9⅞-inch × 10¾-inch production casing string set approximately 3 m into the top completion the sand.

Initially Leviathan wells were drilled with a four-string casing design. A five-string casing design was adopted after the Leviathan-2 well, due to complications encountered. The initial five-string design included an 11⅞-inch liner to case off the Middle Miocene (MM) sands before drilling into the Tamar sands. The previous design proved to have some limitations, including the following:

- The narrow annulus resulted in slow running speeds and high equivalent circulating densities while running the 11⅞-inch liner and 9⅞-inch × 10¾-inch producton casing; and
- If a casing string was set early, no contingency string would be available to ensure the proper hole size for the big-bore completion.

A 16-inch liner has been added to be set approximately 100 m above the base of the salt prior to penetrating the MM sands. This design will allow for a larger hole size shallower in the well, reducing risk as well as providing a high level of confidence that the well will be drilled as planned. The new design utilizes a 13⅝-inch casing string set into the Serravallian to isolate the MM sands and allow for a better cement job. The 9⅞-inch × 10¾-inch production casing will be set into the targeted production zone and will provide an 8½-inch minimum inner diameter for the 12¼-inch high rate open-hole gravel pack completion. Additionally, this design allows for a contingency liner to reach total depth with the required hole size if the casing strings cannot be set at the planned depths. **Figure 3-7** compares the old and new well designs. **Figures 3-8** and **3-9** show “as-built” wellbore schematics for the Leviathan-3/3ST01 and Leviathan-4 wells, respectively, and **Figure 3-10** shows the new wellbore schematic for the Leviathan-5 through Leviathan-10 wells.

[redacted]

Figure 3-7. Wellbore configuration of current and planned Leviathan development wells.

[redacted]

Figure 3-8. “As-built” wellbore schematic for the Leviathan-3/3ST01 well.

[redacted]

Figure 3-9. “As-built” wellbore schematic for the Leviathan-4 well.

[redacted]

Figure 3-10. Planned wellbore schematic for the Leviathan-5 through Leviathan-10 wells (new five-string well design).

36-inch Conductor

The 36-inch conductor is jetted to a setting depth of approximately [redacted] below mud line with 2.5 m of stickup above the mud line for the low pressure wellhead housing. The conductor is designed to accommodate the full load of the 20-inch surface casing and inner cement string at land out. The seafloor and sediments consist of clays, silts, and sands. Well locations have been chosen to have minimal sand in the conductor casing interval.

20-inch Surface Casing

The setting depth of the 20-inch surface casing is approximately [redacted] into the salt at approximately 2,900 m, just above the Messinian Evaporite 40 (ME40) in a clean halite section. This depth was chosen to provide sufficient fracture strength to use mud weights to control pressured salt inclusions that may be encountered before setting the next casing string. This depth is approximately 300 to 400 m deeper than the original Leviathan wells. The casing string will be cemented back to the surface to provide long-term isolation in the shallow formations and structural support for subsequent casing strings, BOP, and riser.

16-inch Liner

The setting depth of the 16-inch liner is planned approximately [redacted] above the base of salt. The liner is designed to isolate the salt and clastic intervals prior to drilling below the base of salt into the MM sands. This depth will provide sufficient fracture strength to drill the pressured MM sands, the reactive shale section, and below the Serravallian markers into the pressure regression. This drilling liner will provide a second barrier below the BOPs as is required prior to penetrating the pressured MM water sands. The 16-inch liner top will be set 100 m inside of the 20-inch casing. The full length of liner will be cemented across the salt section to isolate the remaining clastic interbeds in the salt.

13⅝-inch Casing

The setting depth of the 13⅝-inch casing will be into the Serravallian. This intermediate casing string will perform the following: 1) separate the MM water sands from the Tamar gas sands; 2) isolate the pressured and reactive shales prior to drilling into the production interval; 3) provide the capability to reduce mud weight prior to entering the lower pressure sections of the reservoir; 4) minimize the over-balance to the formation; and 5) allow for sufficient distance to deviate the pilot hole through the reservoir and then plug back and sidetrack for the vertical production hole. The desired departure is approximately 10 to 25 m between the sidetrack and pilot wellbores at the top of the "A" Sand. This casing string will be cemented approximately 150 m into the 16-inch liner providing long-term formation isolation.

9⅞-inch × 10¾-inch Production Casing

The 9⅞-inch × 10¾-inch production casing is designed to top-set the reservoir. The 9⅞-inch casing will be set approximately 3 m into the objective reservoir to isolate the shale and allow for a stable open-hole gravel pack capable of flow rates [redacted] The 9⅞-inch casing string incorporates an approximately 200 m chrome casing section to control corrosion and erosion in the "wet" flow area between the gravel pack and production packers. The 9⅞-inch × 10¾-inch crossover is set approximately [redacted] below mud line, deep enough to allow for installation of a 5½-inch surface-controlled subsurface safety valve (SCSSV) at a depth that provides adequate hydrate inhibition. In addition to the 10¾-inch casing hanger seal assembly, a bridging lockdown hanger will be set. The casing string will be cemented approximately 250 m into the 13⅝-inch liner providing long-term formation isolation.

3.2.6.2 Testing of the Cement and Casing

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 [10 ft] 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. A Cement Bond Log will be run on the production casing string to confirm cement bond and top of cement.

Casing Test Pressures

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. A Cement Bond Log will be run on the production casing string to confrm the cement bond and the top of the cement.

3.2.7 Well Completions

A single zone completion design is proposed for the Leviathan Field development wells. This design is a continuation of the highly engineered and successful Tamar design. A schematic diagram is presented in **Figures 3-11** (for Leviathan-3 ST02), **3-12** (for Leviathan-4 ST01), and **3-13** (for Leviathan-5 through Leviathan-10). The wells will be completed as single zone open-hole gravel pack completions with 7-inch tubing to enable high-rate gas production [redacted] Each well will be equipped with an SCSSV below mud line to prevent an uncontrolled release of hydrocarbons. In addition, each well will be equipped with a dual downhole pressure and temperature gauge for real-time downhole surveillance, included with chemical injection mandrels (CIMs) for mitigation against the potential risk of scale or hydrates.

[redacted]

Figure 3-11. Schematic diagram for completion of the Leviathan-3 sidetrack well (Leviathan-3 ST02).

[redacted]

Figure 3-12. Schematic diagram for completion of the Leviathan-4 sidetrack well (Leviathan-4 ST01).

[redacted]

Figure 3-13. Typical schematic diagram for completion of Leviathan-5 through Leviathan-10 wells.

3.2.7.1 Upper Completion

The upper completion design requires 7-inch tubing in order to deliver the desired gas rate of [redacted]. The top segment of the upper completion will be equipped with a 5½-inch SCSSV and a CIM. The lower segment of the upper completion will be equipped with a downhole pressure and temperature gauge and CIM immediately above a permanent production packer. The top CIM is for injecting methanol above the SCSSV to mitigate hydrate formation. The lower CIM is a contingency should chemical injection be required for scale inhibition or other similar related flow assurance issues.

3.2.7.2 Sand Face (Lower) Completion

The sand face (lower) completion strategy for Leviathan is the same as Tamar; this manages the risk of sand production downhole, which requires sand control. There are various applicable methods employed by the industry when sand control is required. For ultra-high gas rates [redacted], the open-hole gravel pack has been the technical preference, with a track record of efficient completions (low drawdown, low skin) as well as high reserve recovery (+300 billion cubic feet/well). The Leviathan completion design is based on highly engineered Tamar modeling that is based on the successful elements of Noble Energy's Mari-B #7, #9, and #10, as well as key BP wells (Kapok and Cannonball) in Trinidad and the recent Shell Ormen Lange project. The Tamar design also has yielded exceptional performance in the five producing Tamar wells.

3.2.7.3 Sand Control Requirement

The Leviathan sand face strategy is based on regional core control, which indicates that the reservoir is weakly consolidated and prone to sand production. A core scratch test was performed, which estimates an ultimate compressive strength of the core by passing a scratcher down the length of the core and estimating the resistance encountered by the scratcher blade. Based on the scratch tests performed by TerraTek on regional core sections from the "A" Sand interval, the ultimate compressive strength is very low.

3.2.7.4 Completion Operations

Wells will be completed in a batch mode. All new wells will be temporarily plugged and abandoned with production casings set at the top of the proposed reservoir. The typical completion steps are as follows:

- Ensure subsea tree has been installed (preferably offline prior to rig arrival);
- Move on location with the drilling rig;
- Run BOP and riser;
- Run in hole with BOP test assembly. Test BOPs and all other well control equipment. Displace riser to 11.9 pounds per gallon (ppg) brine. Pull out of hole with BOP test tools;
- Run in hole with packer retrieving tool and release upper retrievable packer (except on Leviathan-4, run in hole with 9½-inch drilling BHA and drill surface cement plug at [redacted] with 11.9 ppg brine and gel sweeps). Pull out of hole;
- Run in hole with packer retrieving tool and wellbore clean-out tools and release lower retrievable packer (except on Leviathan-4, run in hole with 8½-inch drilling BHA and drill bridge plug at [redacted] MD-RKB and shoe track with 11.9 ppg brine and gel sweeps);
- Displace well to reservoir drill-in-fluid (RDIF);
- Drill 8½-inch hole to an estimated total depth [redacted] MD-RKB. Pull out of hole;
- Run in hole with 8½-inch × 12¼-inch under-reamer with wellbore clean-out and enlarge 8½-inch open hole to 12¼ inches to an estimated total depth [redacted] MD-RKB;
- Spot solids-free RDIF (SFRDIF) in 12¼-inch open hole and ±150 m in the 9⅞-inch casing;

- Pull out of hole to top of SFRDIF and displace well to approximately 10.65 ppg NaCl/NaBr brine;
- Pull out of hole and prepare to run gravel pack assembly;
- Run gravel pack assembly to depth and set gravel pack packer;
- Circulate SFRDIF out of open hole with 10.65 ppg NaCl/NaBr brine;
- Pump open-hole gravel pack with 10.8 ppg gravel pack carrier fluid;
- Pull out of hole with wash pipe and close reservoir Model RB isolation valve;
- Run in hole and install straddle seal assembly;
- Displace well to 10.6 ppg NaCl/NaBr packer fluid. Pull out of hole;
- Run upper completion with subsea test tree and landing string;
- Set production packer. Land and lock tubing hanger;
- Open Model RB isolation valve and flow test well to rig. Clean up well at [redacted] as required;
- Secure well; and
- Demobilize the rig.

The time for each well completion is estimated to be 40 days.

3.3 PRODUCTION TESTS

3.3.1 Method

The estimated duration of production testing or "flowback" is approximately 49.5 hours per well. The surface well testing equipment will consist of the following:

- Surface flow head;
- Coflexip hose production flow line;
- Kill line to flow head;
- In-line surface safety valve;
- Cyclonic desander;
- Iso-split sampler;
- Data header;
- Double block choke manifold;
- Chemical injection pumps upstream and downstream of choke manifold;
- Three heat exchangers;
- [redacted] 2,000 barrels of water per day (bowpd) separator;
- Dual compartment surge tank;
- Triple compartment gauge tank;
- Four 4-mbtu (thousand British thermal units) steam exchangers;
- Oil manifold;
- Gas manifold;
- Two burner booms and burners with ignition systems;
- Two air compressors;
- Surface well flow and monitoring system;
- Sampling and fluid and gas testing equipment; and
- Dual pot filtration unit.

Well production parameters are summarized in **Table 3-4**. Once all surface safety systems have been tested, the landing string will be displaced to a lighter fluid to underbalance the well at approximately 500 psi. The overall strategy to the flow back is to bring the well online as quickly as necessary to unload liquids and steadily ramp production to the maximum flow rate [redacted] Once at maximum rate, the well will be monitored to determine when it can be considered "cleaned up." After determining the well is clean, flow will be continued until condensate yield is determined and samples are taken. The well will be stepped down in four steps as shown in **Table 3-5**. After shutting in at surface for the pressure buildup, the bottom hole pressure will be monitored and recorded for a minimum of 3 hours at a high frequency scan rate (1-second intervals). Methanol will be injected at the subsea test tree as well as upstream and downstream of the choke manifold for hydrate inhibition.

Table 3-4. Well production parameters.

[redacted]

API = American Petroleum Institute; CO_2 = carbon dioxide; H_2S = hydrogen sulfide; MMscf = million standard cubic feet; MMscfpd = million standard cubic feet per day; MOL% = mole percentage; SG = specific gravity.
[a] The Leviathan-5 well is planned as an "A" Sand completion; however, a "B" Sand completion is a fall-back option for this well. Noble Energy will make the best completion possible based on the data obtained during drilling.

Table 3-5. Timing of flow testing activities.

[redacted]

MMscf = million standard cubic feet; MMscfpd = million standard cubic feet per day.

All produced gas, condensate, and injected methanol will be flared off. Air pollutant emissions from production testing are estimated in **Section 3.5.4**. Any brine, produced water, or condensate water flowed back will be collected, filtered, and tested and discharged overboard as per Noble Energy standards. Any fluid that does not pass will be collected and shipped to an approved waste disposal facility.

Noble Energy will use a high-efficiency burner to minimize the potential for fallout. High-efficiency burners have a unique nozzle design that uses compressed air to atomize the oil in a mixing chamber.

Internal air mix atomizers produce much smaller hydrocarbon droplets than conventional burners. Smaller droplets burn faster, eliminating the potential for raw hydrocarbons to fall out of the flame. Carefully positioned multiple burner tips create maximum flame turbulence and air ingestion. Multiple tips discharge the well effluent in a unique array. The combination of atomized droplets and maximum air ingestion makes the burn very clean. An efficient pilot system with remote igniters provides the ignition source for the finely atomized spray.

Well buildup will be monitored and recorded under a closed SCSSV via the intervention and workover control system for a minimum time of 3 hours until rig activities force the cessation of monitoring and recording bottom hole pressure data.

Once the final buildup period has finished, the SCSSV will remain closed and the tubing pressure will be bled off. A 60% methylene glycol/40% seawater fluid will be lubricated above the SCSSV to the subsea tree. Slickline will be rigged up and the nipple bore protector will be retrieved from the tubing hanger. A 5¼-inch tubing hanger plug will be run and tested to make the well secure. The landing string with the subsea test tree and tubing hanger running tool will be retrieved. The riser will be displaced to seawater and the BOP and riser unlatched from the Cameron subsea tree. The internal tree cap with 5¾-inch plug installed will be run and tested for final well safety. A lightweight debris cap will be installed. The Cameron subsea tree would be made safe and the intervention and workover control system will be retrieved.

3.3.2 Chemical Substances

Chemicals to be used during production testing/flowback are tabulated in **Section 3.7.2.3** for well completions. The flowback is a continuation of the completion phase and therefore the chemicals are the same. During flowback, the completion brine and chemicals are flushed from the production tubing, leaving dry gas in its place and leaving the well ready to flow down the production line.
A table of chemical substances planned to be used during drilling and production testing is included in **Appendix H**, along with Safety Data Sheets (SDSs) for all chemicals.

3.3.3 Hydrogen Sulfide

To date, no hydrogen sulfide (H_2S) has been recorded within the immediate vicinity and the low thermal gradient in the area is not suggestive of H_2S.

3.4 NOISE HAZARDS

3.4.1 Noise from the Drilling Rigs

To assess the impact on marine receptors of underwater sound during drilling, the propagation of sound into the surrounding environment has been modeled by the engineering consulting company Genesis. The sound sources were modeled using representative spectra from published noise measurements. The propagation of this sound into the environment was calculated using Genesis' noise model, which incorporates depth-dependent geometrical spreading and empirical functions for frequency attenuation (Marsh and Schulkin, 1962; Richardson et al., 1995; Jensen et al., 2011). The model was run for a muddy sediment environment in a water depth of approximately 1,700 m. A grid size of 5 km × 5 km was used with a spatial resolution of 50 m.

The drilling program will use a DP drillship or DP semisubmersible. Propeller cavitation is a dominant noise source on DP vessels due to the continuous use of thrusters to maintain position. Drilling rigs also generate underwater noise from the vibrations of machinery and drilling equipment such as pumps, compressors, and generators. On a drillship, these sounds are transmitted through the hull, which is well coupled to the water (Richardson et al., 1995). Drilling noise is typically low and continuous, with most energy below 1 kHz (Richardson et al., 1995). Source levels were found to be less than 195 dB (rms) re 1µPa-m for a drillship (Nedwell and Edwards, 2004). More underwater noise is generated during drilling than during periods of non-drilling due to the use of additional machinery and power demands (McCauley, 1998). Greene (1987) found that the sound generated by a semisubmersible drilling rig did not exceed local ambient levels beyond 1 km, although weak tones were detectable up to 18 km away. Drilling sounds will be continuously generated for long periods throughout drilling.

Sound from Leviathan Field drilling activities was modeled by Genesis using measurements from a drillship (Miles et al., 1987) (**Figure 3-14**). This is a conservative assumption because a drillship is likely to be louder than a semisubmersible drilling rig (e.g., Richardson et al., 1995). The drilling noise was found to have a peak sound pressure level (SPL) of 177 dB re 1 µPa (**Figure 3-15**).

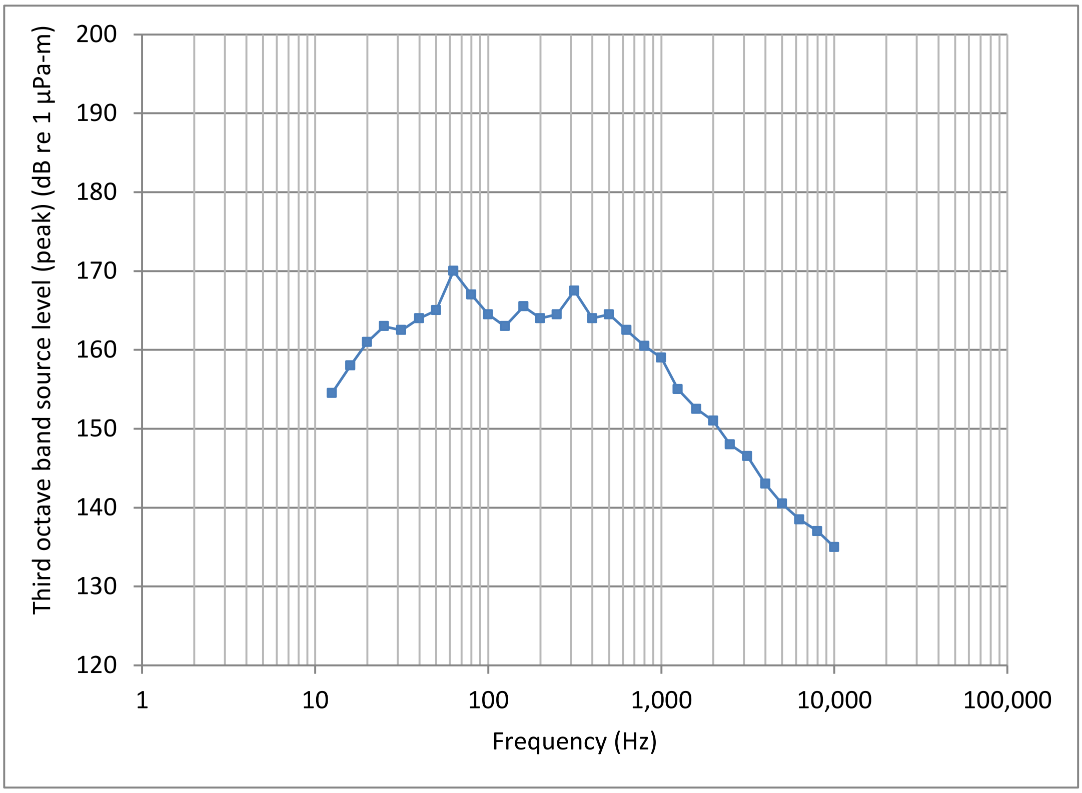


Figure 3-14. Sound source spectrum for a drillship (From: Genesis; based on: Miles et al., 1987).

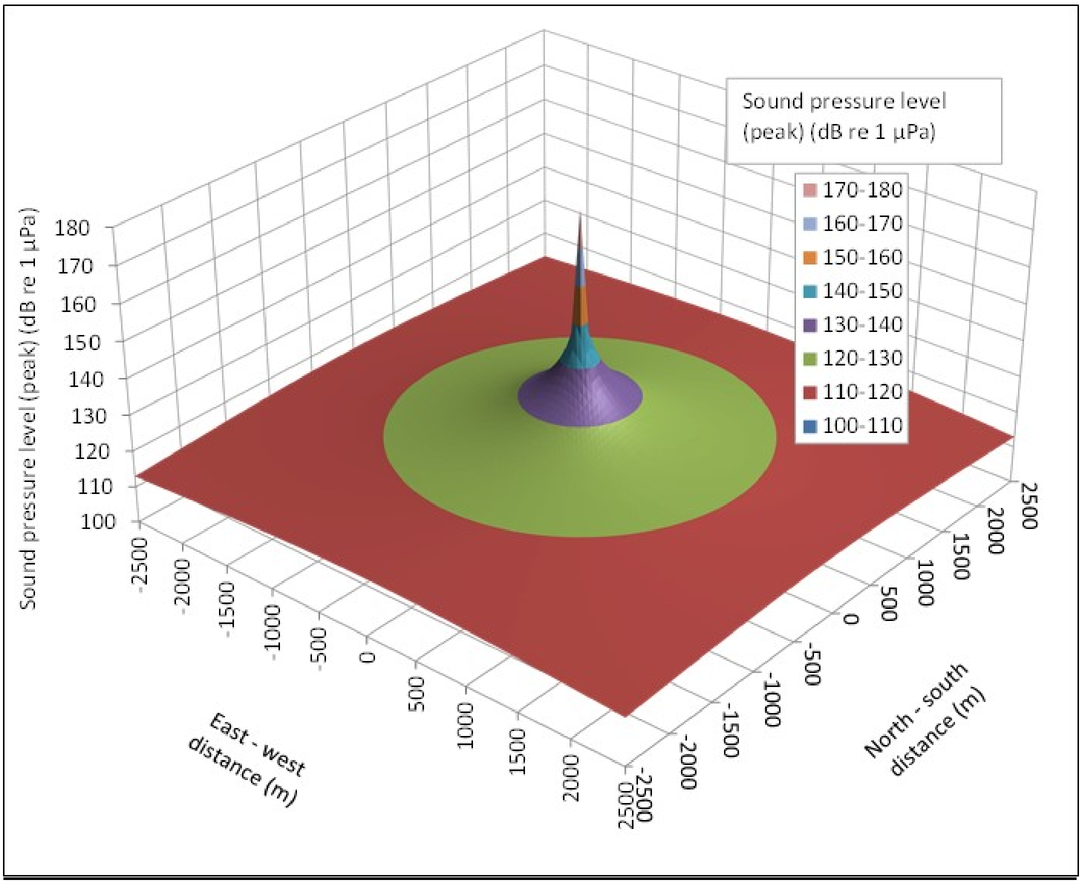


Figure 3-15. Modeled propagation of underwater sound during drilling (From: Genesis).

3.4.2 Noise from Supply Vessels

Figure 3-16 shows a calculated sound source spectrum for a marine supply vessel. 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. The intensity of noise from vessels is roughly related to ship size and speed. Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. For a given vessel, relative noise also tends to increase with increased speed. Support vessels are considered transient sound sources as they move between the shore base and the drilling rigs.

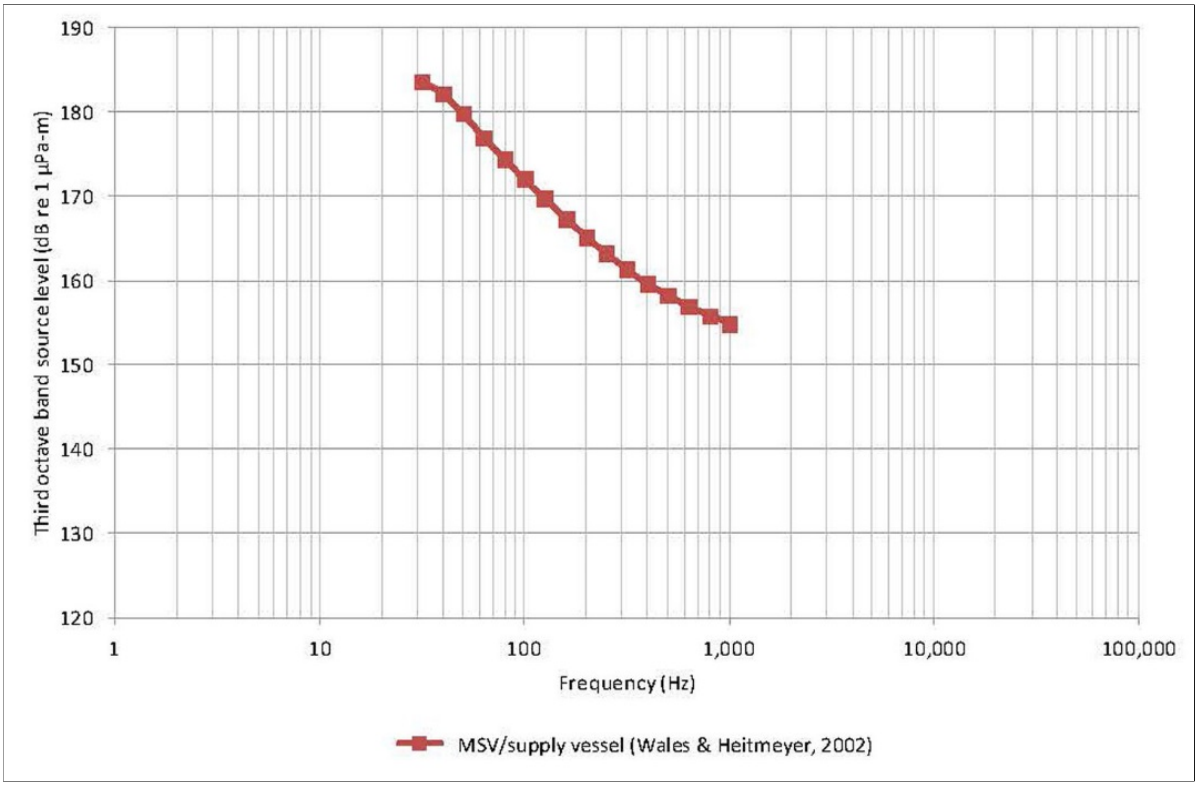


Figure 3–16. Calculated sound source spectrum for a marine supply vessel (Figure from: Genesis; data from: Wales and Heitmeyer, 2002).

3.4.3 Underwater Noise from Helicopters

Helicopters generate both airborne and underwater noise, with the dominant tones at frequencies less than 500 Hz (Richardson et al., 1995). Received SPLs (in water) from aircrafts flying at altitudes of 152 m (500 ft) were 109 dB re 1 µPa for a Bell 212 helicopter, with an estimated source level of 149 dB re 1 µPa (Richardson et al., 1995). 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 aircrafts is much shorter 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). **Figure 3-17** shows examples of sound source spectra for helicopters typically used in offshore oil and gas activities.

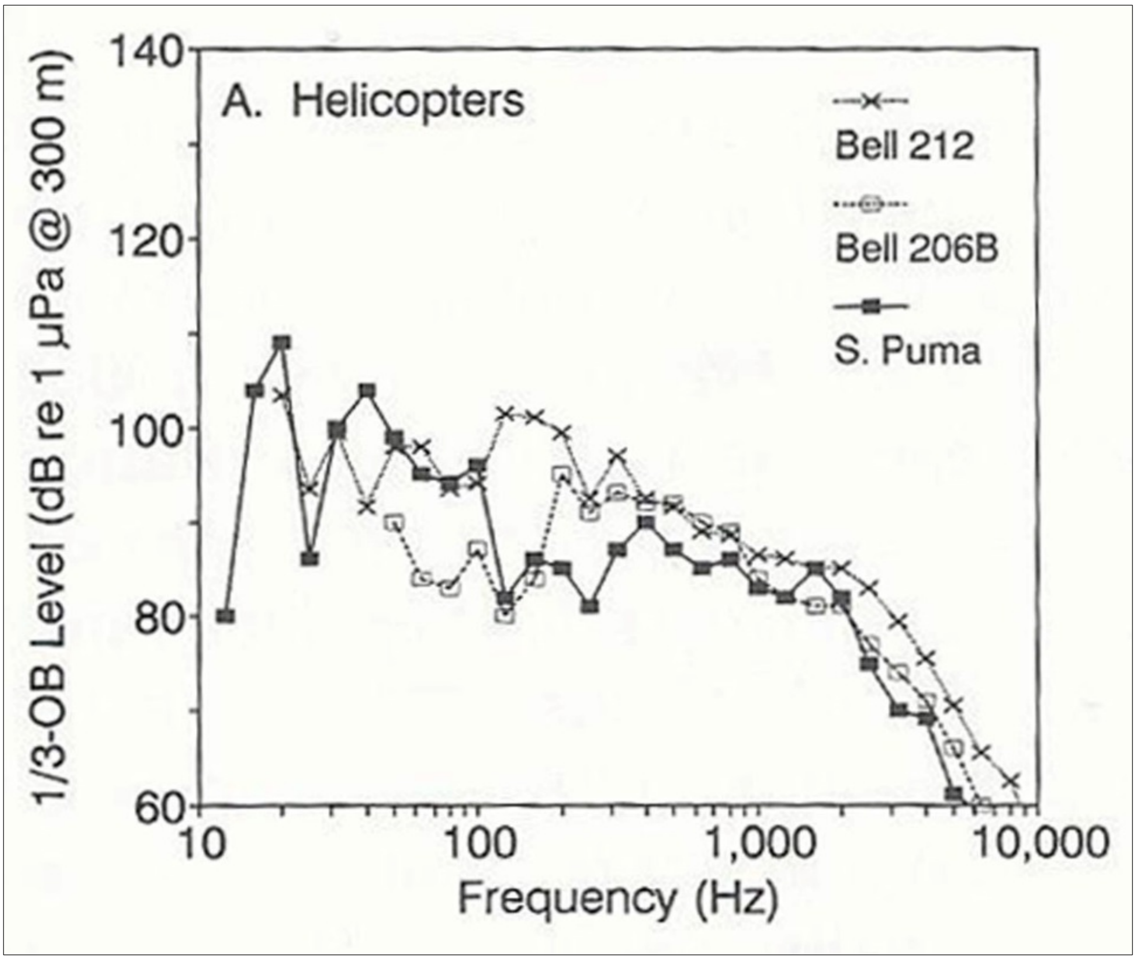


Figure 3–17. Sound source spectra for helicopters typically used in offshore oil and gas activities (From: Richardson et al., 1995). The graph shows estimated 1/3-octave band received levels at the sea surface from a helicopter flying overhead at 300 m altitude.

3.5 AIR QUALITY

3.5.1 Emissions from Drilling Rigs

The drilling rigs will produce emissions from internal combustion engines, including carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), volatile organic compounds (VOCs), and particulate matter (PM), as well as greenhouse gases (GHGs) including carbon dioxide and methane (CH_4). Emissions were estimated using a worksheet developed by BOEM (2014a) based on USEPA AP-42 emission factors. Because specific drilling rigs have not been selected, the emission factors for a generic DP drillship were used, as provided by BOEM (2014b). The rating for a generic DP drillship is 61,800 hp (46,084 kW) and the engines were assumed to be operating 24 hours per day.

Table 3-6 shows the estimated maximum hourly air pollutant emission rates from each drilling rig. **Table 3-7** shows the estimated emissions from a single drilling rig on a per-well basis for three categories of activities: 1) drilling of the Leviathan-3 sidetrack (30 days); 2) drilling of the Leviathan-5 through Leviathan-10 wells (75 days per well); and 3) well completion (40 days per well). Total emissions were calculated for each drilling rig based on the estimated number of days that each drilling rig would be operating (**Table 3-8**). As discussed in **Section 3.2.4**, drilling operations by the first drilling rig are estimated to require 480 days and completion operations by the second drilling rig are estimated to require 320 days. The total time for drilling and completing all of the wells is estimated to be 556 days and there will be a period of approximately 236 days during which both drilling rigs will be operating in the Leviathan Field.

Table 3-6. Estimated air pollutant emission rates from a single drilling rig.

Source	Maximum Emission Rates (kg/hour)							
	CO	NO_x	SO_x	VOCs	PM	CO_2	CH_4	GHGs
Drilling rig	148.50	680.61	90.83	20.42	19.80	32558.56	1.86	32597.54

CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Maximum hourly emission rates were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet and assuming a generic DP drillship (61,800 hp). CO_2 and CH_4 emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + (21 × CH_4).

Table 3-7. Estimated per-well air pollutant emissions from a single drilling rig for three categories of activities.

Source	Duration (days)	Emissions (metric tonnes/well)							
		CO	NO_x	SO_x	VOCs	PM	CO_2	CH_4	GHGs
Leviathan-3 sidetrack	30	106.92	490.05	65.40	14.70	14.26	23,442.16	1.34	23,470.23
Leviathan-5 through -10	75	267.30	1,225.12	163.50	36.75	35.64	58,605.40	3.34	58,675.57
Well Completion	40	142.56	653.40	87.20	19.60	19.01	31,256.21	1.78	31,293.64

CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet and assuming a generic DP drillship (61,800 hp) operating 24 hours/day. CO_2 and CH_4 emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + (21 × CH_4).

Table 3-8. Total estimated air pollutant emissions from each drilling rig during drilling and completion of the eight initial wells.

Drilling Rig	Total Duration (days)	Total Estimated Emissions (metric tonnes)							
		CO	NO_x	SO_x	VOCs	PM	CO_2	CH_4	GHGs
#1	480	1,710.72	7,840.78	1,046.39	235.22	228.10	375,074.56	21.38	375,523.62
#2	320	1,140.48	5,227.19	697.59	156.82	152.06	250,049.71	14.26	250,349.08
Total		2,851.20	13,067.97	1,743.98	392.04	380.16	625,124.27	35.64	625,872.70

CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet and assuming a generic DP drillship (61,800 hp) operating 24 hours/day. CO_2 and CH_4 emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + (21 × CH_4).

3.5.2 Emissions from Support Vessels

The drilling program will be supported by two MMC 87 Class platform supply vessels operating from the port of Haifa; specifications are provided in **Appendix J**. Each supply vessel is expected to make three round trips per week between Haifa and the drilling rig(s). Each MMC 87 Class vessel is powered by four 1,825-kW engines, for a total 7,300 kW (9,788 hp). Maximum hourly emission rates (with all four engines operating) were calculated using the BOEM worksheet (**Table 3-9**). Total emissions were calculated using the BOEM worksheet for each supply vessel based on the estimated number of days the vessels would be operating and assuming that both vessels operate 12 hours/day when in use (**Table 3-10**).

Table 3-9. Estimated air pollutant emission rates from supply vessels.

Source	Emission Rate (kg/hour)							
	CO	NO_x	SO_x	VOCs	PM	CO_2	CH_4	GHGs
Supply Vessel	23.52	107.80	14.39	3.23	3.14	5156.69	0.29	5162.86

CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.

Each vessel was assumed to operate for 12 hours/day on 240 days (3 trips per week times 80 weeks). Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet, with each vessel assumed to have engines totaling 9,788 hp. CO_2 and CH_4 emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + (21 × CH_4).

Table 3-10. Total estimated air pollutant emissions from supply vessels during drilling and completion of the eight initial wells.

Supply Vessel	Operating Days	Total Estimated Emissions (metric tonnes)							
		CO	NO_x	SO_x	VOCs	PM	CO_2	CH_4	GHGs
#1	240	67.74	310.46	41.43	9.31	9.03	14,851.25	0.85	14,869.03
#2	240	67.74	310.46	41.43	9.31	9.03	14,851.25	0.85	14,869.03
Total		135.47	620.92	82.86	18.62	18.06	29,702.50	1.70	29,738.06

CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Each vessel was assumed to operate for 12 h/day on 240 days (3 trips per week times 80 weeks). Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet, with each vessel assumed to have engines totaling 9,788 hp. CO_2 and CH_4 emissions were added to the worksheet using emission factors provided by Wilson et al. (2007). GHG = CO_2 + (21 × CH_4).

3.5.3 Emissions from Helicopters

Helicopter support will be provided by a Bell 412SP operated from Haifa Airport; specifications are provided in **Appendix J**. The Bell 412SP helicopter is equipped with two Pratt and Whitney Canada PT6T-3BE Twin-Pac turboshafts, each producing 900 hp (671 kW). It has been estimated that the helicopter will make one round trip per week between Haifa and the drilling rig(s).

Table 3-11 provides an estimate of air pollutant emissions resulting from helicopter flights based on published emissions estimates for a Bell 412 helicopter (Rindlisbacher, 2009). Assuming a cruising speed of 226 km/hour and a 250-km roundtrip flight distance, each round trip is assumed to require approximately 1.1 hours of flight time plus one landing-takeoff cycle. With one weekly round-trip, there will be 52 trips per year and 80 trips during the entire program (556 days, or approximately 80 weeks).

Table 3-11. Estimated pollutant emissions from helicopters (Bell 412) based on emissions calculations by the Swiss Federal Office of Civil Aviation (From: Rindlisbacher, 2009).

Source	Fuel Usage (kg)	Emissions (kg)			
		NO_x	HC	CO	PM
Single LTO Cycle	77	0.64	0.54	0.69	0.019
One Hour of Flight	541	6.14	1.06	1.27	0.168
Single Round-Trip (LTO + 1.1 hours)	672	7.39	1.71	2.09	0.20
52 round trips/year (1/week)	34,949	384.49	88.71	108.52	10.60
Total (entire program, 80 weeks)	**53,768**	**591.52**	**136.48**	**166.96**	**16.30**

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

3.5.4 Emissions from Production Testing

Air emissions from production testing were estimated based on the flow volumes shown in **Table 3-5.** The estimated volume of gas to be flared (per well) is 230.875 MMscf and the estimated volume of condensate to be flared is 561.75 bbl, with a total flow duration of 49.5 hours. Calculations are summarized in **Table 3-12**. Nearly all of the emissions are from gas flaring. CO_2 emissions from production testing were estimated in **Table 3-5** as 13,920 metric tonnes. Estimated emissions from the 100 bbl of methanol injected during production testing are negligible.

Table 3-12. Estimated air pollutant emissions from production testing (per well).

Source	Amount	Duration (hours)	Emissions (metric tonnes)				
			CO	NO_x	SO_x	VOCs	PM
Gas flaring	230.875 MMscf	49.5	40.64	7.47	0.06	6.31	0.00
Condensate	561.75 bbl	49.5	0.05	0.51	0.00	0.00	0.11
Methanol	100 bbl	49.5	0.00	0.00	0.00	0.00	0.00
		Total	**40.69**	**7.98**	**0.06**	**6.31**	**0.11**

CO = carbon monoxide; MMscf = million standard cubic feet; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet.

3.6 HAZARDOUS MATERIALS

A table of hazardous chemicals planned to be used is included in **Appendix H**, along with SDSs for each chemical. All hazardous chemicals will be handled in accordance with their SDS-specified guidelines, as integrated into the drilling rig operator's guidelines for handling hazardous materials. Materials to be used in drilling (i.e., WBM, MOBM, and additives) are discussed in **Section 3.7.2**.

3.7 DISCHARGES

3.7.1 Overview and Discharge Sources

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

- Drilling discharges, including drilling muds, cuttings, and excess cement; and
- Other routine discharges from the drilling rigs, including sanitary and gray water, cooling water, desalination brine (reverse osmosis concentrate water), and deck drainage.

3.7.2 Drilling and Completion Discharges

Noble Energy plans to drill the new Leviathan Field wells (Leviathan-5 through Leviathan-10) using a combination of WBM and MOBM. The Leviathan-3 sidetrack well (Leviathan-3 ST02) would be drilled with WBM only. Completion of the Leviathan-4 ST01 well will not require additional drilling muds.

For the Leviathan-5 through Leviathan-10 wells, the first two initial well intervals (before the marine riser is set) would be drilled using a water-based "spud mud," and the cuttings and WBM, 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 drilling rig, the remaining well intervals would be drilled with MOBM. Cuttings from MOBM well intervals will be treated in a TCC on board the drilling rig to reduce the MOBM retention on cuttings to less than 1% by weight on dry cuttings in accordance with the effluent limitations currently used in the North Sea/OSPAR region (OSPAR Decision 2000/3). For reference, this limit is well below the discharge limit of 10% by weight on dry cuttings imposed by the Barcelona Convention (Offshore Protocol). Specifications for the TCC are provided in **Appendix I**. The cuttings with retained MOBM would be released below the sea surface, subject to MoEP approval.

[redacted]

The following sections summarize materials consumed and discharged during drilling and completion. A comprehensive table of chemicals and additives is provided in **Appendix H**, along with SDSs.

Table 3–13. Selected physical, chemical, and environmental characteristics [redacted] (From: Imperial Oil and ExxonMobil; see **Appendix G**).

[redacted]

ASTM = American Society for Testing and Materials; LL_{50} = median lethal loading (equivalent to lethal concentration 50 [LC_{50}]); NOEL = no observable effects level; OECD = Organisation for Economic Co-operation and Development.

3.7.2.1 Leviathan-5 through Leviathan-10 Wells

Table 3-14 shows the representative well intervals for the Leviathan-5 through Leviathan-10 wells. The table indicates the type of drilling mud for each well interval, and the estimated discharge rates, volumes, and locations. The representative well consists of six intervals. The first two intervals will be drilled using WBM, with the mud and cuttings released at the seafloor. The remaining well intervals would be drilled with MOBM, and the cuttings would be treated in the TCC and discharged from the drilling rig (at the sea surface), subject to MoEP approval. There would be an end-of-well discharge of completion brine at the sea surface also.

Table 3-14. Drilling program for an individual Leviathan Field well (representative for Leviathan-5 through Leviathan-10 wells).

Section (Interval)	Hole Diameter (inches)	[redacted]	Cuttings Discharge		Drilling Fluid (Mud) Discharge		Mud Type	Release Location
			Vol. (m^3)	Rate (m^3/day)	Vol. (m^3)	Rate (m^3/day)		
1	36	[redacted]	54	45.76	48	40.68	WBM	Seafloor, released continuously with cuttings
2	26	[redacted]	478	90.36	2,980 4,070	1332.72	WBM Brine	Seafloor, released continuously with cuttings
Run 20-inch Casing and BOP/Riser		[redacted]						
3	20	[redacted]	189	35.73	N/A	N/A	MOBM	Sea surface (treated cuttings only)
Log and Run 16-inch Liner		[redacted]						
4	17.5	[redacted]	181	34.22	N/A	N/A	MOBM	Sea surface (treated cuttings only)
Log and Run 13⅝-inch Casing		[redacted]						
5	8.5 (pilot hole, drill, and core)	[redacted]	21	1.98	N/A	N/A	MOBM	Sea surface (treated cuttings only)
Log and Permanent Abandonment of Pilot Hole		[redacted]						
6	12.25 (Production Sidetrack Hole)	[redacted]	18	7.66	N/A	N/A	MOBM	Sea surface (treated cuttings only)
Run 9⅞-inch × 10¾-inch Production Casing and Suspension (Temporary Abandonment)		[redacted]						
7	End of Well Discharge	[redacted]	N/A	N/A	192	3815	Brine	Sea surface

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

<u>Estimated Materials to be Consumed and Discharged</u>

Noble Energy will be using several additives to facilitate drilling and maintaining well control of the well. The type and volume of mud additives is determined primarily by the current state of the drilling mud and existing or anticipated downhole conditions. SDSs for all drilling-related materials are provided in **Appendix H**.

During the first two well intervals, Noble Energy expects to use a total of 1,277.7 metric tons of brine and 1,587.5 metric tons of WBM and additives. Specific products, their function, packaging, and the estimated weight of brine and WBM drilling-related materials to be used are outlined in **Table 3-15**. The main WBM constituent (excluding brine) is barite (93% of the WBM materials by weight). Because none of the WBM materials will remain in the well, the amounts discharged will be the same as the amounts consumed for each material.

Table 3-15. Estimated per-well brine and water-based mud (WBM) total material consumed (and discharged) for an individual Leviathan Field well (representative for Leviathan-5 through Leviathan-10 wells).

[redacted]

During the MOBM well intervals, Noble Energy expects to use 1,545.6 metric tons of MOBM and mud additives (**Table 3-16**). SDSs for all drilling-related materials are provided in **Appendix H**. The main MOBM constituent is barite (73% of the MOBM materials by weight). There will be no discharge of whole MOBM. The only MOBM discharged will consist of small amounts adhering to treated cuttings (less than 1% by dry weight). It is estimated that 2.95 metric tons would adhere to discharged cuttings (**Table 3-16**). The rest of the MOBM consumed would be recovered (1,460 metric tons) or remain in the well (82.7 metric tons).

Table 3-16. Estimated per-well MOBM total material consumption and discharge for an individual Leviathan Field well (representative for Leviathan-5 through Leviathan-10 wells).

[redacted]

HPHT FL = high-pressure high-temperature fluid loss; IBC = intermediate bulk carrier; MOBM = mineral oil-based mud; WPS = water phase salinity. Amounts discharged are based on 1% MOBM retention on cuttings.

Noble Energy has identified a series of mud additives that may be used to maintain well control and address specific issues or drilling problems during drilling using MOBM. These contingency products are identified in **Table 3-17**. Volumes will be on an “as-needed” basis.

Table 3-17. Contingency products that may be used during drilling of Leviathan-5 through Leviathan-10 wells. Volumes will be "as needed."

[redacted]

F, M, C = fine, medium, coarse; S/F = super fine; R = regular. LCM = lost circulation material.

During the drilling phase, the estimated brine consumption is 2,000 bbl (29.9 metric tons), of which 780 bbl (11.7 metric tons) will remain in the well and 1,220 bbl (18.3 metric tons) will be discharged (**Table 3-18**). These quantities are representative for all of the Leviathan wells.

Table 3-18. Brine materials consumed, remaining in well, and discharged for the end-of-well brine discharge for an individual Leviathan Field well (representative for all of the Leviathan wells).

[redacted]

For a representative Leviathan Field well, the estimated amount of cement consumption is 8,000 bbl (901.6 metric tons), of which 6,200 bbl (806.0 metric tons) will remain in the well and 1,800 bbl (95.6 metric tons) will be discharged (**Table 3-19**).

Table 3-19. Estimated per-well cement products consumed, discharged, and remaining in the well for an individual Leviathan Field well (representative for Leviathan-5 through Leviathan-10 wells).

[redacted]

Estimated Amounts of Cuttings to be Discharged

Estimated cuttings to be generated, by hole section, are outlined in **Table 3-20**. A total of 941 m^3 (2,353 metric tons) of cuttings will be released during drilling. This includes 532 m^3 (1,330 metric tons) of WBM cuttings released at the seafloor and 409 m^3 (1,023 metric tons) of MOBM cuttings discharged from the drilling rig after treatment in the TCC. Cuttings weights were calculated assuming a bulk density of 2.5 metric tons/m^3.

Table 3-20. Volume and weight of cuttings to be discharged for an individual Leviathan Field well (representative for Leviathan-5 through Leviathan-10 wells).

Hole Diameter (in.)	[redacted]	Wash-Out Factor (%)	Cuttings Amount with Wash-out Factor			Mud System	Discharge or Release Location
			Volume (bbl)	Volume (m^3)	Weight (metric tons)		
36	[redacted]	0	341	54	135	WBM	Seafloor
26	[redacted]	25	3,008	478	1,195	WBM	Seafloor
[redacted]**BM Cuttings**			**3,349**	**532**	**1,330**	WBM	Seafloor
20	[redacted]	20	1,187	189	473	MOBM	Sea surface (after TCC treatment)
17.5	[redacted]	15	1,138	181	453	MOBM	Sea surface (after TCC treatment)
8.5	[redacted]	10	130	21	53	MOBM	Sea surface (after TCC treatment)
12.25	[redacted]	10	113	18	45	MOBM	Sea surface (after TCC treatment)
Total MOBM Cuttings			**2,568**	**409**	**1,023**	MOBM	Sea surface (after TCC treatment)
Grand Total (all cuttings)			**5,917**	**941**	**2,353**	WBM, MOBM	--

MOBM = mineral oil-based mud; TCC = thermomechanical cuttings cleaner; WBM = water-based mud.

3.7.2.2 *Leviathan-3 ST02 Sidetrack Well*

Estimated Materials to be Consumed and Discharged

The Leviathan-3 ST02 sidetrack well will be drilled using WBM only. WBM materials to be used are summarized in **Table 3-21**. The estimated WBM consumption is 7,200 bbl (980.08 metric tons), of which approximately 250 bbl (34.03 metric tons) will remain in the well and 6,950 bbl (946.05 metric tons) will be discharged.

Table 3-21. Estimated water-based mud (WBM) total material consumed, remaining in the well, and discharged for the Leviathan-3 ST02 sidetrack well.

[redacted]

The estimated brine consumption is 2,000 bbl (456.8 metric tons), of which 780 bbl (178.2 metric tons) will remain in the well and 1,220 bbl (278.7 metric tons) will be discharged (**Table 3-22**).

Table 3-22. Estimated brine materials consumed, remaining in the well, and discharged for the Leviathan-3 ST02 well.

[redacted]

The estimated cement consumption is 200 bbl (57.53 metric tons) of which 190 bbl (54.23 metric tons) will remain in the well and 10 bbl (3.31 metric tons) will be discharged (**Table 3-23**).

Table 3-23. Estimated cement products consumed, remaining in the well, and discharged for the Leviathan-3 ST02 sidetrack well.

[redacted]

In addition, 61.80 metric tons of cement materials will be discharged due to the reentry of the cement plugs from the previous temporary abandonment of the well (**Table 3-24**).

Table 3-24. Estimated cement material to be discharged from drilling through the cement plugs from the previous temporary abandonment of the Leviathan-3 ST02 sidetrack well.

[redacted]

Estimated Amounts of Cuttings to be Discharged

The estimated amount of cuttings discharged for the Leviathan-3 ST02 well is 378 bbl (60 m^3) or 150 metric tons (**Table 3-25**).

Table 3-25. Volume and weight of cuttings to be discharged for the Leviathan-3 ST02 well.

Hole Diameter (in.)	[redacted]	Wash-Out Factor (%)	Cuttings Amount with Wash-Out Factor			Mud System	Discharge or Release Location
			Volume (bbl)	Volume (m^3)	Weight (metric tons)		
12.25	[redacted]	10	378	60	150	WBM	Sea surface

WBM = water-based mud.

3.7.2.3 Well Completions

Estimated Brine and Completion Materials to be Consumed and Discharged

Completion of the Leviathan-3 ST02, Leviathan-4 ST01, and Leviathan-5 through Leviathan-10 wells will require the use of brine materials and specialized completion fluids. **Table 3-26** lists the estimated quantities consumed, remaining in the well, and discharged for each well based on calculations performed for the representative Leviathan-4 ST01 well.

Table 3-26. Estimated brine and completion materials consumed, remaining in the well, and discharged for the Leviathan wells.

[redacted]

Estimated Cuttings Discharges

There will be a small volume of cuttings discharged from completion activities as summarized in **Table 3-27** for each well based on calculations performed for the representative Leviathan-4 ST01 well.

Table 3-27. Estimated cuttings discharges for completion of the Leviathan wells.

Interval	Internal Diameter (in.)	[redacted]	Wash-Out Factor (%)	Cuttings Amount with Wash-Out Factor			Discharge or Release Location
				Volume (bbl)	Volume (m^3)	Weight (metric tons)	
Shallow Cement Plug	9.56		0	36.41	5.79	14.48	Sea surface
Shoe Track	8.625		0	18.02	2.86	7.15	Sea surface
Open Hole	12.25		10	22.10	3.51	8.77	Sea surface
Total				**76.53**	**12.16**	**30.40**	--

3.7.2.4 Drilling Discharge Fate

There are two different locations for drilling discharges. In a representative well, during the first two well intervals, WBM, brine, cuttings, and excess cement slurry will be released at the seafloor. Small amounts of cement will be released at the wellbore during cementing operations. During the well intervals after setting of the marine riser, cuttings with small amounts of adhering MOBM (less than 1% by dry weight) will be discharged from the drilling rigs.

Simulation modeling was conducted to predict the fate of drilling discharges, as described in **Appendix K**. **Chapter 4** includes a detailed summary of the modeling results, including the potential environmental impacts. The following paragraphs outline the general fate of discharged drilling muds and cuttings.

Seafloor Releases

During the first two well intervals, cuttings and "spud mud" will be released at the seafloor. These initial discharges 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 each well to bond the casing to the walls of the hole. Excess cement slurry will emerge from the hole and accumulate on the seafloor, generally within approximately 10 to 15 m around each wellbore (Shinn et al., 1993).

Surface Discharges from the Drilling Rigs

After the first two well intervals are completed, the marine riser will be set and the drilling mud system will be changed over to MOBM. Setting of the riser will allow for muds and cuttings to be returned to the drillship where they will be processed through solids control equipment to separate the cuttings and recover most of the MOBM for reuse and recycling. After being processed through the TCC to achieve less than 1% residual MOBM, and pending MNIEWR approval, the cuttings will be discharged to the ocean. The maximum thickness of cuttings deposited on the seafloor (100 to 200 mm) is predicted to occur within 11 m of the discharge point. The total area of seafloor receiving a thickness of 1 mm or greater is estimated to be 3.5 ha, with a maximum lateral distance of 149 m from the discharge point (**Appendix K**).

Metal Content and Bioavailability

Barite (barium sulfate) is a major insoluble component of drilling fluids and drilling fluid discharges. For the WBM to be released from the wellbore, barium concentrations will increase in bottom sediments around the drillsite. However, barium is toxicologically inert and therefore is not a threat to the viability of living organisms in the affected area. Concentrations of other metals in drilling fluids are similar to those in marine sediments, but some metals such as cadmium, copper, lead, mercury, and zinc may be elevated within a few hundred meters of the drillsite (Boothe and Presley, 1989). However, metals in drilling fluids show very low bioavailability to marine animals and do not pose a risk to benthic organisms or their predators (Neff et al., 1989a,b; Neff, 2008). Additional discussion regarding drilling muds and cuttings impacts is presented in **Chapter 4**.

3.7.2.5 Drilling Mud Testing

Testing will be conducted to verify that TCC-treated cuttings comply with the 1% retention on cuttings limit in accordance with OSPAR Decision 2000/3. The analytical methodology will be agreed upon with the MNIEWR. Applicable methodologies include the retort method specified in the USEPA National Pollutant Discharge Elimination System permit for the western portion of the Gulf of Mexico (GMG290000) (USEPA, 2012; U.S. Government Printing Office, 2014) and the gas chromatography method specified in ISO 16703 (International Organization for Standardization, 2004a). Noble Energy will comply with discharge permit requirements including any specific analytical methodologies.

Chemical testing of drilling muds will be conducted in compliance with discharge permit requirements. The analytes and frequency of testing are outlined in **Table 3-28**.

Table 3-28. Proposed chemical testing of drilling muds for a representative Leviathan Field well.

Frequency of Testing (minimum)	Type of Test/Target Analyte	Method/Standard
Drilling Muds/Liquids		
The sampling frequency below has been determined based on the stages of drilling and based on the drilling plan. Grab sampling in each drilling segment: • 36 in. + 26 in. • 20 in. • 17½ in. • 8½ in. • 12¼ in. sidetrack Total of at least 5 samples	Biological Oxygen Demand (BOD_5)	SM-5210 B
	Total organic carbon	TOC Cell Test
	Suspended solids 105°C (TSS)	SM-2540 D
	Mineral oil (FTIR)	USEPA 418.1
	Total oil and grease (FTIR)	USEPA 1664A
	PAH by GC-MS	USEPA 8270
	Phenol	SM-5530 D
	Cresol	SM-5530 D
	Nitrate (as N)	SM-4500-NO_3 B
	Nitrite (as N)	SM-4500-NO_2 B
	Ammonium nitrogen (as N)	SM-4500-NH_3 C
	Kjeldahl nitrogen (as N)	SM-4500-Norg B
	Total nitrogen (calculated)	SM-4500-Norg B + SM-4500-NO_2 B + SM-4500-NO_3 B
	Reaction value (pH)	SM-4500-H+B
	Total dissolved solids (TDS)	SM-2540 C
	DOX/AOX	Hach-Lange Cell Test
	Chlorides	SM-4500-CI-D
	Broad screening for metals (ICP), including P	USEPA 6010 B
	GC-MS, probability percentages, half quantity concentrations and total concentration	USEPA 8270
	VOCs, probability percentages, half quantity concentrations and total concentration	USEPA 8260

AOX = adsorbable organic halogens; DOX = dissolved organic halides; FTIR = Fourier transform infrared (spectroscopy); GC-MS = gas chromatography-mass spectrometry; ICP = inductively coupled plasma (mass spectrometry); PAH + polycyclic aromatic hydrocarbon(s); TOC = total organic carbon; VOC = volatile organic compound.

Noble Energy has been asked to perform toxicity testing of drilling fluids and drill cuttings in conjunction with its drilling and production operations in Israel. At this point in time, there are no existing laboratories in Israel that have the needed facilities, resources or training to conduct such tests. As a result, it will be necessary to utilize laboratories outside Israel for such tests. Noble Energy's intent will be to contract with laboratories in the United States to perform the needed testing. A report entitled "A Review of Toxicity Testing Evaluating Applicability of Indigenous and Foreign Test Species" has been prepared to examine the use of toxicity tests for the project and is presented in **Appendix L**. The report discusses toxicity test methodology, toxicity test strategies and objectives, and test species selection. It reviews the use of local vs. foreign species and provides recommendations regarding the proposed tests and their applicability to the Israel offshore environment.

Conclusions of the report (**Appendix L**) are as follows:

1) Currently the Eastern Mediterranean lacks the structure needed to conduct toxicity testing. This lack exists for both available labs with needed expertise and experience as well as any prior history of testing with local species;
2) While there may be some data available for Mediterranean species, it is limited and additional methods and species testing is required to establish suitable local standard test species;
3) Well-established laboratories exist in both the North Sea and Gulf of Mexico experienced in conducting toxicity testing using internationally accepted methods for oil and gas operations and chemicals;
4) Standard test organisms from these regions are not indigenous to the Eastern Mediterranean. Gulf of Mexico uses temperate species, North Sea testing uses boreal species.
5) Research has indicated that sensitivities within species groups tends to be similar across geographic regions (i.e. temperate, Arctic and boreal species show similar sensitivities to chemical exposures).

6) North Sea testing focuses more on toxicity testing against individual compounds while Gulf of Mexico focuses on whole effluent toxicities.
7) Testing regimes adopted in the North Sea and Gulf of Mexico both use invertebrates and fish. Invertebrate tests include pelagic and sediment dwelling organisms.
8) Crustaceans, particularly copepods and mysids have generally been shown to be the most sensitive species; the copepod *Acartia* in the North Sea and the mysid *Mysidopsis* in the Gulf of Mexico are the standard species used in their respective regions.

The recommended protocols follow those in the U.S. National Pollutant Discharge Elimination System (NPDES) General Permit for the Gulf of Mexico (USEPA, 2012). This approach allows a comparison of the tests with a large database from Gulf of Mexico drilling which is more comparable to the local conditions than North Sea data. The proposed testing is presented in **Table 3-29** and includes testing of the base fluid, a suspended particulate phase of the used mud, and tests with the solid phase. A schedule for each type of testing is also included.

Table 3–29. Toxicity tests and testing schedule for drill muds and cuttings (From: US Environmental Protection Agency [USEPA], 2012).

DISCHARGE	MONITORED PARAMETER	SPECIES	DISCHARGE LIMITATION	TEST FREQUENCY	METHOD
Drilling fluid	96-hour LC_{50}	*Mysidopsis bahia*	30,000 ppm	Once/month Once/end of well	Drilling fluids toxicity test at 40 CFR Part 435, Subpart A, Appendix 2
Drill cuttings	96-hour LC_{50}	*Mysidopsis bahia*	30,000 ppm	Once/week when drilling	USEPA 1993. *Mysidopsis bahia* acute static 96-hour toxicity test, FR58 (41): 12507-12512
Stock limits for drill cuttings generated using nonaqueous-based drilling fluids (base fluid blend)	10-day LC_{50}	*Leptocheirus* sp.	The ratio of the 10-day LC_{50} of C16 – C18 internal olefin divided by the 10-day LC50 of the base fluid shall not exceed 1.0	Once/year on each base fluid blend	ASTM method E1367-99
Discharge limits for cuttings generated using nonaqueous-based drilling fluids (drilling fluids, removed from cuttings at the solids control equipment)	4-day LC50	*Leptocheirus* sp.	The ratio of the 4-day LC50 of C16 – C18 internal olefin divided by the 4-day LC_{50} of the base fluid shall not exceed 1.0	Once/month.	Modified ASTM method E1367-99

3.7.2.6 Analytical Test Results for Drilling Mud and Cuttings

Data on the chemical characteristics of Leviathan Field drilling mud and cuttings discharges are not available. However, data from the Tamar SW-1 well in the Tamar Field are considered representative since this was the most recent well drilled in the area and it has virtually the same objectives as upcoming Leviathan wells proposed in this EIA. The results are presented for organics and other characteristics of drilling muds (**Table 3-30**), metals in drilling muds (**Table 3-31**), metals in barite (**Table 3-32**), metals in cuttings (**Table 3-33**), and radioactive substances in drillng muds and cuttings (**Table 3-34**).

Table 3–30. Analytical results for organics and other characteristics of the Tamar SW-1 drilling mud.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [m^3/mo]	pH	BOD	TOC	TSS (105°C)	Mineral Oil (FTIR)	Total Oil (FTIR)	PAHs	Phenol	Cresol	DOX	Toxicity	NH_4-N	TKN-N	NO_3-N	NO_2-N	Total N	TDS	Cl^-	Total GC-MS (AS O-xylene)	Total VOCs
10/10/2013	10/10/2013 9:20	C11878	2,688.6	5.6	1,896	11,440	68,340	140	197	--	<0.2	<0.2	--		92	197	2	<1	199	301,896	193,750	93.5	--
10/24/2013	10/24/2013 8:00-14:00	C12587	151.5	7.8	1,640	10,000	--	111	188	--	<0.2	<0.2	--	--	85	302	3	<1	305	266,200	153,400	33	--
11/11/2013	11/12/2013	C13601	525.7	9.1	7,750	23,000	--	8	364	--	<0.2	<0.2	--	--	631	809	<1	<1	809	227,830	117,300	3,488.2	--
11/20/2013	11/20/2013 9:40	C14119	86.4	9.3	6,900	19,920	--	15.5	283	--	<0.2	<0.2	--	--	33	740	22	<1	762	189,750	98,830	4,075.7	--

BOD = biochemical oxygen demand; Cl^- = chloride; DOX = dissolved organic halides; FTIR = Fourier Transform Infrared; GC-MS = gas chromatography-mass spectrometry; N = nitrogen; NH_4 = ammonium; NO_2 = nitrite; NO_3 = nitrate; PAH = polycyclic aromatic hydrocarbon; TDS = total dissolved solids; TKN = total Kjeldahl nitrogen; TOC = total organic carbon; TSS = total suspended solids; VOC = volatile organic compound; -- data not available (analyzed in laboratory reports but not detailed in this table).
Note: units are mg/L unless noted otherwise.

Table 3–31. Analytical results for metals in the Tamar SW-1 drilling mud.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [m^3/mo]	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg - ICP	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr	Ti	V	Zn
10/10/2013	10/10/2013 9:20	C11878	2,688.6	0.1	105	1	2	1,579	<0.05	16,829	<0.05	0.3	0.2	4	805	<0.05	2,296	0.2	198	36	<0.1	175,714	0.2	58	8	671	0.3	<0.05	216	<0.1	92	1	0.2	6
10/24/2013	10/24/2013 8:00-14:00	C12587	151.5	0.1	111	1	0.3	1,529	<0.05	3,263	0.1	0.3	0.2	6	1,048	<0.05	64,731	0.1	219	47	0.05	104,005	0.3	15	213	500		<0.05		<0.1	75	1	0.2	8
11/11/2013	11/12/2013	C13601	525.7	<5	3,370	<5	5	903	<2	17,040	<2	2	6	9	4,039	<2	32,301	<5	1,095	123	<2	70,781	4	60	149	1,712	<5	<5	41	<5	140	68	5	16
11/20/2013	11/20/2013 9:40	C14119	86.4	<5	1,632	<5	5	795	<2	21,918	<2	2	5	10	3,309	<2	32,680	<5	878	91	<2	65,051	3	57	123	1,183	<5	<5	18	<5	85	28	4	20

Ag = silver; Al = aluminum; As = arsenic; B = boron; Ba = barium; Be = beryllium; Ca = calcium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; ICP = inductively coupled plasma; K = potassium; Li = lithium; Mg = magnesium; Mn = manganese; Mo = molybdenum; Na = sodium; Ni = nickel; P = phosphorus; Pb = lead; S = sulfur; Sb = antimony; Se = selenium; Si = silica; Sn = tin; Sr = strontium; Ti = titanium; V = vanadium; Zn = zinc.
Note: units are mg/L unless noted otherwise.

Table 3–32. Analytical results for metals in barite used in drilling the Tamar SW-1 well.

Date of Shipment	Analysis Report Date/Time	Report No.	Hg - Cold Vapor	Ag	As	Cd	Cr	Cu	Ni	Pb	Zn
10/10/2013	10/10/2013 9:20	C-64124.13	2	<5	20	<2	8	121	7	165	109
11/3/2013	11/4/2013 17:00	C13127	1.5			1					
12/4/2013	12/4/2013	C14760	0.7			<2					

Ag = silver; As = arsenic; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; Zn = zinc.
Note: units are mg/kg unless noted otherwise.

Table 3–33. Analytical results for metals in cuttings from the Tamar SW-1 well.

Sampling Date	Sample Reception Date/Time	Report No.	TOC	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
10/29/2013	11/3/2013 20:30	C13130	32,700	<5	<5	<2	9	13	<5	5	98	14
10/30/2013	11/3/2013 22:00	C13130	45,900	<5	<5	<2	2	4	<5	<2	96	7
10/31/2013	11/3/2013 10:40	C13130	34,800	<5	<5	<2	2	4	<5	<2	94	6
11/6/2013	11/12/2013 22:00	C13602	14,000	<5	<5	<2	2	4	<2	<2	83	7
11/8/2013	11/12/2013 22:10	C13602	34,200	<5	<5	<2	46	63	<2	35	207	80
11/11/2013	11/12/2013 5:55	C13602	23,600	<5	<5	<2	34	41	<2	23	127	55
11/12/2013	11/20/2013 16:20	C14135	27,400	<5	5	3	43	56	<2	38	161	89
11/23/2013	12/4/2013 11:00	C14759	31,800	<5	5	<2	40	58	<2	26	249	83
11/24/2013	12/4/2013 21:34	C14759	32,700	<5	<5	<2	56	65	<2	50	116	100
11/27/2013	12/4/2013 0:40	C14759	33,000	<5	<5	<2	48	50	<2	26	118	72
12/7/2013	12/23/2013 15:52	C15700	36,000	<5	8	<2	17	44	<2	9	206	79
12/9/2013	12/23/2013 11:40	C15700	53,000	<5	<5	<2	38	71	<2	41	98	67
12/11/2013	12/23/2013 8:50	C15700	33,800	<5	<5	<2	36	58	<2	25	84	66

Ag = silver; As = arsenic; Cd = cadmium; Cr = chromium; Cu = copper; Hg = mercury; Ni = nickel; Pb = lead; TOC = total organic carbon; Zn = zinc.
Note: units are mg/kg unless noted otherwise.

Table 3–34. Analytical results for radioactive substances in drilling muds and cuttings from the Tamar SW-1 well.

Sampling Date	Time	Sample ID	Radionuclide Concentration (pCi/L)				
			Ra 226	Ra 228	Ra 226/228	Th 228	Pb 210
10/29/2013	20:30	70831.13-C	0.02	0.18	0.111	0.06	0.23
10/30/2013	22:00	70832.13-C	0.02	-0.17	-0.118	0.036	-0.04
10/31/2013	10:40	70833.13-C	0	-0.26	0.000	0.006	0.09
11/6/2013	22:00	73311.13-C	0.05	-0.01	-5.000	0.028	0.12
11/8/2013	22:10	73312.13-C	0.02	0.25	0.080	0.44	0.49
11/11/2013	5:50	73313.12-C	0.02	0.14	0.143	0.38	0.46
11/12/2013	16:20	75340.13-C	0.14	0.7	0.200	0.44	0.74
11/23/2013	11:00	79078.13-C	0.09	0.43	0.209	0.53	0.43
11/24/2013	21:34	79079.13-C	0.13	0.61	0.213	0.37	0.37
11/27/2013	0:40	79080.13-C	0.15	0.39	0.385	0.36	0.52
12/7/2013	12:52	Tamar SW-1 ST01 7/12/13; 12:52PM CUTTINGS	0.052	0.44	0.118	0.179	0.61
12/9/2013	11:40	Tamar SW-1 ST01 9/12/13; 11:40AM CUTTINGS	0.21	0.44	0.477	0.404	1.04
12/11/2013	8:50	Tamar SW-1 ST01 11/12/13; 08:50AM CUTTINGS	0.21	0.79	0.266	0.57	0.85

Pb = lead; Ra = radium; Th = thorium.

3.7.3 Other Routine Discharges

3.7.3.1 Discharge Characteristics

Estimated routine discharges from each drilling rig, exclusive of drilling muds and cuttings and cement, are summarized in **Table 3-35**. The table is based on actual discharge data from the Leviathan-4 well. Discharges will include sanitary waste, gray water, organic (food) waste, cooling water, desalination brine, and deck drainage (runoff). Bilge water discharges will be conducted in accordance with international and local requlations.

Table 3-35. Estimated routine discharges from a drilling rig during Leviathan Field drilling and completion activities (exclusive of drilling muds, cuttings, and cement).

Discharge Type	Actual Discharge Data from Leviathan-4 Well[a]				Estimated Total Quantities for Planned Drilling and Completion Activities (m^3)[b]		
	Average Daily Rate (m^3/day)	Maximum Hourly (m^3/hour)	Maximum Daily (m^3/day)	Maximum Monthly (m^3/month)	Drilling Each New Well (Leviathan-5 through Leviathan-10) (75 days)	Drilling Leviathan-3 Sidetrack (30 days)	Completing Each Well (40 days)
Sanitary Waste (Black Water)	8.3 (=0.072 m^3/day/person)	0.4	9.1	252.6	622.5	249.0	332.0
Gray Water	28.8 (=0.250 m^3/day/person)	2.5	58.8	1,080.0	2,160.0	864.0	1,152.0
Organic Food Waste	0.7	0.8	18.5	27.6	52.5	21.0	28.0
Cooling Water	2,974.6	124.9	2,998.0	92,938.0	223,095.0	89238.0	118,984.0
Desalination Brine	72.2	10.3	246.3	4,207.2	5,415.0	2,166.0	2888.0
Deck drainage (Runoff)	2.1	3.1	74.4	82.4	157.5	63.0	84.0

[a] Average rate, maximum daily rate, and maximum monthly rate are based on actual discharge data from the Leviathan-4 well with an average of 115 persons on board. Maximum hourly rate was calculated as maximum daily rate divided by 24 hours.

[b] Estimated quantities for planned Leviathan Field drilling and completion activities were calculated by multiplying the average daily rate from the Leviathan-4 discharge data by the number of days for drilling a new well (75 days), drilling the Leviathan-3 sidetrack well (30 days), or completing a well (40 days).

The discharge pipe diameter will depend on the specific drilling rigs selected by Noble Energy; specific discharge depths will be provided once the drilling rigs are selected. For this discussion, the *Atwood Advantage* has been used as a representative example of a DP drillship. **Table 3-36** summarizes the discharge pipe diameters using the *Atwood Advantage* as a representative example. A diagram showing the flow of various discharge streams from the *Atwood Advantage* is provided in **Figure 3-18**. Discharges occur through a series of 4-inch, 6-inch, and 12-inch diameter pipes. Discharges are either gravity fed or pumped, with pipe orientation in a vertical, downward direction. Cooling water is discharged through a 12-inch diameter pipe below the sea surface. Brine from the potable water makers is discharged through a 4-inch diameter pipe below the sea surface. Treated sewage (black water) is discharged through a 4-inch diameter pipe below the sea surface.

Comingling occurs only between gray water and organic food waste discharge. These discharges are released through a 6-inch diameter pipe below the sea surface. Other discharges (e.g., sanitary waste, desalination brine, and cooling water) have separate discharge streams.

Table 3-36. Types of routine discharges from a representative drilling rig (exclusive of drilling muds, cuttings, and cement) during Leviathan Field drilling and completion activities. Discharge pipe diameter are based on the *Atwood Advantage* as a representative example.

Discharge Type	Discharge Frequency and Treatment	Discharge Pipe Diameter (using *Atwood Advantage* as an example)
		Pipe Diameter (in.)*
Sanitary Waste (Black Water)	Periodic; chlorinated in IMO-approved sewage treatment plan	4
Gray Water	Continuous; no treatment	6
Organic Food Waste	Periodic; macerated to meet MARPOL requirements	6
Cooling Water	Continuous; no treatment	12
Desalination Brine	Continuous; no treatment	4
Deck drainage (Runoff)	Continuous; drainage from machinery areas passes through OWS; no treatment for other deck drainage	8

* numbers are representative; the actual discharge pipe diameter will depend on the specific drilling rigs selected.
IMO = International Maritime Organization; MARPOL = International Convention for the Prevention of Pollution from Ships; OWS = oil/water separator.

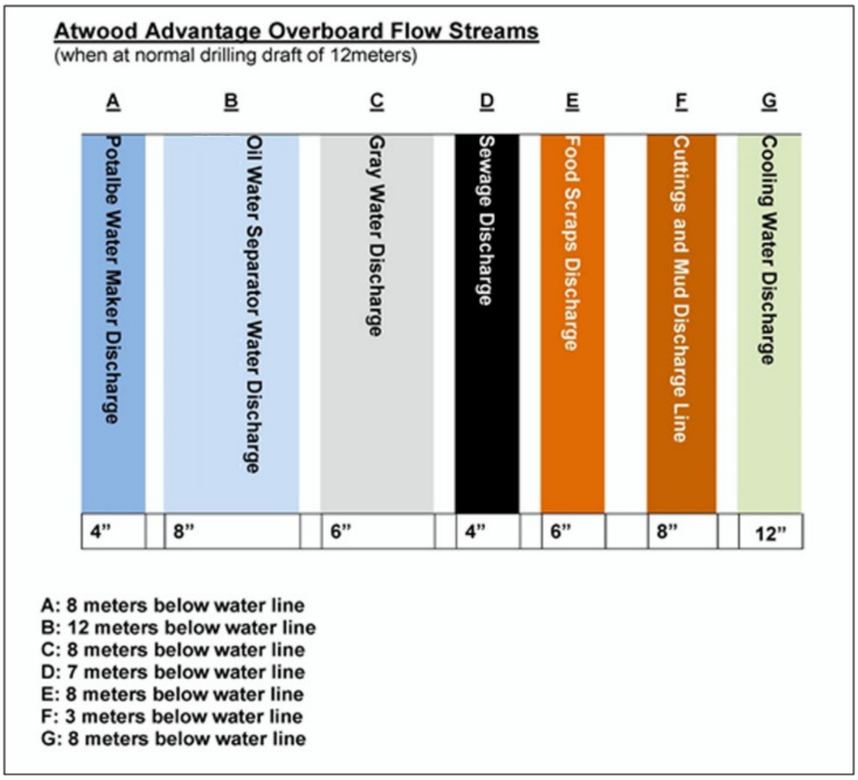


Figure 3-18. Discharge streams for the *Atwood Advantage*.

3.7.3.2 Discharge Treatment

Both drilling rigs 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). Compliance with Annex I and IV will be demonstrated by certification from the rig's flag state via the International Oil Pollution Prevention and International Sewage Pollution Prevention certificates. Compliance with Annex V will be demonstrated by a DNV Statement of Fact. The annual endorsement on the respective certificate stands as *prima facie* evidence that each rig has been surveyed for continuing compliance with the applicable requirements of that MARPOL Annex.

Specific treatment processes are detailed in the following subsections for individual waste streams. With the exception of gray water and organic food waste, which are comingled, all waste streams are discharged separately.

Sanitary Waste

Sanitary waste (i.e., black water or sewage) consists of human body wastes from toilets and urinals. All sanitary waste will be treated using an International Maritime Organization (IMO)-approved sewage treatment unit. The sewage treatment unit 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) resolution includes standards that must be met for the following effluents: Thermotolerant Coliform Standard, Total Suspended Solids Standard, Biochemical Oxygen Demand and Chemical Oxygen Demand Standards, and pH. Treated sewage will be discharged overboard through the sewage treatment plant. On the *Atwood Advantage* (as a representative example), treated sewage is discharged through 4-inch diameter lines located 7 m below the sea surface.

Gray Water

Gray water consists of the water generated from showers, sinks, laundries, and galleys. The gray water discharge system is arranged by gravity directly overboard or is led to the sewage treatment plant by manual valve. This valve is normally closed. A grease trap (1,000 L) is fitted on the drain lines from galley, scullery, and mess service areas except for the drain from the waste disposer. On the *Atwood Advantage* (as a representative example), discharge of gray water occurs through a 6-inch line 8 m below the sea surface.

Organic Food Waste

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. Food waste is ground to less than 25 mm in diameter to meet discharge requirements. Food waste discharges are allowed, when ground, if the vessel is 12 nmi or more from land when within special areas (including the Mediterranean Sea). Aside from grinding, no other treatment of organic food wastes is expected. On the *Atwood Advantage* (as a representative example), macerated food wastes are discharged through a 6-inch line 8 m below the sea surface.

Cooling Water

Cooling water is used to control and maintain proper temperatures on internal combustion engines on board the drillship and project vessels. 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. Where the zone is not defined, the dilution zone typically is considered to be 100 m from the point of discharge. Cooling water discharges consist of seawater that is not exposed to oil or other contaminants. No treatment of cooling water is expected. On the *Atwood Advantage* (as a representative example), cooling water discharges occur through a 12-inch diameter line 8 m below the sea surface.

Desalination Brine

Fresh water will be generated on board the drilling rigs via reverse osmosis water makers, generating brine (i.e., concentrated seawater) as a byproduct. At maximum rated capacity, each unit can generate 6.5 m^3/hour, or 156 m^3/day, of freshwater. Total freshwater generation capacity is 312 m^3/day. Maximum feed water flow rate through the freshwater generating system is approximately 380 m^3/day; maximum brine discharge flow rate is estimated at 318 m^3/day. The actual daily discharges during drilling of the Leviathan-4 well ranged from 0 to 246 m^3/day, with an average of 72 m^3/day.

The excess seawater discharged from the water makers does not contain any added chemicals. The discharge is through a 4-inch line 8 m below the sea surface.

Deck Drainage (Runoff)

Deck drainage from non-machinery areas is discharged overboard without treatment. Drainage from machinery spaces passes through an OWS prior to discharge. All discharges will meet MARPOL requirements for discharges from machinery spaces from fixed or floating platforms (MARPOL Annex I, Resolution MEPC 117[52]). The OWS discharge is through an 8-inch line 12 m below the sea surface.

3.7.3.3 Discharge Quality

All discharges from the drilling rigs and supply vessels will be in compliance with applicable standards (e.g., MARPOL, Barcelona Convention) or consistent with best industry practice. Sanitary wastes will be treated via chlorination in an IMO-approved sewage treatment plant, and organic (food) wastes will be macerated to facilitate degradation in compliance with MARPOL. Other wastes (i.e., cooling water, gray water) do not require treatment.

Effluent quality data collected by Noble Energy during drilling of the Tamar SW-1 well in the Tamar Field are considered as representative for the proposed Leviathan Field activities. Data for sanitary waste, gray water, and organic waste are presented in **Tables 3-37** to **3-39**, respectively.

Table 3–37. Analytical results for sanitary waste discharges for the Tamar SW-1 well.

Sampling Date	Sample Reception Date	Time	Report No.	Flow [m^3/mo]	Flow (Annual) [m^3/yr]	pH Field Test	BOD	TOC	TSS 105°C	Turbidity Field Test [NTU]	Free Chlorine Field Test	Total Chlorine Field Test	Oil & Grease (FTIR)	Mineral Oil (FTIR)	DOX	NO_3-N + NO_2-N	NH_4-N	TKN-N	Total N	Total P	Enterococcus	Fecal coliforms	TDS	Cl^-
																					µ/100 mL			
10/10/2013	10/10/2013	9:30	Starboard - C11857, FWC-09663.13			7.7	33	28	59	46	0.66	2.5	1.2	0.2		71.1	15	40	111	3	2.40E+05	1.70E+05	43,405	22,078
10/12/2013			Port			7				37.4	0.3	1.9												
10/16/2013			Port			7				49.84	0.79	1.1												
10/17/2013			Starboard			7				32.4	2.9	6.4												
10/23/2013			Port	250	250	7				32.4	0.85	1.9												
10/24/2013	10/24/2013	8:00-14:00	Starboard - C12580, FWC-10210.13			7.6	44	49	90	56.3	1	1.45	5.3	0.3		1.2	32	46	47.2	4	79	540	39,570	704
10/24/2013	10/24/2013	8:00-14:00	Port - C12581, FWC-10198.13			6.9	28	36	48	45.7	3.5	6	5.6	0.3		1.8	13	24.4	26.1	3	1.1	5.1	39,520	4,305
10/27/2013			Starboard			8				29.96	2.44	3.5												
11/4/2013	11/4/2013		Starboard			7.5				56	2.8	1.92												
11/5/2013	11/5/2013		Port			8				60	1.13	3.62												
11/9/2013	11/9/2013		Starboard			7.5				59	2.33	2.53												
11/10/2013	11/10/2013		Port			6.5				61	0.29	2.7												
11/17/2013	11/17/2013		Port			8.4				41	0.8	0.15												
11/18/2013	11/18/2013		Starboard	265	515	7.3				20	1.6	2.89												
11/20/2013	11/20/2013	10:30	Starboard - C14099, FWC-11408.13			7.2	32	55	15	45.4	1.3	2.3	1.4	0.2	3.4	1.8	20	114	115.8	3	49	9.20E+05	41,173	22,025
11/20/2013	11/20/2013	10:10	Port - C14100, FWC-11406.13			7.1	23	31	161	22.5	5.1	6	2	0.2	5.6	2.1	8.8	63	65	3	23	1.1	40,395	22,338
11/24/2013	11/24/2013		Starboard			7.3				50	2.6	1.8												
11/25/2013	11/25/2013		Port			7.9				49	1.4	2.65												
12/4/2013	12/4/2013	10:20	Starboard - C14731, FWC-11975.13			7.7	66	54	108	70.2	1.1	1.6	6	3		2.8	24	125	127.8	5	540	1.60E+03	40,415	21,905
12/4/2013	12/4/2013	10:00	Port - C14732, FWC-11875.13			7.2	15	47	18	46	5.2	6	2.4	0.1		2.1	13.5	23	25	3	1.1	1.1	38,910	21,345
12/7/2013			Starboard			7.2				50	0.3	0.95												
12/8/2013			Port	264	779	7.8				48	0.29	3.11												
12/16/2013			Starboard			8				36	1.02													
12/16/2013			Port			8				46	0.82													
12/23/2013			Starboard			8				35.5	1.3													
12/23/2013			Port			8				21.8	1.3													

BOD = biochemical oxygen demand; Cl^- = chloride; DOX = dissolved organic halides; FTIR = Fourier Transform Infrared; N = nitrogen; NH_4 = ammonium; NO_2 = nitrite; NO_3 = nitrate; NTU = nephelometric turbidity units; P = phosphorus; TDS = total dissolved solids; TKN = total Kjeldahl nitrogen; TOC = total organic carbon; TSS = total suspended solids.
Note: units are mg/L unless noted otherwise.

Table 3–38. Analytical results for gray water discharges for the Tamar SW-1 well.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [m^3/mo]	Flow (Annual) [m^3/yr]	TSS 105°C	Oil and Grease (FTIR)	TDS	MBAS - Anionic Detergent
10/24/2013	10/24/2013 8:00-14:00	C12592	659	659	188	748	441	0.9
11/20/2013	11/20/2013 10:00	C14128	697	1,356	8	96	192	1.9
12/4/2013	12/4/2013 10:30	C14755	694	2,050	102	40	422	6

FTIR = Fourier Transform Infrared; MBAS = methylene blue active substances (assay method); TDS = total dissolved solids; TSS = total suspended solids.
Note: units are mg/L unless noted otherwise.

Table 3–39. Analytical results for organic waste discharges for the Tamar SW-1 well.

Sampling Date	Sample Reception Date/Time	Report No.	Flow [kg/mo]	Flow (Annual) [kg/yr]	BOD	TOC	TSS 105°C	Oil and Grease (FTIR)	Total N	Total P
10/13/2013	10/14/2013	C12014	3,293	3,293	43,875	28,157	--	4,488	4,242	227
10/24/2013	10/24/2013 8:00-14:00	C12593			6,300	5,900	14,914	2,771	500.2	66
11/20/2013	11/20/2013 9:20	C14120	3,485	6,778	21,400	22,835	--	12,075	11,682	133
12/4/2013	12/4/2013 10:40	C14756	3,463	10,241	3030	6214	--	197	368	16

BOD = biochemical oxygen demand; FTIR = Fourier Transform Infrared; N = nitrogen; P = phosphorus; TOC = total organic carbon; TSS = total suspended solids; -- data not available (TSS was not analyzed due to analytical difficulties).
Note: units are mg/kg unless noted otherwise.

3.7.4 Summary of Discharge Quantities

Total estimated per-well discharges are summarized in **Table 3-40**.

Table 3-40. Summary of estimated per-well discharge quantities.

Source	Frequency	Average Daily Rate for Calculations[a]	Total Quantity
Leviathan-5 through Leviathan-10 (per well, duration = 75 days)			
WBM and brine	Continuous	--	WBM: 1,160.3 tons Brine: 1,673.1 tons
Cuttings (WBM intervals)	Continuous	--	1,330 tons
MOBM adhering to cuttings	Continuous	--	2.95 tons
Cuttings (MOBM intervals)	Continuous	--	1,023 tons
Cement (at wellbore)	Periodic	--	95.6 tons
End-of-well (completion brine)	Once	--	234.5 tons
Sanitary wastes	Periodic	8.3 m^3/day	622.5 m^3
Gray water	Continuous	28.8 m^3/day	2,160.0 m^3
Organic (food) waste	Periodic	0.7 m^3/day	52.5 m^3
Cooling water	Continuous	2,974.6 m^3/day	223,095.0 m^3
Desalination brine	Continuous	72.2 m^3/day	5,415.0 m^3
Deck drainage (runoff)	Continuous	2.1 m^3/day	157.5 m^3
Leviathan-3 ST02 (duration = 30 days)			
WBM and brine	Continuous	--	WBM: 946.0 tons Brine: 274.7 tons
Cuttings (WBM intervals)	Continuous	--	150.0 tons
Cement (at wellbore)	Periodic	--	3.3 tons
Cement (at wellbore) from TA plugs	Periodic	--	61.8 tons
Sanitary wastes	Periodic	8.3 m^3/day	249.0 m^3
Gray water	Continuous	28.8 m^3/day	864.0 m^3
Organic (food) waste	Continuous	0.7 m^3/day	21.0 m^3

Table 3-40. (Continued).

Source	Frequency	Average Daily Rate for Calculations[a]	Total Quantity
Cooling water	Continuous	2,974.6 m^3/day	89,238.0 m^3
Desalination brine	Periodic	72.2 m^3/day	2,166.0 m^3
Deck drainage (runoff)	Continuous	2.1 m^3/day	63.0 m^3
Leviathan-4 ST01 (duration = 40 days)			
Brine and completion fluids	Continuous	--	1,887 tons
Cuttings (WBM only)	Periodic	--	30.4 tons
Sanitary wastes	Periodic	8.3 m^3/day	332.0m^3
Gray water)	Continuous	28.8 m^3/day	1,152.0 m^3
Organic (food) waste	Continuous	0.7 m^3/day	28.0 m^3
Cooling water	Continuous	2,974.6 m^3/day	118,984.0 m^3
Desalination brine	Periodic	72.2 m^3/day	2,888.0 m^3
Deck drainage (runoff)	Continuous	2.1 m^3/day	84.0 m^3

[a] Average daily rate is based on actual discharge data from the Leviathan-4 well with an average of 115 persons on board.
MOBM = mineral oil-based mud; TA = temporary abandonment; WBM = water-based mud.

3.7.5 Alternatives to On-Site Discharge

Noble Energy has evaluated alternatives to on-site discharge for each effluent.

Available alternatives to the on-site discharge of drilling muds (and cuttings) include injection or discharge into wellbores or subsurface formations, and transport of waste to shore for treatment and disposal. These practices are characterized by their own set of environmental effects, costs, and inherent limitations (e.g., practical and technical considerations). For example, the use of onshore disposal methods requires that the material be transported to shore, with increased risks to the environment and personnel safety through handling, shipping, and transport.

Noble Energy recognizes the potential environmental impacts of discharging WBM and treated MOBM cuttings to the marine environment, and has implemented a series of mechanisms and procedures to ensure that impacts to the marine environment from on-site discharge are minimized. Mechanisms include proper containment (e.g., containment of all chemical storage areas; use of catchment drains, particularly on the rig floor and in the mud pits), drilling mud treatment and processing (e.g., use of solids control equipment to minimize the amount of drilling fluid retained on the cuttings prior to discharge; implementation of chemical testing and toxicity testing protocols); use of a TCC to ensure that MOBM retained on discharged cuttings is less than 1% by weight; consideration of the receiving environment (e.g., assessment of impacts to water quality and benthic communities); and simulation modeling of drilling deposition.

Alternatives to the on-site discharge of other routine effluents either are not practical or are limited. There are no practical, viable alternatives to cooling water discharges. Alternative disposal methods for brine, organic (food) wastes, and sanitary waste and gray water include containerization and shipment to shore. The location of the drilling activity in deepwater, well offshore in an open ocean environment indicates that only limited, localized impacts from these discharges are expected. Containerization and shipment will produce their own set of impacts (e.g., air quality, onshore processing, treatment, and disposal impacts), in addition to increasing safety concerns with loading and offloading additional waste containers.

3.8 WASTE

All wastes will be handled and disposed of according to MARPOL and permit requirements. Wastes that cannot be discharged overboard under MARPOL requirements will be shipped to authorized waste disposal sites onshore in accordance with the regulations.

In order to meet the objectives of the Noble Energy Environmental, Health, and Safety (EHS) Policy, the drilling rigs will manage the generation, storage, and disposal of all solid waste. Drilling and completion operations will be conducted under the preferred waste management hierarchy of "reduce, reuse, recycle, recover" prior to designating waste for disposal, whenever possible. In principle, this is accomplished by reducing the amount of waste generated through process efficiencies, reusing waste materials in their original form, recycling by converting waste back into a usable material, and recovering by extracting material or energy from the waste for other uses. Any waste remaining from these efforts will be managed through proper disposal.

Waste streams generated by drilling and completion operations and processes will be identified and classified. Each identified waste stream is to be classified and handled as scheduled waste or non-scheduled waste in accordance with the drilling rig's EHS management system. The waste classification process includes the following steps:

- Determine if waste stream is scheduled waste (hazardous or toxic) or has characteristics that pose threats to human health or the environment; and
- If waste stream is non-scheduled waste, determine proper classification or other type of waste stream classification (e.g., industrial waste, domestic waste, etc.) according to any local waste management regulations.

Waste classification is conducted by using the following methods:

- Process knowledge – Applying knowledge of the hazardous characteristic(s) of the waste in light of the materials or the processes used; and
- Regulatory listing review – Determining if the waste is listed by waste management regulations or authorities as being considered a hazardous, scheduled, or other type of waste.

Different waste streams will be segregated by type and will not be mixed together or managed in the same container. Under no circumstances will non-hazardous wastes be allowed to be mixed in the same container with hazardous or scheduled wastes. If this occurs, the entire mixture is to be considered hazardous or scheduled waste.

Waste storage areas will be designated on the drilling rigs 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.

3.9 WELL CLOSURE (TEMPORARY ABANDONMENT)

After each new well is drilled, it will be temporarily abandoned and secured with multiple barriers pending completion operations by the second drilling rig. Temporary abandonment will be conducted in accordance with MNIEWR guidelines for "Abandonment of Offshore Oil and Gas Wells." The MNIEWR guidelines are based on sections 30 CFR§250.1710-1722 and 250.1740-1742 of the U.S. regulations and on the API BULL E3 standard.

After each well has reached total depth and production casing has been run, the wellbore will be temporarily abandoned and secured with multiple barriers. A 9⅞-inch × 10¾-inch production casing string will be run to total depth and cemented in place. The cement will be displaced with sufficient mud weight to provide a hydrostatic pressure equal to or greater than the pore pressure plus 300 psi with a seawater column above the mud line. Two mechanical plugs (retrievable packers) will be set, 1) one at the bottom of the casing string; and 2) one within 300 m of the mud line. Both will be weight and pressure tested. The wellbore will then be negative pressure tested with a seawater column to the mud line prior to disconnecting the BOP stack and riser. The wellbore will be kept for future gas production. The planned temporary abandonment wellbore sketch after drilling operations have concluded is shown in **Figure 3-19**.

The chemicals used during well completion activities have been tabulated in **Section 3.7.2**. SDSs for all chemicals used in well drilling and completion activities, including temporary abandonment, are included in **Appendix H**.

[redacted]

Figure 3-19. Wellbore sketch for temporary abandonment of Leviathan Field wells.

CHAPTER 4: EVALUATION OF ENVIRONMENTAL IMPACTS

4.1 INTRODUCTION AND METHODOLOGY

This chapter evaluates the environmental impacts of Noble Energy's proposed drilling and completion activities in the Leviathan Field. The impact assessment includes both routine activities and accidental events. The topics in the impact analysis are those specified in the "Guidelines for Preparation of Environmental Impact Document for Production Drilling, Production Tests and Completion – Development of Leviathan Field (Leases I/14 and I/15)", dated 5 October 2014 (**Appendix A**). A table comparing EIA sections with the guideline requirements is presented in **Appendix B**. 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, 2004b);
- **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, 2004b).

The following aspects and resources were included in the analysis:

Aspects:
- Production testing;
- Seafloor disturbance;
- Drilling discharges;
- Other discharges;
- Air emissions;
- Safety and protection zones;
- Noise hazards;
- Light hazards;
- Waste and marine debris;
- Well closure (temporary abandonment);
- Support vessel traffic;
- Helicopter traffic;
- Accidental fuel spill; and
- Accidental condensate spill from well blowout.

Resources:
- Air quality;
- Water quality;
- Sediment quality;
- Benthic communities;
- Marine mammals;
- Sea turtles;
- Seabirds and migratory birds;
- Fishes;
- Fishing activities and marine farming;
- Culture and heritage sites;
- Marine transportation and infrastructure; and
- Coastal habitats and infrastructure.

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 (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 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.

Aspect	Air Quality	Water Quality	Sediment Quality	Benthic Communities	Marine Mammals	Sea Turtles	Seabirds and Migratory Birds	Fishes	Fishing Activities and Marine Farming	Culture and Heritage Sites	Marine Transportation and Infrastructure	Coastal Habitats and Infrastructure
Production testing	● 4.2.1	● 4.2.2	--	--	--	--	● 4.2.3	--	--	--	--	--
Seafloor disturbance	--		● 4.6.1	● 4.6.1	--	--	--	--	--	● 4.7.1	--	--
Drilling discharges	--	● 4.6.2	● 4.6.2	● 4.6.2	--	--	--	● 4.6.2	--	● 4.7.2	--	--
Other discharges	--	● 4.6.3	--	● 4.6.3	--	--	--	● 4.6.3	--	--	--	--
Air emissions	● 4.8.1	--	--	--	--	--	--	--	--	--	--	--
Safety and protection zones	--	--	--	--	--	--	--	--	● 4.12.1	--	● 4.13.1	--
Noise hazards	--	--	--	--	● 4.5.2	● 4.5.3	--	● 4.5.4	--	--	--	--
Light hazards	--	--	--	--		● 4.4.1	● 4.4.2	● 4.4.3	--	--	--	--
Waste and marine debris	--	● 4.6.6	● 4.6.6	● 4.6.6	● 4.6.6	● 4.6.6	● 4.6.6	--	--	--	--	--
Well closure (temporary abandonment)	--	--	--	--	--	--	--	--	--	--	--	--
Support vessel traffic	--	--	--	--	● 4.6.4	● 4.6.4	● 4.6.4	--	● 4.12.2	--	--	--
Helicopter traffic	--	--	--	--	● 4.6.5	● 4.6.5	● 4.6.5	--	--	--	--	--
Accidental fuel spill	● 4.3.3 4.8.2	● 4.3.3	--	--	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3 4.7.3	● 4.3.3	● 4.3.3
Accidental condensate spill from well blowout	● 4.3.3 4.8.2	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3	● 4.3.3 4.7.3	● 4.3.3	● 4.3.3

Table 4-2. Risk assessment matrix for impact analysis. Overall risk is rated as (green) = Low, (yellow) = Moderate, or (red) = High.

CONSEQUENCE				LIKELIHOOD				
				1 Rare	2 Unlikely	3 Possible	4 Likely	5 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 Noble Energy. 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

4.2 PRODUCTION TESTS

This section evaluates the impacts of production testing as described in **Section 3.3**. The issue of well control and integrity are addressed elsewhere in this document. Detailed BOP specifications are provided in **Section 3.2.5**. The detailed casing design and testing are described in **Section 3.2.6**. Noble Energy's methods for risk assessment and management are summarized in **Section 5.2.1**.

The estimated duration of production testing or "flowback" is 49.5 hours per well. SDSs for all chemicals used in production testing are included in **Appendix H**.

All produced gas, condensate, and injected methanol will be flared off. [redacted] Any brine, produced water, or condensate water flowed back will be collected, filtered, and tested and discharged overboard as per Noble Energy standards. Any fluid that does not meet discharge criteria will be collected and shipped to an approved waste disposal facility.

Resources potentially affected by production testing include air quality, water quality, and seabirds and migratory birds (**Table 4-1**).

4.2.1 Impacts on Air Quality

Air pollutant emissions from production testing were estimated in **Section 3.5.4.** The total estimated emissions for a single well are 40.69 metric tonnes of CO, 7.98 metric tonnes of NO_x, 0.06 metric tonnes of SO_x, 6.31 metric tonnes of VOCs, and 0.11 metric tonnes of PM. Nearly all of the CO, NO_x, and VOC emissions would be from gas flaring, whereas condensate would be the source for all of the PM emissions. CO_2 emissions from production testing were estimated at 13,920 metric tonnes per well (see **Section 3.3.1**).

The magnitude of emissions from production testing (sum of all eight initial wells) is negligible in comparison with annual regional emissions from shipping in the Mediterranean (**Table 4-3**). The air pollutant emissions from flaring are expected to disperse rapidly in the atmosphere and may produce localized, transient impacts on air quality near the drilling rig. Dispersion depends on factors such as emission height, atmospheric stability, mixing height, exhaust gas temperature and velocity, and wind speed (BOEM, 2012). Due to the distance from shore (greater than 120 km), no impacts on coastal air quality are expected.

Table 4-3. Comparison of production testing emissions to regional emissions from shipping.

Source	Emissions (metric tonnes)				
	CO_2	NO_x	SO_2	VOC	PM
Production testing (per well)	13,920	7.98	0.06	6.31	0.11
Production testing of all eight initial wells	111,360	63.84	0.48	50.48	0.88
Annual (2005) emissions from Mediterranean shipping industry[a]	64,936,000	1,447,000	863,000	54,000	98,000
Production testing of all eight initial wells as percentage of annual shipping emissions	0.171	0.004	0.000	0.093	0.001

[a] Total emissions from shipping (at sea, maneuvering, and at berth) in the Mediterranean Sea in 2005 (Entec UK, 2007).
CO_2 = carbon dioxide; NO_x = nitrogen oxides; PM = particulate matter; SO_2 = sulfur dioxide; VOC = volatile organic compound.

4.2.2 Impacts on Water Quality

There is the potential for water quality impacts during flaring due to “fallout” of oil droplets from the flare. Noble Energy will use a high-efficiency burner to minimize the potential for fallout.

Any brine, produced water, or condensate water flowed back will be collected, filtered, and tested and discharged overboard as per Noble Energy standards. Discharges from production testing will be rapidly dispersed in the ocean and no significant impacts on water quality are expected.

4.2.3 Impacts on Seabirds and Migratory Birds

There is the potential for seabirds to be attracted to the flare (i.e., as a light source) during a production test. This potential impact, along with other lighting impacts, are discussed separately in **Section 4.4.2**. Due to the brief duration of flaring (49.5 hours per well), a single production test is not likely to result in collisions or other significant adverse impacts on seabird or migratory bird populations. Individual production tests are expected to be 40 days apart (the duration of well completion).

4.2.4 Mitigation Measures

Noble Energy will use a high-efficiency burner for flaring to minimize the potential for incomplete combustion and/or creating a sheen on the sea surface due to oil droplets. High efficiency burners have a unique nozzle design that uses compressed air to atomize the oil in a mixing chamber. Internal air mix atomizers produce much smaller hydrocarbon droplets than conventional burners. Smaller droplets burn faster, eliminating the potential for raw hydrocarbons to fall out of the flame. Carefully positioned multiple burner tips create maximum flame turbulence and air ingestion. Multiple tips discharge the well effluent in a unique array. The combination of atomized droplets and maximum air ingestion maks the process very efficient. A pilot system with remote igniters provides the ignition source for the finely atomized spray.

Any brine, produced water, or condensate water flowed back will be collected, filtered, and tested and discharged overboard as per MARPOL and permit requirements. Any fluid that does not pass will be collected and shipped to an approved waste disposal facility.

4.2.5 Impact Significance

The significance of potential impacts from production testing is summarized in **Table 4-4**. In evaluating the likelihood of air quality impacts, a 100-m mixing zone has been assumed around the drilling rig (i.e., it is referring to the likelihood of detectable impacts beyond the mixing zone). The likelihood of air quality impacts is rated as possible (3). The likelihood of fallout of oil droplets is considered unlikely (2) and impacts on seabirds are rated as possible (3). The consequences are rated as insignificant (1) in all cases and the residual risk is Low for all impacts.

Table 4-4. Summary of potential impacts from production testing.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Flaring	Air quality	Localized, transient elevations in air pollutant concentrations near drilling rig	• Use of high-efficiency burner to minimize air pollutants from incomplete combustion	3	1	3 Low
	Water quality	Possible sheen on sea surface due to fallout of droplets during flaring; localized impacts due to discharge of treated effluent	• Use of high-efficiency burner to minimize "fallout" of oil droplets • Treatment of effluent to meet standards prior to discharge	2	1	2 Low
	Seabirds and migratory birds	Possible attraction and/or disorientation including circling behavior and collisions with rig structure	• None recommended	3	1	3 Low

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

4.3 ACCIDENTAL POLLUTION EVENTS

4.3.1 Spill Scenarios

Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a blowout. The fuel spill scenario assumed an instantaneous release of 8,415.6 m^3 from the drilling rig. The condensate spill scenario assumed a blowout resulting in the release of [redacted] 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, 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 assure 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 3.2.5** and the design and testing of the casing to prevent a loss of well control are described in **Section 3.2.6**.

A large diesel spill, such as one releasing the entire fuel contents of a drilling rig, 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 rig-related diesel spill being approximately 238 m^3 (1,500 bbl) (Anderson et al., 2012). The most likely type of spill 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 Dr. Steve Brenner of Bar-Ilan University for the ML-1X wellsite in the Leviathan Field. Modeling of a condensate spill was conducted by Dr. Brenner using the Leviathan-6 drillsite as a release point. All of the modeling was conducted in accordance with the requirements specified in Section 4.3 of the

"Framework Guidelines for Preparation of Environmental Document Accompanying License for Exploration Purposes – Exploratory (Experimental) Drilling and Offshore Production" (**Appendix A**). Spill trajectory modeling methods and results are presented in **Appendix M**.

4.3.2 Fuel Spill Modeling Results

The fuel spill scenario assumes the instantaneous release of the entire fuel supply of a drilling rig. 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 by Dr. Steve Brenner of Bar-Ilan University using MEDSLIK Version 5.3.6. Spill fate was modeled for 30 days from the beginning of the spill. 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. Noble Energy's Oil Spill Contingency Plan (OSCP) provides detailed information about the response capabilities and methods that Noble Energy would use to minimize the potential for significant impacts. The drilling rig contractor will also implement oil spill prevention methods as part of its Shipboard Oil Pollution Emergency Plan (SOPEP).

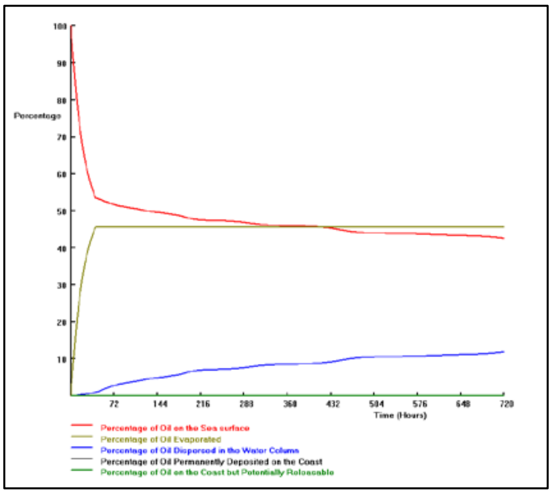
Table 4-5 and **Figure 4-1** summarize the modeling results for a fuel spill under the four scenarios. The model predicts that diesel fuel would evaporate rapidly, with approximately 45.6% of the spill evaporating in the first 42 to 55 hours in the four scenarios. A spill is predicted to reach the shoreline 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 4–5. Trajectory and weathering model results at the end of 30 days for a fuel spill under four environmental scenarios.

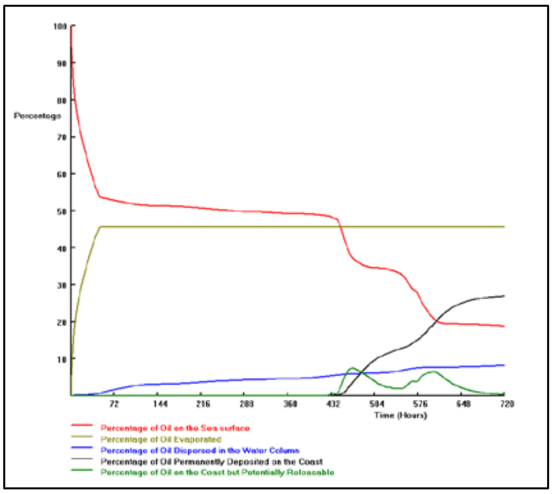
Scenario	Percent Evaporated	Percent on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspots
1 extreme winter storm	45.6	42.5	11.9	0.003	--	Negligible	Southern coast of Cyprus	Paphos, Cyprus (very 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)

Table 4-5. (Continued).

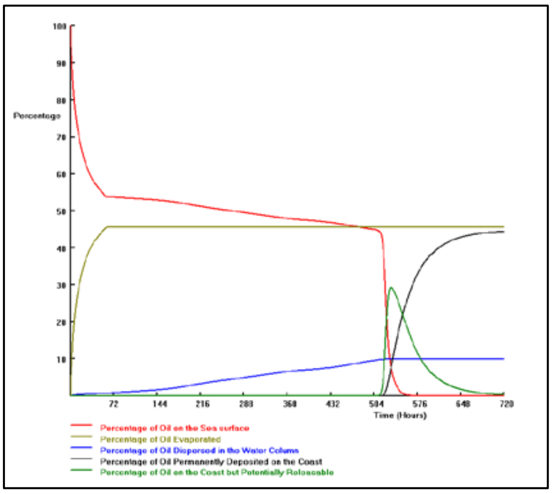
Scenario	Percent Evaporated	Percent on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspots
3 typical summer conditions	45.6	0.0	9.8	44.6	21	61	South of Beirut	Jieh, Lebanon (typically 1 m^3/km, 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)



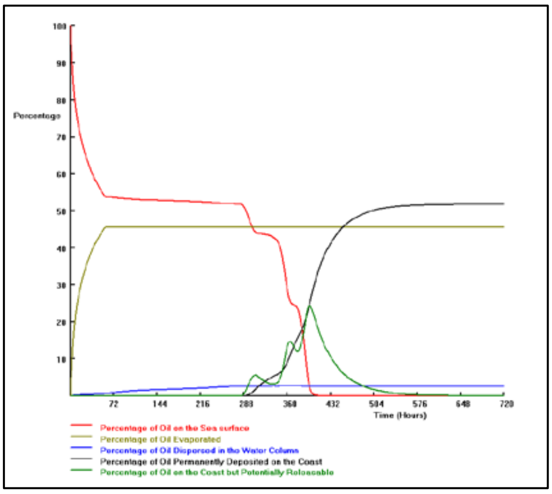
Scenario 1: Extreme winter storm.



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.

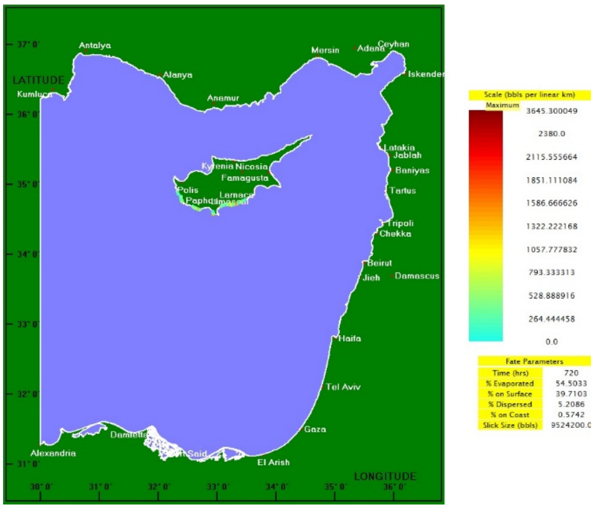
Figure 4-2 shows the predicted extent and concentration of diesel fuel deposited on the coast for the four scenarios. In summary:

- 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.

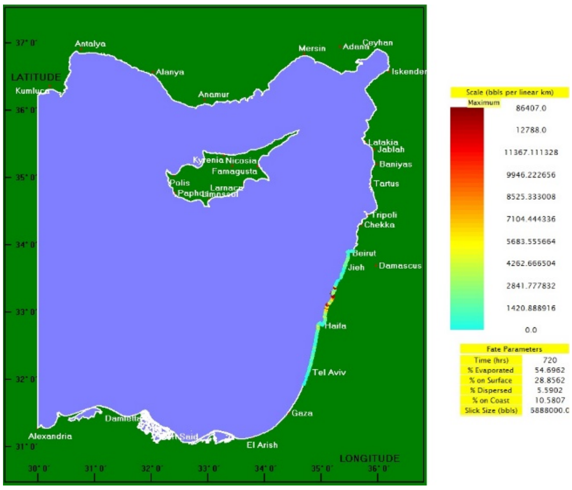
- Scenario 2 (typical winter conditions) is predicted to result in the maximum linear extent of shoreline oiling (220 km), extending from Ashkelon to Beirut. Hotspots for shoreline deposition are Rosh Hanikra and southern Lebanon (typically 15 to 20 m^3/km, but locally as high as 50 m^3/km).

- 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 m^3/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).

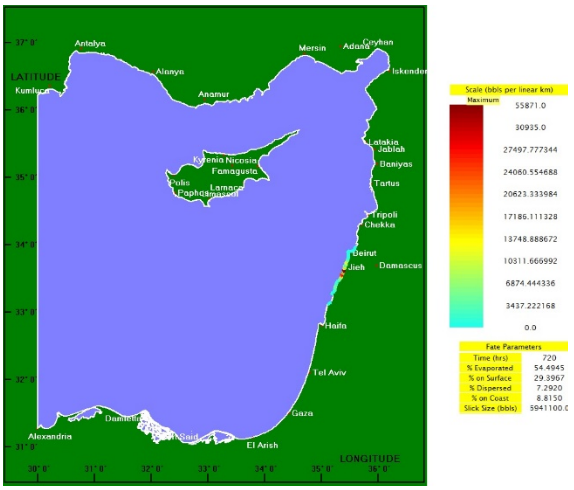
The potential area of influence based on all of the modeling scenarios is within a box bounded by the following coordinates: within a box bounded by the following coordinates: 31°30’ to 35°45’N latitude, 32° to 35°30’E longitude. The actual area affected by a particular spill would be much smaller. For 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.



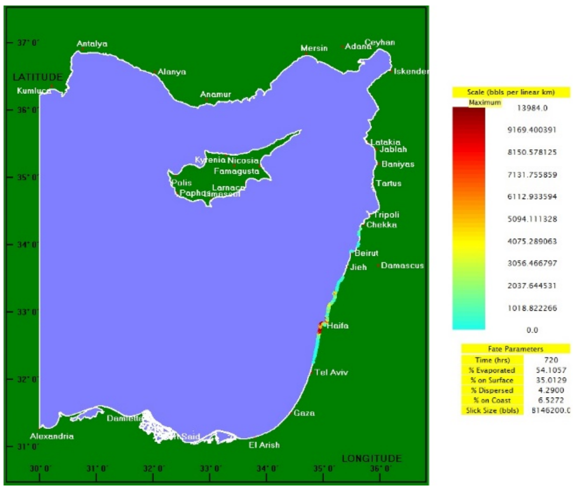
Scenario 1: Extreme winter storm.



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.

4.3.3 Condensate Spill Modeling Results

The condensate spill scenario assumed a blowout of condensate [redacted], continuing for a period of 30 days. The technical basis for the condensate spill scenario is provided in **Appendix N**. Spill fate was modeled for 30 days from the beginning of the spill.

Modeling of a condensate spill was conducted by Dr. Steve Brenner of Bar-Ilan University using MEDSLIK Version 5.3.6. The Leviathan-6 drillsite 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.

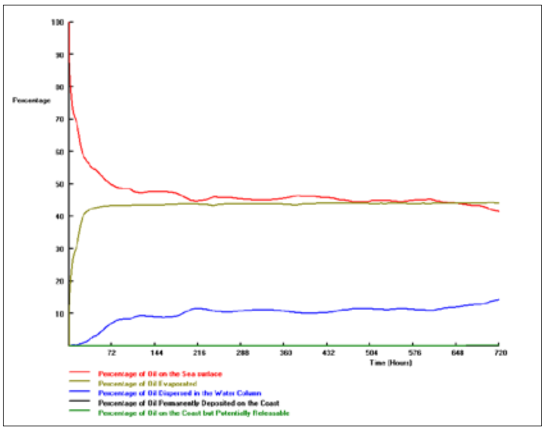
For simplicity, the condensate modeling essentially assumed that the daily spill volume ([redacted]) would be released at the sea surface. In reality, a condensate spill from a seafloor blowout would rise rapidly through the water column and could be affected by dissolution, dispersion, adsorption to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

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. Noble Energy's OSCP provides detailed information about the response capabilities and methods that Noble Energy would use to minimize the potential for significant impacts.

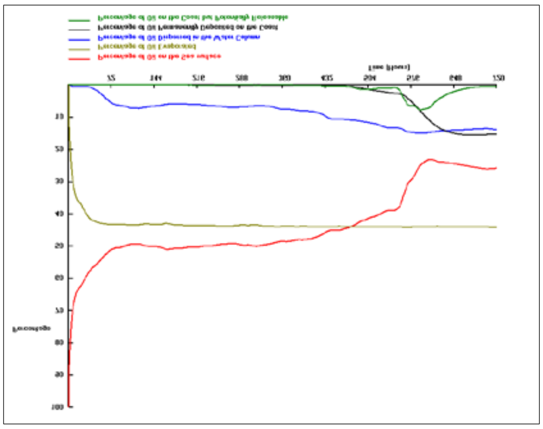
Table 4-6 and **Figure 4-3** summarize the modeling results for a condensate spill under the four scenarios. The model predicts that nearly 40% of the spill would evaporate in the first 24. A spill is predicted to reach the shoreline after 7 days under Scenario 2, 13 days under Scenario 4, after 23 days 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 4–6. Trajectory and weathering model results at the end of 30 days for a condensate spill under four environmental scenarios.

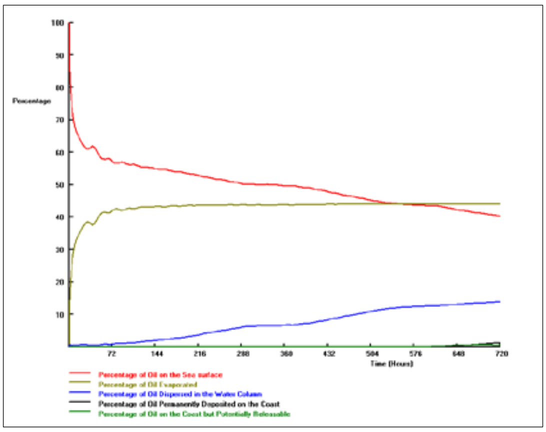
Scenario	Percent Evaporated at 30 days	Percent on Sea Surface	Percent Dispersed	Percent Deposited on Coast	Days Until Initial Shoreline Impact	Length of Coastline Affected (km)	Coastline Affected	Impact Hotspots
1 extreme winter storm	44.1	41.5	14.2	0.3	25.75	54.2	northern Lebanon and southwestern Cyprus	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 ofLatakiya, 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)



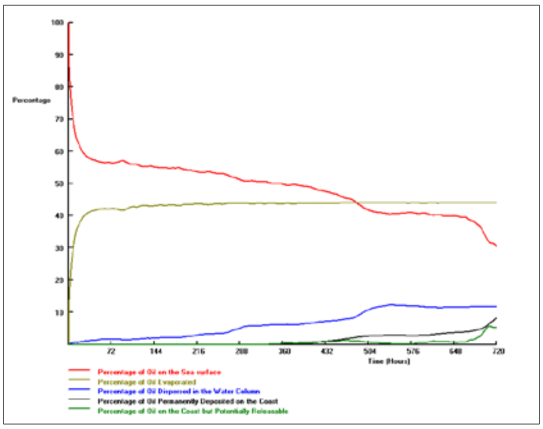
Scenario 1: Extreme winter storm.



Scenario 2: Typical winter conditions.



Scenario 3: Typical summer conditions.

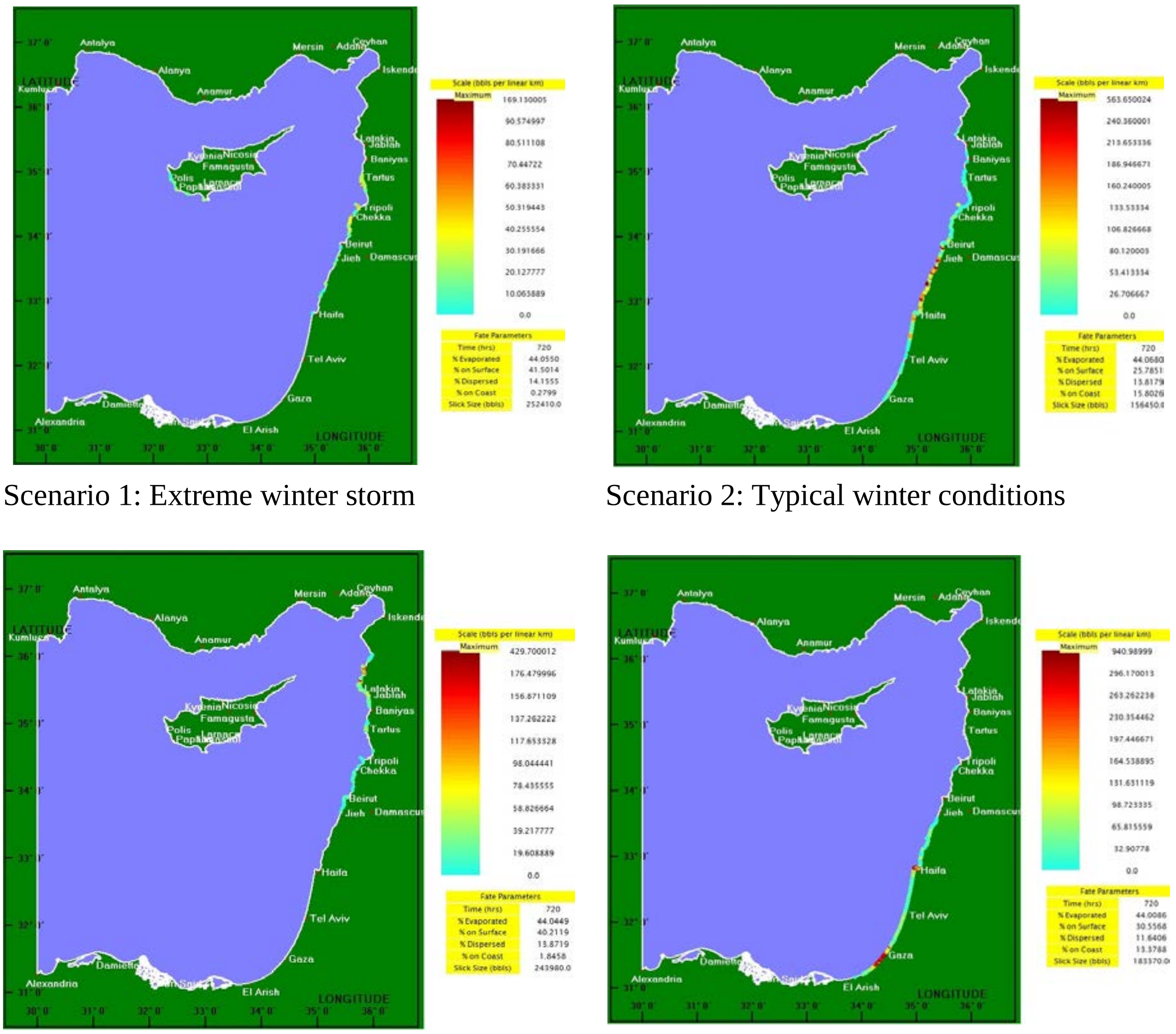


Scenario 4: Typical autumn conditions.

Figure 4-3. Spill fate parameters for a condensate spill at the Leviathan-4 drillsite 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 northen coast of Lebanon from Jieh north into Syria;
- 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 drillsite 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 [redacted] (i.e., [redacted] 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.

4.3.4 Potential Impacts

4.3.4.1 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.

4.3.4.2 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, 2003). Diesel fuel is readily and completely degraded by naturally occurring microbes (National Oceanic and Atmospheric Administration, 2006). 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 SDSs 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.

4.3.4.3 Impacts on Sediment Quality and Benthic Communities

A fuel spill would not affect sediment quality or benthic communities near the drillsite because the spill is assumed to occur at the surface in a water depth of 1,540 to 1,800 m. A blowout resulting in a condensate spill could affect sediments and benthic communities in the immediate vicinity of the drillsite. 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.

4.3.4.4 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 be evaporated or dispersed 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.

4.3.4.5 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 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, 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 shoreline of Israel. 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 Noble Energy'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.

4.3.4.6 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 4.3.4.2**. 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 evaporated or dispersed 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.

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 IBAs designated in Israel, two include coastal habitats (BirdLife International, 2014c):

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

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, Noble Energy'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. Noble Energy 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.

4.3.4.7 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 be evaporated or dispersed 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.

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 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.

4.3.4.8 Impacts on Fishing Activities and Marine Farming

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 (see **Section 1.6.3**).

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 the Israel/Lebanon border south to Ashkelon (fuel spill) or the Egyption border (condensate spill), with the most extensive impacts during typical winter conditions. As discussed in **Section 1.12**, 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.

Three open water fish farms are identified in **Section 1.12**. From north to south, they are: 1) 1.6 nmi west of Michmoret; 2) approximately 5 nmi west of Palmachim; and 3) inside Ashdod port. The Michmoret location is within the range of potential contacts for typical winter conditions and typical autumn conditions for either a fuel spill or condensate spill. The Palmachim location is predicted to be contacted by either a fuel spill or condensate spill under typical winter conditions, but in small amounts (i.e., 2 m^3/km for a condensate spill). The Ashdod location 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.

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. Noble Energy'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.

4.3.4.9 Impacts on Culture and Heritage Sites

Potential culture and heritage sites in the Leviathan Field are discussed in **Section 1.8**. 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 1,540 to 1,800 m. A condensate spill from a seafloor blowout is also unlikely to contact seafloor features because the condensate is expected to rise through the water column to the sea surface. A blowout may physically disturb sediments within a radius of 300 m around a drillsite (BOEM, 2012), but there are no known archaeological sites within this radius of the drillsites (the nearest are 3 km away as discussed later in **Section 4.7**).

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. 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, Noble Energy'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.

4.3.4.10 Impacts on Marine Tranportation 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 1.11.3**. 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, Noble Energy'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 Noble Energy's OSCP, coastal resources and infrastructure would be a high priority for protection in the event of a spill.

4.3.4.11 Impacts on Coastal Habitats and Infrastructure

Table 4-7 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 beach (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 4-8 provides further details concerning the coastal habitats and infrastructure along the coast of Israel. The shoreline is divided into 24 segments according to Noble Energy'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 4.3.3**. 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 tyical 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 4–7. Percentage occurrence of Environmental Sensitivity Index (ESI) shoreline types along the coast of Israel (from Noble Energy'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, seastars, limpets, sea anemones, shore crabs, polychaetes, and macroalgae are often very abundant. Oil reaching this shoreline type is held offshore by wave 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 4-7. (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 beachface. 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 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 beachface 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	Riprap is composed of cobble- to boulder-sized blocks of granite, limestone, or concrete. Riprap 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 4-7. (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 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 4-8. Coastal habitats and infrastructure along the Israel coast. The coastline is divided into 24 segments as indicated in Noble Energy'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 4-8. (Continued).

Coastal Segment No.	Condensate on Shoreline (m^3/km) after 30 days under each Spill Scenario 1 Extreme Winter	2 Typical Winter	3 Typical Summer	4 Typical Autumn	Coastal Area (Point-to-Point)	Habitat Type (Sandy/Rocky)	ESI Shoreline Types and Lengths	Infrastructure	Major Streams and Estuaries	Comments
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 4-8. (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
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

Table 4-8. (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						
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 Le-Zion; 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
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.

4.3.5 Mitigation Measures

Mitigation for accidental spills includes both spill prevention and response measures. Noble Energy 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 3.2.5**. The detailed casing design and testing are described in **Section 3.2.6**. In addition, once the drilling rig to be used has been identified, Noble Energy and the drilling rig's owner will engage in a comprehensive inspection and testing of the rig'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. Noble Energy has committed to operating in Israel per BSEE regulations, unless superseded by MNIEWR 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, Noble Energy'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. Noble Energy's OSCP provides detailed information about the response capabilities and methods that Noble Energy would use to minimize the potential for significant impacts.

4.3.6 Impact Significance

Impact significance for accidental spills is summarized in **Table 4-9**. The likelihood of a large fuel spill or a worst-case condensate spill from a blowout is rated as unlikely (2), taking into account Noble Energy'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 4–9. Summary of potential impacts from accidental pollution events.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Accidental spills: Fuel spill from the drilling rig (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 • Drilling rig 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 4-9. (Continued).

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Accidental spills: Condensate spill from a blowout ([redacted] 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 blowout site; sediment contamination unlikely		2	2	4 Low
	Benthic communities	Physical impact to benthic organisms within 300 m of blowout 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

4.4 LIGHT HAZARDS

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

All drilling rigs maintain exterior lighting for navigational and aviation safety. The total time for drilling and completing all of the wells is estimated to be 556 days (see **Section 3.2.4**). Drilling operations by the first drilling rig will require an estimated 480 days. The completion operations by the second drilling rig will require an estimated 320 days. There will be a period of approximately 236 days during which both drilling rigs will be operating in the Leviathan Field. The drilling program will be supported by two MMC 87 Class platform supply vessels operating out of the port of Haifa (see **Section 3.2.3**). Each supply vessel is expected to make three round trips per week between Haifa and the drilling rig(s).

In addition to the exterior lighting on board the drilling rigs, light will be emitted due to flaring during production testing. The estimated duration is 49.5 hours per well (see **Section 3.3**). Due to the short duration at each wellsite, flaring is considered negligible as source of lighting impacts.

Resources potentially affected by artificial lighting include sea turtles, seabirds and migratory birds, and pelagic fishes. Marine mammals are unlikely to be directly affected as they are not known to use lighting cues (in air) in their foraging, reproduction, or other activities.

4.4.1 Potential 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 drilling rigs 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 drilling rigs 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 drilling rigs 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, drilling rig 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 supply vessels would be brief and typical of normal maritime activities in the Mediterranean.

4.4.2 Potential Impacts on Seabirds 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 drilling rigs will not be visible to migrating birds that routinely migrate along or near the coast. Consequently, drilling rig lighting is unlikely to have significant impact on seabird or migratory bird populations.

4.4.3 Potential Impacts on Fishes

Offshore structures typically attract epipelagic fishes such as tunas, dolphin, billfishes, and jacks (e.g., Holland et al., 1990; Higashi, 1994). Drilling rigs, as floating structures in the deepwater environment, essentially act as fish aggregating devices (FADs). 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 rigs 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 drilling rigs are temporary structures and will be moving between wellsites, any impacts on fish populations are likely to be insignificant.

4.4.4 Mitigation Measures

Navigational lighting onboard both the drilling rigs and supply 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. 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.

4.4.5 Impact Significance

Impact significance for light hazards is summarized in **Table 4-10**. 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 4–10. Summary of potential impacts from light hazards.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Artificial lighting on drilling rigs 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 rig 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

4.5 NOISE

Sources of underwater noise during the drilling and completion program include the drilling rigs, supply vessels, and helicopters. The source characteristics are summarized in **Section 3.4**. 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, 2013; 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 of 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 drilling rigs, supply vessels, and helicopters is continuous, it could be considered transient insofar as a stationary receiver is concerned.

4.5.1 Source Characterization

Drilling Rigs. Drillships and semisubmersible produce primarily continuous, broadband sound, with strong tonal components at low frequencies (Richardson et al., 1995). Sound from Leviathan Field drilling activities was modeled by Genesis using measurements from a drillship (Miles et al., 1987). This is a conservative assumption because a drillship is likely to be louder than a semisubmersible drilling rig (e.g., Richardson et al., 1995). The drillship noise was estimated to generate a peak SPL of 177 dB re 1 µPa (see **Section 3.4.1**).

Drilling rigs 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 556 days (see **Section 3.2.4**). Drilling operations by the first drilling rig will require an estimated 480 days. The completion operations by the second drilling rig will require an estimated 320 days. There will be a period of approximately 236 days during which both drilling rigs will be operating in the Leviathan Field. Each drilling rig will emit sound from a fixed location when drilling or completing a well, but the location will change as the rig moves between wells. The duration of activities at individual drillsites is 75 days for drilling the Leviathan-5 through Leviathan-10 wells, 30 days for drillng the Leviathan-3 sidetrack, and 40 days for each well completion.

Supply Vessels. The drilling program will be supported by two MMC 87 Class platform supply vessels operating out of the port of Haifa (see **Section 3.2.3**). Each supply vessel is expected to make three round trips per week between Haifa and the drilling rig(s). 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 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 drilling rigs.

Helicopter. A Bell 412SP will make one round trip per week between Haifa and the drilling rig(s). Received SPLs (in water) from aircrafts flying at altitudes of 152 m (500 ft) were 109 dB re 1 µPa for a Bell 212 helicopter, with an estimated source level of 149 dB re 1 µPa (Richardson et al., 1995). 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 drilling rigs.

4.5.2 Potential 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; 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.

4.5.2.1 *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 supply vessels are expected to be in the range of 170 to 180 dB_{rms} re 1 µPa (see **Section 3.4.1**). 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 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 (2013) has proposed draft criteria for the onset of two types of auditory impacts: permanent threshold shift (PTS) and temporary threshold shift (TTS). Dual criteria were proposed based on peak SPL and cumulative sound exposure level (**Table 4-11**). 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 drilling rig or supply vessels.

Table 4–11. 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, 2013).

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 – 30 kHz)	Fin whale Minke whale Humpback whale	230 dB_{peak} and 198 dB SEL_{cum}	224 dB_{peak} and 178 dB SEL_{cum}
Mid-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	230 dB_{peak} and 198 dB SEL_{cum}	224 dB_{peak} and 178 dB SEL_{cum}
High-frequency cetaceans (200 Hz – 180 kHz)	Dwarf sperm whale[b] Harbor porpoise[b]	201 dB_{peak} and 180 dB SEL_{cum}	195 dB_{peak} and 160 dB SEL_{cum}
Pinnipeds in water (75 Hz – 100 kHz)	Mediterranean monk seal[b]	235 dB_{peak} and 197 dB SEL_{cum}	229 dB_{peak} and 183 dB SEL_{cum}

[a] Dual acoustic threshold levels: Use whichever level [dB_{peak} or dB SEL_{cum}] is exceeded first. All SEL_{cum} acoustic threshold levels (re 1 μPa^2-s) are weighted.

[b] Indicates vagrant species whose presence is in the Levantine Basin is not confirmed (see **Section 1.6.2**).

4.5.2.2 *Potential Impacts: Behavioral Responses*

Low-frequency noise from drilling rigs and 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 are most odontocetes (toothed whales and dolphins), which have their best hearing in high frequencies.

The NMFS has historically used a criterion of 120 dB_{rms} re 1 µPa as a threshold 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 vessel may be exposed to sound levels sufficient to elicit behavioral responses (**Table 4-12**). 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 4-12. Sound sources associated with the Leviathan Field drilling program and calculated distances to the current U.S. National Marine Fisheries Service criterion for behavioral response to continuous sources.

Sound Source	Source Levels (dB_{rms} re 1 μPa at 1 m)	Criterion for Behavioral Response (dB_{rms} re 1 μPa)	Calculated Distance to Threshold (m)[a]
Drillship	177	120	708
Supply vessels	170-180	120	316-1,000

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

The NMFS 120-dB criterion 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 drilling rig and supply vessels 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.

4.5.2.3 Potential Impacts: Masking

Masking refers to obscuring of 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 drilling rig and supply vessels 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.

4.5.3 Potential 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 1.6.2.2**). 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).

Recently, 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 4-13**.

Table 4-13. 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 (hundred 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

Based on the table, sea turtles more than a few hundred meters from the drilling rig 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 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.

4.5.4 Potential 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).

Recently, 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 4-14**.

Table 4-14. 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 drilling rig 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 drilling rigs 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.

4.5.5 Mitigation Measures

There are no planned mitigation measures to reduce underwater noise. Drilling rig and support 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. 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 556 days).

4.5.6 Impact Significance

Impact significance for noise is summarized in **Table 4-15**. 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 4–15. Summary of potential impacts from underwater noise.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Noise from drilling rigs, 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

4.6 NATURE AND ECOLOGY

4.6.1 Impacts of Seafloor Disturbance

4.6.1.1 Impacts on Sediment Quality and Benthic Communities

Because a DP drillship or DP semisubmersible will be used, there will be no anchoring. DP drilling rigs 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 1.6.1**, only soft bottom benthic communities are present at and near the wellsites, 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 benthic communities are evaluated as negligible.

4.6.1.2 Mitigation Measures

No mitigation measures are recommended for seafloor disturbance due to the small area affected and the unavoidable nature of the impact. Noble Energy will conduct a post-drilling ROV survey/inspection at each drillsite 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.

4.6.1.3 Impact Significance

Impact significance for seafloor disturbance is summarized in **Table 4-16**. The consequence of potential impacts to sediment quality and benthic communities is insignificant (1) due to the small area affected around each drillsite. In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drilling rig (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 4–16. 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 wellsite	None	3	1	3 Low

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

4.6.2 Impacts of Drilling Discharges

4.6.2.1 Discharge Characteristics

Drilling discharge quantities and components have been summarized in **Section 3.7.2**. Noble Energy plans to drill the new Leviathan Field wells (Leviathan-5 through Leviathan-10) using a combination of WBM and MOBM. The Leviathan-3 sidetrack well (Leviathan-3 ST02) will be drilled with WBM only. The Leviathan-4 ST01 well will be completed but will not require additional drilling muds.

For the Leviathan-5 through Leviathan-10 wells, the first two initial well intervals (before the marine riser is set) would be drilled using a water-based "spud mud," and the cuttings and WBM, 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 drilling rig, the remaining well intervals would be drilled with MOBM. Cuttings from MOBM well intervals will be treated in a TCC onboard the drilling rig to reduce the MOBM retention on cuttings to less than 1% by dry weight in accordance with the effluent limitations currently used in the North Sea/OSPAR region (OSPAR Decision 2000/3). The cuttings with retained MOBM would be released below the sea surface, subject to MoEP approval.

[redacted]

4.6.2.2 Modeling of Discharge Fate

Drilling discharges were modeled by ASA using the Leviathan-9 drillsite as a representative location. The modeling was conducted using the MUDMAP 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 Noble Energy for MOBM well cuttings treated in a TCC unit (see **Section 2.3.3.2**). Two seasonal scenarios were modeled: winter (December to February), and summer (July to September). 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 4-17** and **4-18**.

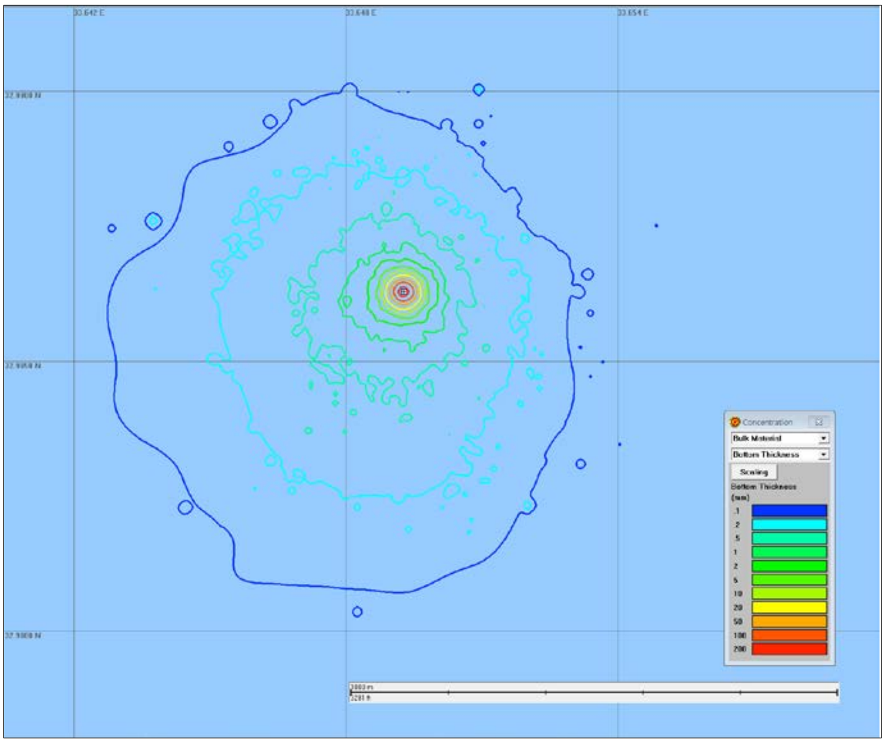


Figure 4-5. Cumulative deposition thickness for drilling discharges from the Leviathan-9 drillsite for the winter (December to February) scenario.

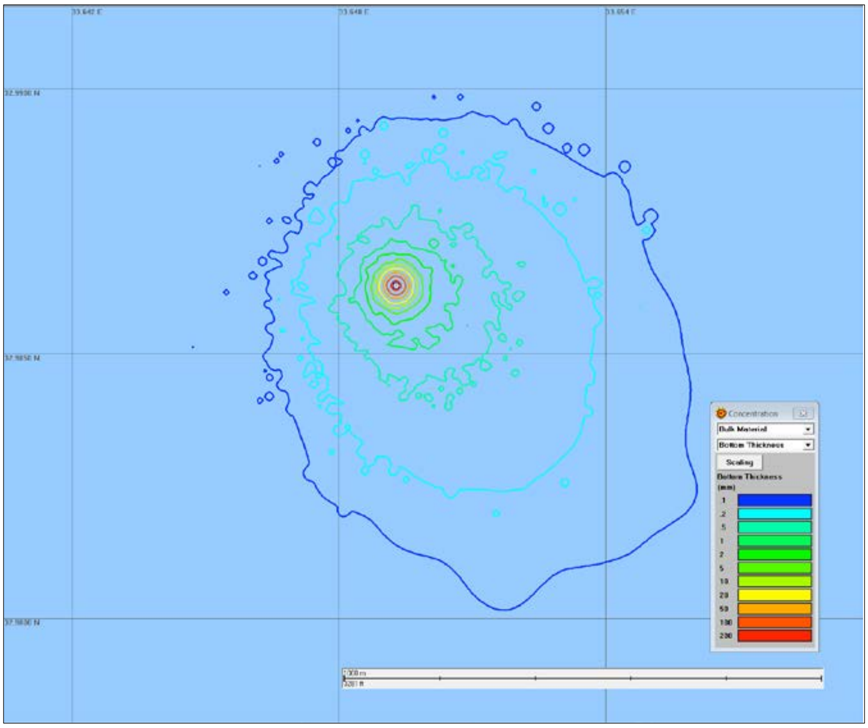


Figure 4-6. Cumulative deposition thickness for drilling discharges from the Leviathan-9 drillsite for the summer (July to September) scenario.

Table 4-17. Areal extent of seafloor deposition of drilling discharges for two seasonal scenarios at the Leviathan-9 drillsite. Burial thresholds from Smit et al. (2008) are in bold.

Deposition Thickness (mm)	Area (km^2)	
	Scenario 1 – Winter (December to February)	Scenario 2 – Summer (July to September)
≥0.1	0.7309	0.6913
≥0.2	0.3316	0.3365
≥0.5	0.0951	0.0958
≥1	0.0327	0.0348
≥2	0.0159	0.0158
≥5	0.0090	0.0092
≥6.3	**0.0079**	**0.0080**
≥10	0.0060	0.0061
≥20	0.0041	0.0041
≥50	0.0023	0.0023
≥54	**0.0021**	**0.0021**
≥100	0.0012	0.0012
≥200	0.0003	0.0003

Table 4-18. Maximum extent of thickness contours resulting from drilling discharges for two seasonal scenarios at the Leviathan-9 drillsite. Burial thresholds from Smit et al. (2008) are in bold.

Deposition Thickness (mm)	Maximum Extent from Discharge Point (m)	
	Scenario 1 – Winter (December to February)	Scenario 2 – Summer (July to September)
≥0.1	676	775
≥1	136	149
≥6.3	**54**	**55**
≥10	45	47
≥54	**27**	**27**
≥100	20	21
≥200	11	11

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

- In both scenarios, drilling discharges are transported in a concentric pattern around the drillsite.

- 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 limited to 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.

To aid in the interpretation of the modeling results, the tables include burial thresholds proposed by Smit et al. (2008) for benthic organisms:

- 54 mm is the median burial thickness affecting 50% of benthic species tested. The modeling predicts that deposits exceeding this thickness would be limited to 27 m from the discharge point.

- 6.3 mm is the burial thickness affecting 5% of benthic species. This thickness essentially can be considered a predicted no effect concentration (PNEC) because only a small percentage of species would be affected by such a thin layer. The modeling predicts that deposits exceeding this thickness would be limited to 54 to 55 m from the discharge point.

4.6.2.3 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).

During the subsequent well intervals using MOBM, the drill cuttings with small quantities of adhering MOBM (less than1% by weight) will be discharged from the drilling rigs, pending MNIEWR approval. It is expected that the cuttings discharges will produce a visible plume that will move with the currents as these materials are diluted and settle to the seafloor. In general, turbid water may extend between a few hundred meters and several kilometers down-current from the discharge point and to persist for several hours after each discharge. Studies have demonstrated reductions in water clarity within a few hundred meters to approximately 2 km of drilling rigs during drilling fluid discharges; dispersion to background levels typically requires several minutes to several hours (Neff, 1987).

Suspended cuttings in the water column could affect plankton and pelagic organisms, mainly due to the physical stress of particles rather than toxicity (Bakke et al., 2013). However, the levels of suspended cuttings causing effects typically are above 0.5 mg/L (Bakke et al., 2013) and such levels are typically restricted to a radius of less than 1 to 2 km from the discharge point. Paulsen et al. (2003) modeled the potential water column impacts of TCC-treated cuttings and calculated the area where the predicted environmental concentration (PEC) of cuttings in the water column would exceed the PNEC. The volume of seawater where PEC/PNEC exceeded 1.0 was 7,800,000 m^3 for TCC-treated cuttings and 15,300,000 km^2 for WBM cuttings. To put this in perspective, a volume of 7,800,000 m^3 would be equivalent to the volume within the top 100 m of the water column within a radius of 178 m.

A risk assessment for TCC-treated cuttings was conducted by Aquateam COWI AS (2014). With regard to water column impacts, they concluded that 1) the environmental risk associated with discharges of TCC-treated cuttings will correspond to that of WBM cuttings; 2) the levels of oil, PAH and metals in treated OBM cuttings are expected to be similar to those in WBM cuttings; 3) chemical pollution is expected to have a negligible effect on pelagic organisms; and 4) no effects are expected in the water column.

In conclusion, cuttings discharges from the drilling rigs will produce intermittent turbidity in the water column but are expected to have little or no impact on plankton or fish due to the low toxicity of the proposed MOBM system, the low percentage of MOBM retained on cuttings (1% or less), and the expected rapid sinking of the cuttings through the water column.

4.6.2.4 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).

During the subsequent well intervals using MOBM, drill cuttings with small quantities of adhering MOBM will be discharged from the drilling rigs, pending MNIEWR approval. The cuttings will sink through the water column and be deposited on the seafloor. The modeling predicts that deposition will occur in all directions around the drillsite, 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 4-18**).

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/injest 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 wellsites 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 drillsites. 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 risk assessment of TCC-treated cuttings was conducted by Aquateam COWI AS (2014). With regard to benthic organisms, they concluded that 1) the environmental risk associated with discharges of TCC-treated cuttings will correspond to that of WBM cuttings; 2) the levels of oil, PAH and metals in treated OBM cuttings are expected to be similar to those in WBM cuttings; and 3) chemical pollution is expected to have a negligible effect on benthic organisms. The main concern is smothering of benthic organisms.

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 MUDMAP model predicts that deposition having a thickness of 6.3 mm or more would affect approximately 0.008 km^2 around each drillsite 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 six new wells (Leviathan-5 through Leviathan-10) would be 0.048 km^2, or approximately 0.010% 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 MUDMAP model predicts that deposition having a thickness of 54 mm or more would affect approximately 0.002 km^2 around each drillsite under either scenario and would extend approximately 27 m from the discharge point. The total area receiving this thickness of deposition from the six new wells (Leviathan-5 through Leviathan-10) would be 0.012 km^2, or approximately 0.002% of the seafloor area in the Leviathan Field blocks (500 km^2).

The benthic communities around all of the proposed wellsites 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.

4.6.2.5 Mitigation Measures

The following mitigation measures are included in Noble Energy's plan:

- Low-toxicity drilling fluids have been selected [redacted] According to the SDS (**Appendix H**), the base fluid is readily biodegradable and not expected to be harmful or exhibit chronic toxicity to marine organisms.

- Cuttings from MOBM well intervals will be treated in a TCC onboard the drilling rig to reduce the MOBM retention on cuttings to less than 1% by dry weight in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3). Specifications for the TCC are provided in **Appendix I**. The low levels of MOBM retention on cuttings will reduce the potential for toxicity of MOBM components as well as anoxia due to organic enrichment of seafloor sediments.

- A background monitoring survey has been conducted and confirms that there are no deepwater coral communities or other hard bottom communities near the proposed drillsites (**Appendix D**).

- Simulation modeling has been conducted to evaluate the potential deposition of cuttings on the seafloor around the drillsites (**Appendix K**). The modeling confirms that a relatively small area of seafloor around each wellsite will receive deposits sufficiently thick to cause burial or smothering of benthic organisms.

4.6.2.6 Impact Significance

The significance of impacts from drilling discharges is summarized in **Table 4-19**. 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 drilling rig (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 4–19. 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 of drilling rigs during discharges	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings	5	1	5 Mod
	Sediment quality	Deposition of cuttings particles on the seafloor, causing changes in grain size and mineralogy	• Use of TCC to minimize MOBM retention on cuttings	4	2	8 Mod
	Benthic communities	Localized burial and smothering of benthic organisms. Burial impacts are most likely within 61 to 65 m of drillsites. Anoxia and other benthic impacts may occur due to adhering MOBM and changes in sediment grain size.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings • Background monitoring survey conducted to verify there are no deepwater coral or other hard bottom communities present	4	2	8 Mod

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

4.6.3 Impacts of Other Discharges

Routine discharges from each drilling rig (exclusive of drilling muds and cuttings), will include sanitary waste, gray water, organic (food) waste, cooling water, desalination brine, and deck drainage (see **Section 3.7.3**). 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). Specific treatment processes are detailed in the **Section 3.7.3** for individual waste streams.

4.6.3.1 Impacts on Water Quality and Fishes

Sanitary and gray water as well as organic food waste from the drilling rigs 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. Gray water will be discharged without treatment while food waste will be macerated to pass through a 25-mm mesh in accordance with MARPOL requirements. These discharges are expected to be diluted rapidly in the open sea (BOEM, 2012). 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 any added chemicals or contaminants. 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 drilling rig 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) (IPIECA and International Association of Oil & Gas Producers [OGP], 2010; IMO, 2004). The introductions can occur when drilling rigs 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 (IPIECA and OGP, 2010; Lovell and Stone, 2005). Noble Energy will operate in accordance with the guidelines developed by IPIECA and OGP (2010), 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 drilling rigs 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 drilling rigs are unlikely to reach Israeli coastal waters.

4.6.3.2 Mitigation Measures

The drilling rigs will comply with MARPOL Annex I (oil pollution prevention), Annex IV (sewage pollution prevention), and Annex V (garbage pollution prevention). Specific treatment processes are detailed in the **Section 3.7.3** for individual waste streams and summarized briefly here:

- Sanitary waste will pass through an IMO-approved sewage treatment plant prior to discharge.
- Gray 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 gray water and discharged overboard more than 12 nmi from shore.
- Cooling water, desalination brine, and deck drainage from non-machinery areas will be discharged without treatment as these effluents do not contain any added chemicals or contaminants.
- 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.
- Noble Energy will operate in accordance with the guidelines developed by IPIECA and OGP (2010) to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. The drilling rigs will have a Ballast Water Management Plan and be equipped with an IMO-approved ballast water management system to minimize the risk of introducing AIS.

4.6.3.3 *Impact Significance*

Potential impacts of other discharges are summarized in **Table 4-20**. The consequence of potential impacts is insignificant (1). In evaluating likelihood for impacts, a 100-m mixing zone was assumed around the drilling rig (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 4–20. 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 gray water, food waste, cooling water, desalination brine, deck drainage)	Water quality; fishes	Localized, transient impacts on water quality within a few meters to a few hundred meters of drilling rigs	• Compliance with MARPOL requirements	3	1	3 Low
Other discharges (ballast water)	Fishes; benthic communities	Potential introduction of AIS in ballast water	• Noble Energy will operate in accordance with guidelines developed by IPIECA and OGP (2010) to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. Drilling rigs 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 drilling rig (i.e., it refers to the likelihood of impacts occurring beyond this radius).

4.6.4 Impacts of Vessel Traffic

Vessel traffic during the drilling program will include routine supply vessel trips between the shore base in Haifa and the drilling rigs. The drilling program will be supported by two MMC 87 Class platform supply vessels as explained in **Section 3.2.3**. Each supply vessel is expected to make three round trips per week. Supply vessels may disturb marine mammals or turtles, and there is a small possibility of a vessel striking a marine mammal or sea turtle. The risk is similar to that from existing ship traffic in the region.

The movements of the drilling rigs, including initial mobilization, movements between drillsites, 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.

4.6.4.1 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). The two MMC 87 Class platform supply vessels for this program are at the low end of this range, with an overall length of 87 m and a design speed (maximum continuous rating) of 14 knots.

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 tug boats. There were also instances in which sperm whales approached vessels too closely and were injured by propellers (NMFS, 2010).

4.6.4.2 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 marine mammal or 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.

4.6.4.3 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 drillsites 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.

4.6.4.4 Impact Significance

Potential impacts of support vessel traffic on marine mammals and sea turtles are summarized in **Table 4-21**. 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 4–21. 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

4.6.5 Impacts of Helicopter Traffic

Helicopter support will be provided by a Bell 412SP operated from Haifa Airport as explained in **Section 3.2.3**. The helicopter will make one round trip per week between Haifa and the drilling rig(s).

Corporate policies for helicopter companies typically require a minimum altitude of 210 m during transit to and from a drilling rig and a minimum altitude of approximately 150 m while traveling between rigs 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.

4.6.5.1 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 drilling rigs.

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.

4.6.5.2 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.

4.6.5.3 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.

4.6.5.4 Impact Significance

Potential impacts of helicopter traffic on marine mammals, sea turtles, and seabirds and migratory birds are summarized in **Table 4-22**. The likelihood of the aspect is rated possible (3); although the 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 4–22. 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

4.6.6 Impacts of Marine Debris

Noble Energy'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 drilling rig operator's Garbage Management Plan as required by MARPOL Annex V and the additional waste managements requirements set by Noble Energy. Potential impacts of marine debris are discussed in the following subsections, and additional impact considerations for waster are analyzed in **Section 4.9**.

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

Debris accidently 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 may have a minor, localized impact on sediment quality beneath the rig 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; National Ocean Service, 2013). The potential impacts on water quality from marine debris are expected to be similar to those from the existing shipping and fishing industries.

4.6.6.2 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.

4.6.6.3 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.

4.6.6.4 Mitigation Measures

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

4.6.6.5 Impact Significance

Potential impacts of marine debris on marine mammals, sea turtles, and seabirds and migratory birds are summarized in **Table 4-23**. 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 4–23. 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	• Rig operator's Garbage Management Plan and the additional requirements set by Noble Energy 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 and migratory birds	Potential entanglement, ingestion	• Rig operator's Garbage Management Plan and the additional requirements set by Noble Energy will minimize the potential for accidental loss of items overboard	2-3	1	2-3 Low

4.7 CULTURE AND HERITAGE SITES

As explained in **Section 1.8**, Noble Energy contracted GEMS to conduct an archaeological assessment in the Leviathan Field. Of 397 unidentified sonar contacts, 38 were interpreted to represent possible cultural resources with potential archaeological significance. GEMS recommended a 305-m archaeological avoidance zone for possible wreck sites. A 31-m archaeological avoidance zone was recommended for other contacts, which may represent associated debris from the wreck sites. Noble Energy will implement the recommended avoidance zones to avoid damaging archaeological resources as instructed by United States Department of the Interior - Minerals

Management Service - Gulf of Mexico Region NTL No. 2005-G07. The actual distances from the proposed drillsites to the nearest sonar contacts are more than 305 m, ranging from 3.0 to 5.4 km.

4.7.1 Impacts of Seafloor Disturbance

All potential impacts of seafloor-disturbing activities are expected to be avoided. Because a DP drillship or DP semisubmersible will be used, there will be no anchoring. All of the new drillsites (Leviathan-5 through Leviathan-10) are beyond the recommended avoidance zones, with a minimum distance of at least 3.0 km from the nearest sonar contact. The other two drillsites (Leviathan-3 and Leviathan-4) are existing wells that will be reentered with little or no additional seafloor disturbance; these are 3.3 km and 5.2 km, respectively, from the nearest sonar contact.

4.7.2 Impacts of Drilling Discharges

No significant impacts are expected from drilling discharges. Simulation modeling of drilling discharges is presented in **Appendix K**, and the results are summarized in **Section 4.6.2**. The modeling predicts that thicknesses of 1 mm or greater would be limited to distances of 279 to 290 m from the drillsite, and thicknesses of 0.1 mm or greater would be limited to distances of 1,070 to 1,100 m from the drillsite. Because all of the drillsites are at least 3.0 km from the nearest sonar contact, no significant deposition is expected.

4.7.3 Impacts of Accidental Spills

Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a blowout (see **Section 4.3**). 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 drilling rig at the sea surface in a water depth of 1,540 to 1,800 m. Spilled fuel will float and disperse at the sea surface and will not contact wreck sites on the seafloor.

A condensate spill from a blowout could result in physical disturbance around the wellsite. BOEM (2012) estimated that a seafloor blowout could physically disturb a radius of approximately 300 m around a wellsite. Because all of the drillsites are at least 3.0 km from the nearest sonar contact, no impacts are expected. 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 4.3**, 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, Noble Energy'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.

4.7.4 Mitigation Measures

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

- An archaeological assessment has been conducted by GEMS as discussed in **Section 1.8**. Noble Energy 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. The actual distances from the proposed drillsites to the nearest sonar contacts are more than 305 m, ranging from 3.0 to 5.4 km.

- During routine operations, should any object be determined to likely represent an antiquity, Israel's Antiquities Authority 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, Noble Energy'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.

4.7.5 Impact Significance

Impact significance for culture and heritage sites is summarized in **Table 4-24**. 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 4-24. 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	• 305-m avoidance zone for potential wreck sites and 31-m avoidance zone for other sonar contacts (actual distances are more than 3.0 km away)	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 (actual distances are more than 3.0 km away)	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 (actual distances are more than 3.0 km away) • Oil spill response will prioritize protection of archaeological sites if a spill reached the shoreline	2	2	4 Low

4.8 AIR QUALITY

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

Section 4.8.1 of the Guidelines requires that the impact of the Application on generation of the secondary pollutant ozone (O_3) must be assessed via a photochemical model. For this purpose, Noble Energy has provided emissions files from all of the sources of emissions of the ozone generating pollutants to the Air Quality Division at the Ministry of Environmental Protection, which has an appropriate model.

4.8.1 Impacts of Air Emissions

Sources of air pollutant emissions during the project include engines onboard the drilling rigs, support vessels, and helicopters, as well as flaring of hydrocarbons during production testing. Impacts from production testing have been analyzed separately in **Section 4.2**. The following analysis focuses on emissions from drilling rig, support vessel, and helicopter engines.

Engines on the drilling rigs, support vessels, and helicopters will produce emissions including CO, NO_x, SO_x, VOCs, and PM, as well as GHGs such as CO_2 and CH_4. In **Section 3.5**, emissions were estimated using a worksheet developed by BOEM (2014a) based on USEPA AP-42 emission factors. Because specific drilling rigs have not been selected, the emission factors for a generic DP drillship were used, as provided by BOEM (2014b). The emission factors were used to calculate a single emissions estimate for each drilling rig. Supply vessel calculations were based on the engine specifications for MMC 87 Class vessels. Helicopter calculations were based on published emissions estimates for a Bell 412 helicopter (Rindlisbacher, 2009). **Table 4-25** summarizes the estimated total emissions for drilling rigs and support vessels during drilling and completion of the eight initial wells. Helicopter emissions are considered negligible (less than 1 metric tonne for each of the pollutants estimated; see **Section 3.5.3**) and are omitted from the table.

Table 4–25. Total estimated air pollutant emissions from two drilling rigs and two supply vessels during drilling and completion of the eight initial wells.

Source	Operating Days	Total Estimated Emissions (metric tonnes)							
		CO	NO_x	SO_x	VOCs	PM	CO_2	CH_4	GHGs
Drilling Rig #1	480	1,707.11	7,824.27	1,044.18	234.73	227.62	374,284.47	21.34	374,732.59
Drilling Rig #2	320	1,138.08	5,216.18	696.12	156.49	151.74	249,522.98	14.23	249,821.73
Subtotal Drilling Rigs		2,845.19	13,040.45	1,740.30	391.22	379.36	623,807.45	35.57	624,554.32
Supply Vessel #1	240	67.74	310.46	41.43	9.31	9.03	14,851.25	0.85	14,869.03
Supply Vessel #2	240	67.74	310.46	41.43	9.31	9.03	14,851.25	0.85	14,869.03
Subtotal Supply Vessels		135.47	620.92	82.86	18.62	18.06	29,702.50	1.70	29,738.06
Total		**2,980.66**	**13,661.37**	**1,823.16**	**409.84**	**397.42**	**653,509.95**	**37.27**	**654,292.38**

CO = carbon monoxide; CO_2 = carbon dioxide; CH_4 = methane; GHG = greenhouse gas; NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compound.
Emissions were calculated using the U.S. Bureau of Ocean Energy Management (2014a) air emissions worksheet as discussed in **Section 3.5**.

Regional Significance of Estimated Emissions. The magnitude of estimated emissions from the drilling rigs and supply vessel is negligible in comparison with regional emissions from shipping in the Mediterranean (**Table 4-26**). The total emissions estimate is less than 1% of the annual shipping emissions for each pollutant.

Table 4-26. Comparison of total estimated emissions from drilling rigs and support vessels during drilling and completion of the eight initial wells with annual emissions from Mediterranean shipping.

Source	Annualized Total Emissions (metric tonnes/year)				
	CO_2	NO_x	SO_2	VOCs	PM
Drilling rigs and support vessels	2,980.66	13,661.37	1,823.16	409.84	397.42
Mediterranean shipping industry (2005)[a]	64,936,000	1,447,000	863,000	54,000	98,000
Drilling rigs and support vessel emissions as percentage of annual Mediterranean shipping industry emissions	0.004	0.944	0.211	0.759	0.405

CO_2 = carbon dioxide; NO_x = nitrogen oxides; PM = particulate matter; SO_2 = sulfur dioxide; VOC = volatile organic compound.
[a] Total emissions from shipping (at sea, maneuvering and at berth) in the Mediterranean Sea in 2005 (Entec UK, 2007).

Conclusion. Air pollutant emissions from engines on the drilling rigs will produce localized, transient impacts on air quality near the drilling rig. The total time for drilling and completing all of the wells is estimated to be 556 days (see **Section 3.2.4**). Drilling operations by the first drilling rig will require an estimated 480 days. The completion operations by the second drilling rig will require an estimated 320 days. There will be a period of approximately 236 days during which both drilling rigs will be operating in the Leviathan Field. Although emissions will be occurring over a long period, the annual emission rates represent a small percentage of the emissions from shipping in the Mediterranean. Due to the distance of the drillsites from shore (greater than 120 km), no impacts on coastal air quality are expected.

4.8.2 Impacts of Accidental Spills

Spill scenarios are described in **Section 4.3**. Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a blowout. The fuel spill scenario assumed an instantaneous release of 8,415.6 m^3 from the drilling rig. The condensate spill scenario assumed a blowout resulting in the release of [redacted] 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. 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.

4.8.3 Mitigation Measures

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

- All drilling rig and support vessel engines, generators, and other emission sources will be operated and maintained in accordance with manufacturers' recommendations to avoid excessive emissions.

- The drilling rigs 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 drilling vessels will meet the requirements of Regulations 14 and 18 of Annex VI of MARPOL 73/78.

- During production testing (flowback), a high-efficiency, smokeless burner will be used to ensure complete combustion and minimize the potential for fallout of oil droplets into the water.

- 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.

4.8.4 Impact Significance

Impact significance for air quality is summarized in **Table 4-27**. For routine air emissions from the drilling rigs, support vessels, and helicopters, as well as air emissions from flaring during production testing, the consequence of impacts is rated as insignificant (1). In evaluating likelihood for air quality impacts, a 100-m mixing zone was assumed around each source (i.e., it is referring to the likelihood of air quality impacts occurring beyond the mixing zone). 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 4-27. Summary of potential impacts on air quality.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Air emissions (drilling rig)	Air quality	Localized, transient elevations in air pollutant concentrations near drilling rig; 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 (support vessels and helicopters)	Air quality	Localized, transient elevations in air pollutant concentrations along 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 drilling rig; 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 drilling rig (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 • Drilling rig Shipboard Oil Pollution Emergency Plan • Oil Spill Contingency Plan	2	2	4 Low
Accidental spills: Condensate spill from a blowout ([redacted] 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 drilling rig (i.e., it is referring to the likelihood of impacts occurring beyond this radius).

4.9 WASTE

Waste management for the well drilling and completion program is described in **Section 3.8**. All wastes will be handled and disposed according to MARPOL requirements and permit requirements. 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 disposal sites onshore in accordance with the regulations. Waste storage areas will be designated on the drilling rigs 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 program are expected to be negligible relative to the available services and landfill capacity in Israel.

4.10 HAZARDOUS MATERIALS

Drilling and completion activities will include the use of hazardous materials including MOBM and additives; the chemicals and quantities to be used per well are summarized in **Section 3.7.2**. All hazardous materials will be handled in accordance with their SDS-specified guidelines (**Appendix H**), as integrated into the drilling rig operator's guidelines for handling hazardous materials. 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 drilling rigs 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.

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

In the event that H_2S is encountered in the Leviathan Field, 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 rig. H_2S scavenger will be available on the rig 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 drilling rig. The Control Room Operator and supervisory personnel will be alerted should the presence of H_2S be detected. The drilling rig contractor has procedures for responding to an H_2S alarm on the drilling rig, including instructions to crew members in the event of an alarm.

4.11 MEASURES FOR REDUCTION OF GEOLOGICAL AND SEISMIC RISKS

Noble Energy has considered seismic risk (including potential earthquakes) in developing the proposed drilling and completion program. The design and engineering of the wells takes into account any identified seismic risk as well as seafloor and shallow geohazards.

Regional seismicity is discussed in **Section 1.4.5**. 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 drillsites.

Noble Energy's Emergency Response Plan will deal specifically with the actions to be taken in the event of emergencies including earthquakes. Noble Energy will also require the drilling rig 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 drilling rig contractor's offshore installation manager, is in overall command. The drilling rig contractor's Emergency Response Plan and procedures must be applied to manage wellsite emergency situations to ensure safe evacuation, escape, and rescue of wellsite personnel. The maintenance and safe operation of evacuation and escape equipment is the responsibility of the drilling rig contractor. Noble Energy and the drilling rig 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 Noble Energy's OSCP. The potential impacts of accidental events including a fuel spill and condensate spill from a well blowout are evaluated in **Section 4.3**.

4.12 FISHING ACTIVITIES AND MARINE FARMING

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 within 30 km from the Application area (see **Section 1.12**). Due to the water depth and the distance from coastal fishing and marine farming areas, no impacts are expected from routine drilling and completion activities.

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

4.12.1 Impacts of Physical Presence and Safety Zone

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

4.12.2 Impacts of Support Vessel Traffic

The drilling program will be supported by two MMC 87 Class platform supply vessels operating out of the port of Haifa (specifications are provided in **Appendix J**). Each supply vessel is expected to make three round trips per week between Haifa and the drilling rig(s). The vessels will normally follow the most direct route between the shore base and the drilling rigs, weather permitting. As discussed in **Section 1.11** and shown in **Figure 1-3**, 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.

4.12.3 Impacts of Accidental Spills

Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a blowout (see **Section 4.3.1**). 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 (see **Sections 1.6.3** and **1.12**).

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. As discussed in **Section 1.12**, 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.

Three open water fish farms are identified in **Section 1.12**. From north to south, they are: 1) 1.6 nmi west of Michmoret; 2) approximately 5 nmi west of Palmachim; and 3) inside Ashdod port. The Michmoret location is within the range of potential contacts for typical winter conditions and typical autumn conditions for either a fuel spill or condensate spill. The Palmachim location is predicted to be contacted by a fuel spill under typical winter conditions or condensate spill under typical winter and typical autumn conditions. The Ashdod location is within the range of shoreline impacts for a condensate spill under typical autumn conditions and for a diesel fuel under typical winter conditions.

4.12.4 Mitigation Measures

Prior to commencing the Leviathan Field drilling and completion program, Noble Energy will issue a Notice to Mariners to inform fishing vessels and other vessel operators of planned vessel movements and the buffer zone around the drilling rigs.

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. Noble Energy'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.

4.12.5 Impact Significance

Impact significance for fishing activities and marine farming is summarized in **Table 4-28**. Impacts on fishing activities due to the physical presence of the drilling rigs and safety 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 activities and marine farming.

Aspect	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Physical presence and safety zone	Fishing activities	Exclusion of fishing vessels from 500-m buffer zone around drilling rig(s)	• 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 drilling rig(s)	• 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 blowout)	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

4.13 SAFETY AND PROTECTION ZONES

Consistent with international industry practice, Noble Energy will establish a 500-m radius safety zone around the drilling rigs, 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 safety zone. A standby vessel (e.g., a supply vessel) supporting the drilling will keep watch also and will be used to enforce the safety zone, intervening if any vessel makes a close approach.

The resources potentially affected by the safety zone are marine transportation system and infrastructure. Potential impacts on fishing activities have been discussed in **Section 4.12**.

4.13.1 Impacts on Marine Transportation System and Infrastructure

As discussed in **Section 1.11** and shown in **Figure 1-3**, 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.

4.13.2 Mitigation Measures

Noble Energy proposes the following measures regarding safety and protection zones, consistent with international industry practice:

- Noble Energy will establish a 500-m radius safety zone around the drilling rigs, 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 safety zone. A standby vessel (e.g., a supply vessel) supporting the drilling will keep watch also and will be used to enforce the safety zone, intervening if any vessel makes a close approach.

- Navigational markings onboard both the drilling rigs 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, Noble Energy will consult with Haifa port authorities and provide Notice to Mariners to inform the public of planned vessel movements and the safety zone around the drilling rigs.

- Noble Energy 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 drillsites and the shore base.

4.13.3 Impact Significance

Impact significance for safety and protection zones is summarized in **Table 4-29**. Impacts on marine transportation and infrastructure due to the physical presence of the drilling rigs and safety zone are considered unlikely (2) and the consequence is rated insignificant (1), with a residual risk of Low.

Table 4-29. 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 drilling rig(s)	• Provide Notice to Mariners in advance of proposed activities • Use standard navigation markings	2	1	2 Low

4.14 MONITORING AND CONTROL PROGRAM

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

4.14.1 Environmental Monitoring

Noble Energy conducted a Background Monitoring Survey of the marine environment as required by the "Framework Guidelines for Preparation of a Background Monitoring Plan for the Marine Environment Accompanying a License for Exploration Purposes – Exploratory (Experimental) Drilling and Offshore Production. The survey report is provided in **Appendix D**.

Noble Energy will conduct a post-drilling environmental monitoring in the Leviathan Field. The post-drilling survey will include sampling of seawater, sediments, and infauna. The survey will use the same sampling grid, sampling methods, analytes, and analytical methodologies used in the Background Monitoring Survey (**Appendix D**). Reporting of results will include comparison of baseline and post-drilling survey results.

The following additional environmental monitoring is planned:

- Noble Energy is currently conducting current and wave monitoring at current meter moorings in the Leviathan Field as summarized in **Section 1.5**. This monitoring is expected to continue.
- Noble Energy will visually monitor waters in the vicinity of the drilling rigs 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 drilling rig or support vessel.
- Noble Energy will conduct post-drilling ROV surveys to ensure that the seafloor around each drillsite is clear of equipment and debris.

4.14.2 Discharge Monitoring

Discharge monitoring includes the following elements:

- Monitoring of drilling discharges will be conducted as part of daily monitoring activities on the drilling rig. This includes the testing of drilling muds and associated chemicals, and periodic toxicity testing of drilling muds during drilling in accordance with discharge permit requirements. The well-specific monitoring will be identified in a drilling fluid monitoring program. Further information about monitoring of drilling discharges, including a table listing analytes and methodologies, is presented in **Section 3.7.2.5**.
- Noble Energy will conduct a performance assessment at least once during the drilling of each well to confirm compliance with that the discharge monitoring and reporting requirements on the drilling rigs. 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 drilling rig(s) and per the Offshore Discharge Program that will be prepared.

4.14.3 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:

- Noble Energy 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.
- Noble Energy will conduct performance assessments for each drilling rig used in the Leviathan Field 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 assessments will be reviewed and updated annually.
- Noble Energy will conduct a performance assessment to confirm that a Notice to Mariners was issued and support vessels were instructed to monitor and enforce the safety zone.
- Waste management will be evaluated during a performance assessment on the drilling rigs 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.

4.14.4 Marine Environment Background Monitoring Plan

As explained in **Section 4.14.1**, Noble Energy will conduct post-drilling environmental monitoring in the Leviathan Field. A separate Marine Environment Background Monitoring Plan is not presented. However, the post-drilling survey will include sampling of seawater, sediments, and infauna and will use the same sampling grid, sampling methods, analytes, and analytical methodologies used in the Background Monitoring Survey (**Appendix D**). Reporting of results will include comparison of baseline and post-drilling survey results.

4.15 WELL CLOSURE (TEMPORARY ABANDONMENT)

After each new well is drilled, it will be temporarily abandoned and secured with multiple barriers pending completion operations by the second drilling rig. Temporary abandonment will be conducted in accordance with MNIEWR guidelines for "Abandonment of Offshore Oil and Gas Wells." The MNIEWR guidelines are based on sections 30 CFR§250.1710-1722 and 250.1740-1742 of the U.S. regulations and on the API BULL E3 standard. Specific details of temporary well abandonment are outlined in **Section 3.9**, including a wellbore sketch.

Temporary well abandonment is not expected to produce any additional impacts. The impacts of drilling discharges have been analyzed in **Section 4.6.2**. Other aspects related to the presence and routine operation of a drilling rig have been analyzed previously, including light hazards (**Section 4.4**), noise (**Section 4.5**), air quality (**Section 4.8**), waste (**Section 4.9**), hazardous materials (**Section 4.10**), and drilling rig presence and safety zone (**Section 4.13**). Accidental events are discussed in **Section 4.3**.

Noble Energy will conduct a post-drilling ROV survey/inspection at each drillsite to ensure that the seafloor is clear of equipment and debris from drilling and completion activities.

The design life of production wells in the Leviathan Field is approximately 30 years. Near the end of this time, Noble Energy will evaluate the Israeli regulations in place pertinent to offshore wells and will propose abandonment plans that comply with existing regulations. Possible abandonment approaches include complete removal of the facility, cutting of the upper portions of the structure to eliminate navigational hazards, or toppling of the structure in place. Potential impacts will be evaluated at that time in accordance with Israeli regulations, based on the abandonment methodology selected by Noble Energy.

4.16 IMPACT SUMMARY

Table 4-32 summarizes the potential environmental impacts analyzed in this EIA. The table is organized by aspect (i.e., IPF) and consolidates information from the individual tables presented earlier in this chapter. Each impact is evaluated as having Low, Moderate, or High risk based on the risk matrix (**Table 4-2**), using the methods explained in **Section 4.1**.

4.16.1 High Risk Impacts

No High risk impacts were identified in the evaluation from routine activities or accidental events.

4.16.2 Moderate Risk Impacts from Routine Activities

Drilling discharges are the only aspect of routine activities identified as having Moderate risk impacts. Impacts of drilling discharges on water quality, fishes, sediment quality, and benthic communities were evaluated as Moderate risk. For impacts on water quality and fishes, the consequence was rated as insignificant (1) and the likelihood was rated almost certain (5). For impacts on sediments and benthic communities, the consequence was rated as minor (2) and the likelihood was rated likely (4). In evaluating likelihood, a 100-m mixing zone was assumed around the drilling rig (i.e., it refers to the likelihood of impacts occurring beyond this radius).

Drilling discharges will produce intermittent turbidity that could extend up to a few kilometers from each drillsite (see **Section 4.6.2.3**). Water quality impacts would be transient and would not persist for more than a few hours after the discharges cease. Suspended cuttings in the water column could affect fish, plankton, and other pelagic organisms, mainly due to the physical stress of particles rather than toxicity. However, any ecological impacts are expected to be insignificant due to the low toxicity of the proposed MOBM system, the low percentage of MOBM retained on cuttings (1% or less), and the rapid dispersal of the suspended cuttings particles in the water column.

Drilling discharges are likely to produce detectable, persistent impacts on the benthic environment in a small area around each drillsite. Assuming a PNEC threshold of 6.3 mm for burial of benthic organisms, the discharges are predicted to affect approximately 0.01 km^2 around each drillsite and would extend approximately 61 to 65 m from the discharge point (see **Section 4.6.2.4**). The total area receiving this thickness of deposition from the six new wells (Leviathan-5 through Leviathan-10) would be 0.048 km^2, or approximately 0.010% of the seafloor area in the Leviathan Field blocks (500 km^2). The benthic communities around all of the proposed drillsites are expected to consist of soft bottom organisms. The Background Monitoring Survey confirmed that there are no deepwater coral or other hard bottom communities present. Soft bottom areas buried by cuttings eventually will be recolonized through larval settlement and migration from adjacent areas. Recovery may require several years 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.

4.16.3 Moderate Risk Impacts from Accidental Events

Two accidental spill scenarios were evaluated: a fuel spill and a condensate spill from a blowout (see **Section 4.3.1**). The fuel spill scenario assumed an instantaneous release of 8,415.6 m^3 from the drilling rig. The condensate spill scenario assumed a blowout resulting in the release of [redacted] continuing for a period of 30 days. The likelihood of either a large fuel spill or a worst-case condensate spill from a blowout is rated as unlikely (2), taking into account Noble Energy's well control, blowout prevention, and other spill prevention measures.

Both the fuel spill and condensate spill were evaluated as having several Moderate risk impacts. For the fuel spill, the consequence of potential impacts on seabirds and migratory birds as well as coastal habitats and infrastructure was rated as medium (3), resulting in a Moderate risk rating. For the condensate spill, the consequence of potential impacts on marine mammals, sea turtles, fishes, seabirds and migratory birds, fishing activities and marine farming, and coastal habitats and infrastructure were rated as medium (3), resulting in a Moderate risk rating. The condensate spill is considered to have the potential for greater consequences (and therefore a greater number of Moderate risk impacts) because of the extended time period (30 days) for the spill event and the greater volumes of oil potentially reaching the shoreline.

The Moderate risk ratings for potential impacts on coastal habitats, wildlife, and infrastructure are based on simulation modeling that does not take into account any response measures to disperse a spill or prevent it from reaching sensitive shorelines. The Leviathan Field is approximately 120 km from the nearest shoreline and the modeling predicts the earliest landfall would be 7.5 days for a condensate spill and 12 days for a fuel spill (see **Section 4.3**). Noble Energy expects that, in the event of a spill, most significant impacts would be avoided (or the likelihood of impacts would be substantially reduced) through the implementation of the response measures included in the OSCP.

4.16.4 Low Risk Impacts

The remaining impacts summarized in **Table 4-30** are rated as Low risk. For all impacts of routine activities other than drilling discharges, the impact consequence is rated as insignificant (1) or minor (2) and the likelihood ranges from unlikely (2) to possible (3). For all of the Low risk impacts of accidental spills, the likelihood is unlikely (2) and consequence is minor (2).

Table 4-30. Impact summary table.

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Seafloor Disturbance						
Seafloor disturbance	Sediment quality	Physical disruption and resuspension of sediments.	None recommended	3	1	3 Low
	Benthic communities	Localized burial and crushing of individual organisms.	None recommended	3	1	3 Low
	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 (actual distances are more than 3.0 km away)	2	2	4 Low
Drilling Discharges						
Drilling discharges (treated cuttings)	Water quality; fishes	Turbidity within a few tens of meters to a few kilometers of drilling rigs during discharges.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings , in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3)	5	1	5 Mod
	Sediment quality	Deposition of cuttings particles on the seafloor, causing changes in grain size and mineralogy.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings , in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3)	4	2	8 Mod
	Benthic communities	Localized burial and smothering of benthic organisms. Burial impacts are most likely within 61 to 65 m of drillsites. Anoxia and other benthic impacts may occur due to adhering MOBM and changes in sediment grain size.	• Selection of low-toxicity MOBM • Use of TCC to minimize MOBM retention on cuttings , in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3)	4	2	8 Mod

Table 4-30. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
			• Background monitoring survey conducted to verify there are no deepwater coral or other hard bottom communities present			
	Culture and heritage sites	Possible burial or contamination of wreck sites.	• 305-m avoidance zone for potential sites	2	2	4 Low
Other Discharges						
Sanitary waste and gray water, organic food waste, cooling water, desalination brine, deck drainage	Water quality; fishes	Localized, transient impacts on water quality within a few meters to a few hundred meters of drilling rigs.	• Compliance with MARPOL requirements	3	1	3 Low
Ballast water	Fishes; benthic communities	Potential introduction of alien invasive species in ballast water.	• Noble will operate in accordance with guidelines developed by IPIECA and OGP (2010) to increase awareness of AIS risks and to prepare and plan for, avoid, and monitor for such impacts throughout the project life cycle. Drilling rigs will have a Ballast Water Management Plan and be equipped with an IMO-approved ballast water management system	3	1	3 Low
Light Hazards						
Artificial lighting on drilling rigs and support 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 (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 rig 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						
Noise from drilling rigs, support vessels, and helicopters	Marine mammals	Behavioral responses such as avoidance; potential for auditory masking.	None recommended	3	1	3 Low
	Sea turtles	Behavioral responses such as avoidance; potential for auditory masking.	None recommended	3	1	3 Low
	Fishes	Behavioral responses such as avoidance; potential for auditory masking.	None recommended	3	1	3 Low

Table 4-30. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Vessel Traffic						
Support vessel traffic between shore base (Haifa) and drilling rig(s)	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
	Fishing activities	Potential interactions with fishing vessels or gear.	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
Helicopter Traffic						
Helicopter traffic between shore base (Haifa) and drilling rig(s)	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						
Marine debris accidentally lost overboard	Water quality; sediment quality; benthic communities	Potential accumulation of metal debris on the seafloor, with growth of fouling biota.	• Noble Energy's waste management procedures and rig operator's Garbage Management Plan 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 and migratory birds	Potential entanglement; ingestion.	• Noble Energy's waste management procedures and rig operator's Garbage Management Plan will minimize the potential for accidental loss of items overboard	2-3	1	2-3 Low
Air Emissions						
Air emissions from drilling rig	Air quality	Localized, transient elevations in air pollutant concentrations near drilling rig; 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 from support vessels and helicopters	Air quality	Localized, transient elevations in air pollutant concentrations along 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

Table 4-30. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Air emissions from flaring during production testing (flowback)	Air quality	Localized, transient elevations in air pollutant concentrations near drilling rig; greenhouse gas emissions.	• Use of high-efficiency burner to minimize air pollutants from incomplete combustion	3	1	3 Low
	Water quality	Possible sheen on sea surface due to fallout of droplets during flaring; localized impacts due to discharge of treated effluent.	• Use of high-efficiency burner to minimize "fallout" of oil droplets • Treatment of effluent to meet standards prior to discharge	2	1	2 Low
Safety and Protection Zones						
Safety and protection zones (500-m buffer zone around drilling rig(s)	Fishing activities	Exclusion of fishing vessels from buffer zone	• Provide Notice to Mariners in advance of proposed activities	3	1	3 Low
	Marine transportation system and infrastructure	Exclusion of other vessels from buffer zone.	• Provide Notice to Mariners in advance of proposed activities • Use standard navigation markings	2	1	2 Low
Accidental Spills						
Fuel spill from the drilling rig (8,415.6 m^3)	Air quality	Elevated VOC concentrations due to evaporation of volatile hydrocarbons (mostly in first 24 to 48 hours).	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Water quality	Sheen or slick on water surface; elevated hydrocarbon concentrations in water column.	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Marine mammals	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Sea turtles	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of nesting beaches)	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.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of coastal bird habitats)	2	3	6 Mod
	Fishes	Potential impacts due to direct contact with oil or ingestion of fouled prey items.	• Spill prevention measures • Drilling rig SOPEP • OSCP	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.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including notification procedures and protection of fishing and marine farming areas)	2	2	4 Low

Table 4-30. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Fuel spill from the drilling rig (8,415.6 m^3) Continued.	Culture and heritage sites	Potential contamination of culture and heritage sites (including coastal sites if spill reached shoreline).	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of coastal archaeology sites) • 305-m avoidance zone for potential wreck sites; 31-m avoidance zone for other sonar contacts (actual distances are more than 3.0 km away)	2	2	4 Low
	Marine transportation and infrastructure	Potential disruption or rerouting of ship traffic due to response activities.	• Spill prevention measures • Drilling rig SOPEP • OSCP	2	2	4 Low
	Coastal habitats and infrastructure	Potential contamination of beaches, shorelines, parks, preserves, marinas, ports, etc.	• Spill prevention measures • Drilling rig SOPEP • OSCP (including protection of coastal habitats and infrastructure)	2	3	6 Mod
Condensate spill from a blowout ([redacted] for 30 days)	Air quality	Elevated VOC concentrations due to evaporation of volatile hydrocarbons (mostly first 24 to 48 hours).	• Spill prevention measures • OSCP	2	2	4 Low
	Water quality	Sheen or slick on water surface; elevated hydrocarbon concentrations in water column.	• Spill prevention measures • OSCP	2	2	4 Low
	Sediment quality	Physical impact to sediments within 300 m of blowout site; sediment contamination unlikely.	• Spill prevention measures • OSCP	2	2	4 Low
	Benthic communities	Physical impact to benthic organisms within 300 m of blowout site; benthic community impacts due to sediment contamination are unlikely.	• Spill prevention measures • OSCP	2	2	4 Low
	Marine mammals	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • OSCP	2	3	6 Mod
	Sea turtles	Potential impacts due to inhalation, ingestion, direct contact with skin, or ingestion of fouled prey items.	• Spill prevention measures • OSCP (including protection of nesting beaches)	2	3	6 Mod

Table 4-30. (Continued).

Aspect and Description	Resources Affected	Potential Impact	Mitigation	Likelihood	Consequence	Residual Risk
Condensate spill from a blowout ([redacted] for 30 days) Continued	Seabirds and migratory birds	Potential impacts due to inhalation, ingestion, direct contact with feathers, or ingestion of fouled prey items.	• Spill prevention measures • OSCP (including protection of coastal bird habitats)	2	3	6 Mod
	Fishes	Potential impacts due to direct contact with oil or ingestion of fouled prey items.	• Spill prevention measures • OSCP	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.	• Spill prevention measures • OSCP (including notification procedures and protection of fishing and marine farming areas)	2	2-3	4-6 Mod
	Culture and heritage sites	Potential contamination of heritage sites (including coastal sites if spill reached shoreline).	• Spill prevention measures • OSCP (including protection of coastal archaeological sites) • 305-m avoidance zone for potential wreck sites; 31-m avoidance zone for other sonar contacts (actual distances are more than 3.0 km away)	2	2	4 Low
	Marine transportation and infrastructure	Potential disruption or rerouting of ship traffic due to response activities.	• Spill prevention measures • OSCP	2	2	4 Low
	Coastal habitats and infrastructure	Potential contamination of beaches, shorelines, parks, preserves, marinas, ports, etc.	• Spill prevention measures • OSCP (including protection of coastal habitats and infrastructure)	2	3	6 Mod

AIS = alien invasive species; IMO = International Maritime Organization; MARPOL = International Convention for the Prevention of Pollution from Ships; MOBM = mineral oil-based mud; OSCP = Oil Spill Contingency Plan; ROV = remotely operated vehicle; SOPEP = Shipboard Oil Pollution Emergency Plan; TCC = thermomechanical cuttings cleaner; VOC = volatile organic compound.

CHAPTER 5: PROPOSED GUIDELINES FOR PLAN FOR PRESERVATION AND PREVENTION OF HARM TO THE ENVIRONMENT

5.1 GENERAL

This section outlines Noble Energy’s 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 Field drilling and completion activities.

5.1.1 Noble Energy Environmental Health & Safety Management

Environmental, Health and Safety management of Noble Energy activities is implemented through a hierarchy of policies, plans, and procedures that cascade from the corporate level to the business units and their individual operations. Based upon these high level policies, Noble Energy Israel is developing an Operations Management System (OMS) that provides specific procedures and guidelines for implementing its EHS systems.

The OMS provides a framework for establishing performance goals and incorporates Noble Energy’s legal requirements and best practices into an umbrella framework within a model that integrates elements from both Safety and Health Management Systems and Environmental Management Systems. The OMS provides the framework for implementing a program designed to make offshore gas development safe for workers and protective of the environment.

The OMS will be 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 the Noble Energy OMS and contractor operations will be implemented through Bridging Documents that identify common processes and approaches to address any differences in procedures between Noble Energy and the contractor as well as any site-specific hazards of the Leviathan Field drilling and completion activities. Noble Energy will conduct an extensive comparison and review of vessel plans, processes, and procedures relative to the Noble Energy OMS 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

As part of its OMS, Noble Energy is developing an Environmental Management System (EMS) based on an environmental policy that stresses development of the energy resources in a responsible manner and working diligently to reduce risks to the environment and human health. Noble Energy 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.

5.2 GUIDELINES AND PLANS

5.2.1 Drilling and Production Test Performance (Guidelines Section 5.5.1)

- Noble Energy takes a risk assessment approach that analyzes safety and environmental hazards and establishes 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.

- All 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 drilling rig 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 drilling rig well control standards.

- Trainings of employees and contractors to be cognizant of company and industry practices to prevent major incidents.

5.2.2 Handling of Hazardous Materials (Guidelines Section 5.5.2)

- Hazardous materials will be handled in accordance with their Material Safety Data Sheet (MSDS) specified guidelines, as integrated into the operator’s guidelines for handling hazardous materials. All hazardous materials will be properly identified, stored, and handled, per MSDS requirements and in such a manner that secures no spill/discharge to sea. In addition, hazardous materials will be handled with MSDS-based exposure limits.

- Hazardous materials storage areas will be designated on the drilling rigs 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 MSDS, and will not be mixed together 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 Israel specific hazardous waste handling guidelines, and guidelines as detailed in the drilling rig environmental management procedures

- Firefighting Equipment will be available on board.

5.2.3 Reduction and Prevention of Harm to Seafloor, Seawater and the Coastline including Marine Ecology, Cultural and Heritage Sites, Fishing, and Marine Farming (Guidelines Section 5.5.3)

- All discharges to the sea will be according to the discharge permit requirements.

- The operator will maintain his solid control equipment (e.g. shakers, centrifugies, screens etc) in operating conditions.

- The operator will maintain its Marine Sanitary Device in operating conditions.

- 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 drilling rig, the remaining well intervals would be drilled with MOBM.

- Low-toxicity drilling fluids shall be used. [redacted] According to the MSDS (**Appendix H**), the base fluid is readily biodegradable and not expected to be harmful or exhibit chronic toxicity to marine organisms.

- Cuttings from MOBM well intervals will be treated in a TCC onboard the drilling rig to reduce the MOBM retention on cuttings not greater than 1% by dry weight in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3).

- As part of its post drilling surveys Noble Energy will conduct a post-drilling ROV survey at each drill site to ensure that the seafloor is clear of equipment and debris from drilling and completion activities.

- Noble Energy will implement a 305-m radius avoidance zone for any contacts with potential wreck sites, and a 31-m radius avoidance zone for any contacts that may represent associated debris. No seafloor-disturbing activities will be conducted within these avoidance zones.

- Noble Energy will operate in accordance with guidelines developed by OGP/IPIECA (2010) 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 drilling rigs will have a Ballast Water Management Plan and be equipped with an IMO-approved ballast water management system to minimize the potential for introducing AIS.

- 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 Noble Energy's waste management, procedures and the drilling rig operator's Garbage Management Plan as required by MARPOL Annex V and Israel Regulation.

- Due to the distance from shore, Noble Energy does not expect any significant impacts on fishing or marine farming.

- Prior to commencing the Leviathan Field drilling and completion program, Noble Energy will issue a Notice to Mariners to inform fishing vessels and other vessel operators of planned vessel movements and the buffer zone around the drilling rigs.

- Due to the distance from shore, Noble Energy does not expect any impacts on coastal habitats, infrastructure or resources.

- In the event of a spill the response would take into account 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.

5.2.4 Preservation of Fauna and Flora, Including Pelagic Species (Guidelines Section 5.5.4)

- Low-toxicity drilling fluids shall be used. [redacted]. According to the MSDS the base fluid is readily biodegradable and not expected to be harmful or exhibit chronic toxicity to marine organisms.

- 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 Noble Energy's waste management, procedures and the drilling rig 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.

- As part of its post drilling surveys Noble Energy will conduct a post-drilling ROV survey at each drill site to ensure that the seafloor is clear of equipment and debris from drilling and completion activities, that can cause harm to the marine fauna and flora.

- 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 for a vessel striking a marine mammal or sea turtle.

5.2.5 Monitoring (Guidelines Sections 5.5.5 and 5.5.6)

- Noble has conducted a wide field sampling program that established the base line for water and sediment quality and infaunal communities. A Pre-drilling ROV survey is conducted to establish a baseline of the seafloor surroundings around each drill site.

- As part of Nobles' post drilling surveys a Post-drilling ROV survey shall be conducted, to ensure that the seafloor around each drill site is clear of equipment and debris.

- Monitoring program shall be prepared and conducted following completion of drilling. This Post-Drilling Monitoring survey shall include sampling of seawater, sediments, and infauna. Reporting of results will include comparison of Pre-Drilling and Post-Drilling Survey results.

- Mud samples will be taken for every drilling section in compliance with discharge permit requirements, including the periodic toxicity testing of drilling muds during drilling.

- Noble Energy has conducted current monitoring at current meter moorings in the Leviathan Field

- Waters in the vicinity of the drilling rigs shall be visually monitored for oil sheen on a daily basis.

- Discharges shall be monitored according to discharge permit requirements.

5.2.6 Preventing/Reducing Light Hazards (Guidelines Section 5.5.7)

- 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 drilling rigs 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.

5.2.7 Reducing Air Contaminant Emissions (Guidelines Section 5.5.8)

- All drilling rig and support vessel engines, generators, and other emission sources will be operated and maintained in accordance with manufacturers' recommendations to avoid excessive emissions.

- The drilling rigs and supply vessels will comply with applicable MARPOL Annex VI regulations.

5.2.8 Measures for Preventing or Reducing Noise (Guidelines Section 5.5.9)

- Drilling rig and support vessel engines will be operated and maintained in accordance with manufacturers' specifications to avoid excessive noise.

5.2.9 Drilling Mud and Cuttings (Guidelines Section 5.5.10)

- 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 drilling rig, the remaining well intervals would be drilled with MOBM.

- Low-toxicity drilling fluids shall be used. [redacted]. According to the MSDS (Appendix H), the base fluid is readily biodegradable and not expected to be harmful or exhibit chronic toxicity to marine organisms.

- Cuttings from MOBM well intervals will be treated in a TCC onboard the drilling rig to reduce the MOBM retention on cuttings not greater than 1% by dry weight in accordance with the effluent limitations used in the North Sea/OSPAR region (OSPAR Decision 2000/3).

- Simulation modeling has been conducted to evaluate the potential deposition of cuttings on the seafloor around the drill sites.

5.2.10 Other Discharges (Guidelines Section 5.5.11)

- All drilling rig discharges to sea will comply with the appropriate requirements of MARPOL Annex I (oil pollution prevention), Annex IV (sewage pollution prevention), Annex V (garbage pollution prevention) and the discharge permit requirements.

- Sanitary waste will pass through an IMO-approved sewage treatment plant prior to discharge to sea.

- Gray water will be discharged to sea without treatment.

- Food waste will be macerated to pass through a 25-mm mesh in accordance with MARPOL Annex V requirements.

- Cooling water, desalination brine, and deck drainage from non-machinery areas will be discharged without treatment as these effluents do not contain any added chemicals or contaminants.

- Bilge water and deck drainage from machinery areas will pass through an oil-water separator prior to discharge to sea (in accordance with MARPOL Annex I requirements) or be retained on board to be disposed of onshore.

- The drilling rigs will have a Ballast Water Management Plan and be equipped with an IMO-approved ballast water management system to minimize the risk of introducing AIS.

5.2.11 Safety and Protection Zones (Guidelines Section 5.5.12)

- Noble Energy will establish a 500-m radius safety zone around the drilling rigs, 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 safety zone.

- Navigational markings onboard both the drilling rigs 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, Noble Energy will consult with Ministry of Transportation and provide Notice to Mariners to inform the public of planned vessel movements and the safety zone around the drilling rigs.

5.2.12 Waste Treatment and Removal (Guidelines Section 5.5.13)

- 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.

5.2.13 Emergency Procedures (Guidelines Section 5.5.14)

- Noble Energy will update the Oil Spill Contingency Plan (OSCP) to reflect Leviathan drilling activities. The plan will be submitted to MOEP.

- Accidental spills shall be reported to the relevant authorities.

- Noble Energy's OSCP outlines Tier II and III equipment and resource requirements. Noble Energy will maintain appropriate oil spill response and cleanup equipment and supplies to efficiently address spill incidents.

- Noble Energy requires the drilling rig contractor(s) to have Emergency Response Plans to deal specifically with the actions to be taken in the event of emergencies.

- Noble Energy and the drilling rig contractor 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.

- Noble Energy Conducts oil spill dispersion modeling to determine likely trajectories and resources at risk.

5.2.14 Geological and Seismic Risks (Guidelines Section 5.5.15)

- Noble Energy commissioned a 3D geohazards survey of the Leviathan Field. The findings from the geohazards survey were taken into account in the siting of the proposed drill sites. Noble Energy will commission a 3D geohazard assessment (Well Clearance Letter) for each drill site.

- The response to any spills resulting from an earthquake or other emergency would be conducted in accordance with Noble Energy's OSCP.

5.2.15 Periodical Reporting and incident notification (Guidelines Section 5.5.16)

- Periodical reporting shall be done according to the specific requirements laid out in the discharge permit.

- Incident notification shall be done according to Noble Energy's incident notification procedure.

5.2.16 Changes in Development Plan (Guidelines Section 5.5.17)

- Noble Energy will periodically report any changes in the drilling and completion plan, including the impact of such changes on the environment.

5.2.17 Coordination Team (Guidelines Section 5.5.18)

- Noble Energy shall nominate its representative to the Coordination team, by request of the MEWR.

CHAPTER 6: LITERATURE CITED

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Appendices

Appendix A

Guidelines for Preparation of Environmental Impact Document for Production Drilling, Production Tests and Completion
Development of Leviathan Field (Leases I/14 and I/15)

State of Israel
Ministry of National Infrastructure, Energy and Water
Natural Resources Administration
Ministry for Environmental Protection
Marine and Coastal Division

11 Tishri, 5774
October 5, 2014

Instructions for Preparation of Environmental Impact Document for Production Drilling, Production Tests and Completion – Development of Leviathan Field (Leases I/14 and I/15)

Introduction

These Instructions are given for the purpose of preparation of an environmental impact document (hereinafter: the **"**Document**"**) which shall accompany the application for the development plan for the Leviathan Field, for the performance of production drilling, production testing and the completion thereof (hereinafter: the **"**Application**"**). The Instructions have been drafted by the Ministry of National Infrastructure, Energy and Water and the Ministry for Environmental Protection, based on the framework instructions for offshore exploration drilling and the environmental appendix attached to NOP 37H.

The Instructions relating to production drillings, production tests and the completion thereof, as part of the development of the Leviathan Field. This is one of a number of stages and components in the performance of the project of development of the Leviathan Field. In order to enable the obtaining of an overall picture of development of the field as a whole, the authors of the Document must add, in an extended summary as set out in section F below, a description of all of the actions planned during the course of development of the Leviathan Field, even though such are not included in the Application up to the connection to the coast.

The other components and stages in the project will require the preparation of a separate environmental impact document, for which separate instructions will be provided. An Environmental Management and Maintenance Plan (EMMP) shall be submitted to the Natural Gas Licensing Authority and the Professional Inter-Ministerial Team (as defined in NOP 37H) in the course of submission of the application for issue of building permits for infrastructure located within the territorial waters, which shall be prepared in accordance with the provisions of NOP 37H and the environmental appendix which constitutes part of the NOP, which were approved by the National Planning and Building Council in June 2014.

The Document shall be prepared in accordance with the details below:

General Requirements

A. The Environmental Impact Document will be drafted at the responsibility of the Leaseholders, and will include the name of the person responsible for its performance and the names of the professional service providers that participated in its preparation and performance.

B. The Environmental Impact Document will be prepared and performed by a company with experience and expertise in evaluation of environmental impact and marine research. The Company preparing the Document shall have proven experience in examining the environmental impact of projects similar to the Leviathan Field development project.

C. The Company that prepares the Document shall include, in addition to experts examining the environmental impact of the oil and gas offshore production industry, experts with proven experience and professional know-how in issues of the specific marine environment of Israel and the Eastern Mediterranean Sea with respect to marine ecology and biology, including deep sea systems, marine chemistry, hydrodynamics, sedimentology, geology, atmospheric chemistry and marine geophysics. In the event that the Company is a foreign company, it shall be assisted by Israeli experts with proven experience in the fields of content set out above, or by environmental impact documents (the experience of each of the experts shall be set out in accordance with Table 1 at the end of this Document). The team shall be presented at the time of submission of the Application for the approval of the Commissioner and the Ministry for Environmental Protection, if necessary.

D. For the purpose of preparing the Environmental Document, it shall be possible to rely on the most up-to-date information in existence collected in the context of the background survey for the development of the Leviathan Field, information from surveys conducted by Noble Energy for exploration and production in the adjacent areas including Tamar, Carish and Tanin, and other relevant information that complies with scientific criteria collected over the past decade.

E. The author of the document and the professional consultants shall fill in and sign the appropriate affidavits (Form 1, 2) in the form appearing in section 14(c) of the Planning and Building (Environmental Impact Studies) Regulations, 5763-2003.

F. The Environmental Impact Document will be submitted in Hebrew and in English and will include an extended summary at its start, which shall contain the principal findings, conclusions and recommendations for implementation of the Application. Likewise, a full bibliography and the sources of the data used by the authors of the document, separately for each of the environmental aspects, shall also be attached. Submission of the Environmental Impact Document in English shall only be possible after receipt of prior, written consent. In the event that the Environmental Document is submitted in English, an extended summary will be attached to it containing the main findings, conclusions and recommendations for implementation of the Application in Hebrew as well.

G. The Environmental Impact Document shall be submitted, in accordance with the details set out in the Introduction, in digital form as well (PDF and DOC files). Digital vector maps and the sketches in the document shall also be submitted in DWG (AutoCad) format, and in SHP (ArcGis) format. Ground and aerial photographs (including orthophotos) used for the document shall be submitted in JPEG, TIFF and GeoTIFF or ECW or MrSID formats, in accordance with the kind of result or other format approved in advance and in writing. By the Commissioner, acting on behalf of the Ministry of National Infrastructure, Energy and Water The data shall also be required to be submitted in Excel format, as set out in the Instructions.

H. The maps and aerial photographs that are submitted on digital media shall be at the highest possible resolution employed in the process of preparation thereof. On the other hand, the maps and aerial photographs that are to be prepared for the purpose of preparation of the Document and that are to be attached to the hardcopy of the document shall be adjusted, in terms of scale, to the guidelines set out in the relevant section of the document. The maps shall set out the date of preparation and the name of the entity that prepared and approved them, including the signature of the persons who performed the mapping.

I. The document shall contain full reference to every section of the guidelines, in accordance with the order of the guidelines. It should be noted that the process of examination of a document that is submitted incompletely might be delayed until completion of the missing items, and in certain cases, the document may be returned to the parties who submit it without being examined.

J. If a particular section is submitted in a format that is different from the requested format, the prior written approval for such must be obtained from the Commissioner, and the change as compared with the guidelines must be set out and explained. **For the sake of the efficiency of the process, the Developer is requested to submit reasoned requests for amendment as soon as possible, and not to wait until the formal stage of submission of the Document.** Leaseholders and authors of the document shall be responsible for including topics, findings or other impacts that are discovered during the course of preparation of the Application and the Document, that are not mentioned in these Instructions.

K. These Instructions shall constitute a part of the Document, and shall be attached to it as an appendix.

L. In order not to cause harm to commercial secrets, confidential information in the Document must be marked in order to enable publication of the Environmental Document without the disclosure of such information. It is clarified that the fact that materials constitutes a commercial secret shall be in accordance with the provisions of the Freedom of Information Law.

M. The document must be submitted to the Petroleum Commissioner, in one copy and to the Ministry for Environmental Protection, in three copies, as a drafted, continuous and complete paper document, and in digital form as well.

N. The document shall be approved by the Petroleum Commissioner and the Ministry for Environmental Protection, who shall be assisted by the relevant entities.

O. These Instructions for the preparation of the Document shall be valid for two years after the date of publication of them, and shall be updated after two years if necessary.

1. Chapter A – Description of the current Maritime Environment to which the Application Relates

1.1. General

1.1.1. The existing environmental system is the starting point for forecasting environmental impacts in the future. The environmental areas set out in this Chapter shall be used later on for examining and describing the possible environmental impacts expected to develop due to development of the Leviathan Field and production of the gas therefrom.

1.1.2. The current condition of the marine and coastal environment shall be described in detail, including the scientific knowledge in terms of biological, ecological, chemical, sedimentological, atmospheric, geological, hydrodynamic aspects and aspects related to cultural and heritage sites.

1.1.3. The environmental condition of the entire marine and coastal area expected to be affected or likely to be affected as a result of the actions must be described in the Application. The area of impact shall be assessed, inter alia, in accordance with the current regimen at sea in the various areas. For the purpose of preparing the Document, it shall be necessary to rely on the most up-to-date, relevant and focused information that exists in the professional literature and on the Environmental Impact Survey in NOP 37H (Chapters A-B) and the Marine Environment Monitoring Survey for the Development of the Leviathan Field – Production Drilling, Field Development and Offshore Production, which was prepared in accordance with the Leviathan Field Development Background Monitoring Survey Offshore – Scope of Work / Sampling and Analysis Plan, April 2014, Israel), and the documents attached thereto. The Plan was prepared in reliance upon Appendix B1 (Guidelines for Monitoring the Marine Environment due to Oil and Natural Gas Exploration Activity in Israel, Draft for Public Comment – December 2013), and was approved together with comments and conditions for performance on April 9, 2014 (Leviathan Field - FPSO) and on May 18, 2014 (Transmission Pipeline).

1.1.4. The level of chemical, physical and biological homogeneity of the seabed must also be examined based on the findings of surveys conducted in the past around the exploration drillings.

1.1.5. A special survey must also be included with an emphasis on the seabed breached as a result of the exploration activities performed in the Leviathan Field, including a verbal and other description of the nature of the disturbance, including the presence of collections of mud and discharge, bacterial carpets and salt pools as a result of the Leviathan 2 drilling, changes in the nature and composition of the seabed and the content of pollutants and metals on the seabed. Furthermore, the proportion of the area of the Field that has not yet been disturbed must be estimated and the rate of rehabilitation of the injured systems must be assessed based on the findings of the various monitoring plans effected in the area of the Application.

1.1.6. Additional actions currently being taken in the areas covered by the Application such as shipping, trawler fishing and pelagic fishing, sea sport etc., must also be noted, along with the nature of the interface between such actions and the actions under the Application.

1.2. **Boundaries of the Document and Area of Influence**

1.2.1. The area of the Document marked with a blue line: shall include the marine zone that is up to 2 km away from the production drillings and from the area of the field, including salvage drilling sites if planned. The maritime area will include the water column, seabed and sub-seabed, and the maritime infrastructure and facilities situated at this site.

1.2.2. The area of influence of the Document shall cover the entire maritime and coastal zones that might be environmentally impacted as a result of ongoing activities or a fault in one of the drilling sites. It is clarified that the area of impact varies and therefore, the author of the Document must consult with the Ministry for Environmental Protection in order to obtain a specific delineation of the various impact boundaries, prior to preparing the Document.

1.3. **Maps and Orthophoto**

1.3.1. All of the maps and orthophotos that are to be prepared for the purpose of the Environmental Document shall be on the New Israeli Grid, and in accordance with the regulations of the Israel Mapping Center.

1.3.2. In addition to the above, the location of all components of the Application must be marked on a geographic grid (Lat, Lon and UTM grid) and must be described in detail in words.

1.3.3. The distance between the drilling sites and points of reference on the coast (Rosh Hacarmel, Hadera) and the perpendicular distance of the PRMP platform from the coast must also be noted.

1.3.4. A general depth map must be presented at a scale of 1:250,000 of the deep sea off the coast of Israel, with the location of all of the components of the Application, including the drilling sites, existing and proposed maritime boundaries and areas, including marine reserves and Defense Regulation lines (the "Defense Regulations of 2005"), existing gas transmission / supply pipelines and shipping routes being noted on it.

1.3.5. A series of regional depth maps must be presented at a scale of 1:20,000, at a 2 km distance from each of the drilling sites, with the exposed rocky areas, the seabed, the type of ground (for instance: clay, silt, sand), fractures, channels, land-slides and above- and underwater infrastructures and facilities found in each region being noted on it. The differences between the depth contours on the maps shall be 5 meters and the mapping data shall be the most up-to-date in existence. If there is information at a distance of more than 2 km, it should be presented too.

1.3.6. Detailed depth maps of the Application area (blue line) are to be set out at a scale of 1:5,000 around each of the sites, and mark on them the exposed rocky areas, the seabed, the type of ground (for instance: clay, silt, sand), sensitive ecological systems (seaweed carpets, cold springs) and above water and underwater infrastructures and facilities existing in any area. The differences between the depth contours on the maps shall be 1 meter and the mapping data shall be updated to the last decade. The sedimentological characteristics of the seabed shall be based on a granulometric and mineralogical survey which faithfully represents the sediment in the area of the Application on the basis of the background survey, as set out in section 1.1.3.

1.3.7. Maritime transportation and infrastructure systems, electricity infrastructure and facilities, communications and energy lines, corridors, pipelines and terminals for various infrastructures (gas, petrol, hazardous materials, desalination, etc.) in the area of the Application must be set out on a maritime map at a scale of 1:100,000.

1.4. Geological, Seismic and Sedimentological Characteristics

An exhaustive and detailed geo-hydrological description of the site, including:

1.4.1. Describe, in words, the general geographical location of the production drilling sites, their proximity to seismically active areas and the rock foundations upon which they will be constructed.

1.4.2. A general geological / geomorphological / bathymetric map must be set out at a scale of 1:250,000 of the sea off the coast of Israel, and mark thereupon the location of the production drilling sites. On this map, mark geological fractures, with an emphasis on fractures that are active or that are suspected of being active. Fractures described as being **"**suspected of being active**"** by the Israel Geological Institute or similar entities shall be deemed to be active unless it is proven that they are not active using the usual methods (conduct of research and geophysical cross-sections, and paleoseismological analysis). Likewise, mark locations of historical earthquakes of a magnitude of more than 2.5, areas liable to landslides and other geological and morphological phenomena which are notable.

1.4.3. A series of regional geological / geomorphological / bathymetric maps at a scale of 1:20,000, of the seabed around all of the planned drilling sites must be prepared with geological fractures being marked upon them, with an emphasis on active (young) fractures or fractures suspected of being active, including the Or Yehuda Fracture and the average rate of their movement. Furthermore, the location of historical earthquakes of a magnitude of more than 2.5 must be marked, along with areas slated for landslides, instability, exposed rocky infrastructure on the surface of the seabed, and the age thereof, and other geological and morphological phenomena that need to be noted including transportation of sediment, previous sediment slides and activity, shallow gas springs, channels and depressions in the seabed. The distance at which the data from the planned production drilling sites will be presented shall be 2 km at least.

1.4.4. If there is an intention to discharge or dump drilling mud and cutting discharge into the sea, set out the area of dispersal of the muds and other cuttings on a geophysical survey conducted via side-scan sonar and underwater information, physical changes in the seabed due to the effects of anchoring and excavation, the build-up of waste, etc.

1.4.5. Describe in detail the rock infrastructure at each of the production drilling sites. Set out detailed information that might clarify the characteristics of the land (for instance: the speed of shear stress waves, the depth to the bedrock, characteristics that affect non-linear conduct, etc.).

1.4.6. The potential existence of active geological fractures or of fractures that are suspected of being active, and geological phenomena with a risk potential as set out in sections 1.4.2 and 1.4.3 within the area of the Application and its immediate environs must also be addressed.

1.5. **Hydrodynamic Regime**

1.5.1. The information regarding the various zones must be set out in accordance with the depth range in each zone.

1.5.2. Describe the characteristic wave regime within the area of the Application. This description shall be based on wave characteristics measured in the south eastern Mediterranean in general, and off the coast of Israel over the last 20 years in particular. Set out the statistical breakdown of wave characteristics within the timeframe of one year (significant and maximum height, direction, cycle time at the top of the spectrum, and average cycle time), and within a longer timeframe of 5, 10, 20, 50 and 100 years, statistics of storm durations for various maritime conditions.

1.5.3. Refer to the affect of waves in extreme storms and the possibility of the development of killer waves, including due to a seismic source, on the stability of the marine structures within the area of the Application.

1.5.4. Describe the regime of the currents in the area of the Application, created due to the winds, and other oceanic variables (for instance: astronomic tides, Coriolis force, jet streams along the edge of the continental shelf, seasonal changes of seawater mass, temperature, salinity, etc.). This description shall be based on meteorological-oceanographic information collected since the mid-20th Century, in the Eastern Mediterranean in general and along the coast of Israel in particular.

1.5.5. Set out the statistical division of the wind regime in the Eastern Mediterranean, including the annual frequency of wind directions, wind magnitude (including gusts), seasonal effects, and extreme winds. The minimum resolution shall be 22.5° for wind direction and 2 m/s for speed.

1.6. **Nature and Ecology**

1.6.1. Set out the various habitats that exist in the body of water, and in the various seabed environments including hard and soft bed zones, sponge gardens, deep coral reefs, seaweed carpets, cold springs. A detailed description must be provided of fauna and flora societies in each of these habitats, including coverage percentages, and taxonomic information regarding the identity of species in the region. A map of the various habitats in the area of the Application must be included.

1.6.2. **The species within the area of the Application and within the area of its impact (as described in section 1.2.2) must be described including micro and macro algae, seaweeds, seabed dwelling fauna, sedentary or territorial.** In addition, describe the coastal natural monuments, as the case may be, situated within the area of the Application and within the area of its impact. The information regarding natural phenomena will be in reliance upon a detailed biological survey (as set out in the approved Background Monitoring Plan – section 1.1.3) which will be conducted within the area of the Application and impact, and on information, if such exists in this area, from prior surveys. The information included shall be set out in tables, maps, graphs, pictures, video, and shall be accompanied by a detailed verbal description of the findings and with lists of inventory, including scientific names based on taxonomic classification. Note the presence of rare, unique or delicate organisms.

1.6.3. The condition of marine mammals, sea turtles, permanent sea birds, migrating birds (based on seasons and hourly distribution), and species of pelagic fish located in the region of the planned infrastructure, must be presented in accordance with information from the most up-to-date professional literature and from field surveys and population sizes must be estimated.

1.6.4. Pursuant to the above sections, a detailed analysis must be conducted of the information including on the basis of the following issues:

1.6.4.1. Identification of the creatures to a species level or to the most detailed taxonomical level possible.
1.6.4.2. Density of individuals.
1.6.4.3. Richness of species (in the various taxonomic groups).
1.6.4.4. Variety, the appropriate index must be chosen from the acceptable variety indexes such as: Shanon-Wiener, Simpson (2004) ,Magurran, and give reasons for the choice.
1.6.4.5. Fixed and mobile species.
1.6.4.6. **"**Target species**"**: key species, species of commercial value, most common species (breeding season, egg-laying season, area in which drilling operations will be tolerable, heavy metals and organic contaminants in target species).
1.6.4.7. Classification of species based on origin: Mediterranean-Atlantic, species with broad geographical distribution, invasive species.

1.6.5. Fishing areas within the area of the Application must be set out. Set out trawler fishing routes, fishing (note the kind of fishing - rod fishing, etc.), and the quantities of fish collected over a monthly and annual cross-section. This data must be set out on a map at a scale of 1:50,000 and in a GIS layer.

1.7. **Sea Water and Sediment Quality**

1.7.1. Set out the characteristics of the sea water and sediment quality within the area of impact, around each of the planned drillings and the zone planned for development of the field. The information regarding the quality of the seawater and sediment shall be based on a seawater and sediment quality survey (section 1.1.3) conducted in the area of impact of the Application and on additional relevant information if any in this area, from the monitoring plan and previous surveys. The information included shall be set out in maps, graphs and shall be accompanied by a detailed verbal description of the findings.

1.7.2. Set out the quantity of floating material in the water column, in a variety of marine climatic conditions (winds, waves, currents). The presentation of this data shall be based on sediment samples in accordance with the details in section 1.1.3 and on additional relevant information if such exists in this area. The turbidity of the water shall be measured at the surface, in the center of the water column and near to the seabed at each of the sites. Likewise, set out the climatic conditions at the time of taking the samples.

1.7.3. Set out the levels of chlorophyll in the water column, within the area of the Application. Likewise, an assessment of the dispersion of chlorophyll must be conducted over the entire area of impact, using remote sensing methods.

1.7.4. Describe, in detail, the chemical characteristics of the water column (dissolved oxygen, pH, salinity, temperature, nutrients), within the area of the Application, around each of the sites.

1.7.5. Describe, in detail, the chemical characteristics of the sediment within the above area of the

Application. The description shall focus on toxic substances, on chemical derivatives of heavy metals, TOC, PAH, SBF and their derivatives (including the results of decomposition), oxygen concentration in sediments. The sediment sampling system (the number of stations and their location) will be approved prior to performance as is set out in section 1.1.3.

1.7.6. Likewise, describe the characteristics as set out in section 1.7.5 of the fauna on the hard bed (if any) and of the fauna on the soft bed and of the fauna within the bed (in filtering animal tissue such as clams, snails, worms, polychaetes and crabs and fishes). The extent of the sampling shall be approved in advance prior to performance, as set out in section 1.1.3.

1.8. **Culture and heritage sites**

The information regarding antiquities and cultural heritage sites shall be based on a detailed archeological survey or as a result of processing of a visual survey, a geo-hazard survey, a remote sensing survey (side sonar scanner, multi-beam, ROV movies, etc.) which shall be conducted within the area of the Application and on information that exists regarding the area from prior surveys. The sites known to the Antiquities Authority (both declared and as yet undeclared sites) and other sites containing information about archeological findings or sunken ships from must be included. The total raw data shall be presented on maps at a scale of 1:20,000, near to the planned drilling sites, and 1:100,000 at a depth of more than 1,000 m for the entire Field and shall be provided to the Marine Archeology Unit at the Antiquities Authority, and shall include the archeological sites, pictures, video and be accompanied by detailed verbal descriptions of the findings within the area of the Application and its immediate environs. The information presented in the Document shall be determine following consultation with the Antiquities Authority, Marine Archeology Unit. The approval of the Marine Archeology Unit at the Antiquities Authority shall be attached to the Document as an appendix.

1.9 **Meteorology and Air Quality**

1.9.1. Describe the existing meteorological conditions in the area of the Application and its environs.

1.9.2. Special meteorological conditions that might cause conditions of dispersal that will give rise to high air pollution concentrations in the environment must be noted.

1.9.3. The status of the air quality in the area of the Application and in the onshore areas that will be affected by the planned activity must be described. Up-to-date monitoring data regarding the pollutants NO_x, SO^2 PM_{10} and other relevant pollutants must be addressed if relevant. The monitoring data will be from the past five years, and will be examined on the basis of the environment and target values (**Air Quality** Value Regulations, 2011) and if there is no target value, on the basis of the reference value. The availability of the data will not be less than 95% over a period of five years.

1.10. **Noise**

1.10.1. Set out the magnitude of the sub-marine noise at a number of representative points near to each of the components of the Application (as set out in section 1.6).

1.11. **Marine Transportation System and Infrastructure**

On the basis of section 1.3.7, describe, in words, the marine transportation and infrastructure system in the chosen area of the Application (the Leviathan Field). Set out the current operations of the system: Traffic volumes, entry and exit directions of vessels in accordance with the various classes of vessel, fuel containers, fishing boats, maritime farming service boats, yachts, tugboats and small operations vessels, etc.

Chapter B – Reasons for Preference of the Location of the Proposed Plan and Possible Alternatives

2.1. General

This Chapter must contain all of the reasons for choosing the proposed sites in the Application for production drilling. In addition, please refer to geological and seismic, environmental, planning, engineering and economic aspects, such as proximity to existing and planned infrastructure, exploitation of additional natural resources, impact on natural monuments, air quality, noise, etc. Data from drilling operations and development plans effected in the past near to the area of the Application, if any, must also be addressed.

2.2. **Location alternatives:** Give details of and explain the various reasons that led to the determination of the proposed site of the exploratory drilling as set out in section 2.1. Set out the location alternatives examined, the preferred alternative and the reasons that gave rise to the choice of it.

For each location alternative, the following criteria at least will be examined: Structural analysis issues, the size of the field and the location of the target stratum; landslides and liquefaction; marine reserves; regions defined as special regions such as ridges, canyons or deep coral reefs, sponges, clams or other sedentary organisms; habitats of animals in danger of extinction; shipping lanes; infrastructure, communications and energy lines; current regime; fish reproduction zones and times; fishing lanes and zones.

2.2.1. **Technological alternatives:** Set out the various technological alternatives examined and the various considerations that gave rise to the decision to use the technology set out in the Application, including the drilling technology (including vertical, angular, horizontal); the type of platform; BOP; drilling mud and liquids – composition, treatment, cutting discharge and drilling mud disposal targets. If use is planned to be made of mineral / oil based drilling mud, set out the criteria and limitations for use of one kind as opposed to another. Including reference to relevant regulations from around the world. Furthermore, set out alternatives to the method of treatment and discharge into the sea of the various fluids.

In summary of this Chapter, the alternatives shall be set out in a comparison table, with each topic under examination being ranked, according to weight, together with the professional reasons for selecting it. An example of a criteria table is attached in Appendix B2 on the website of the Ministry of National Infrastructure, Energy and Water.

Chapter C – Description of Actions Stemming from Performance of the Application

3.1. General

This Chapter shall set out the drilling plan in accordance with the various planned stages of work and development, including production drillings, production testing, completion of production drilling, construction, running and operation. The distance between the production drillings must be noted. The Application must be presented on simulation photographs, on a bathymetric map, noting the distances between the various drillings (both existing and planned) on the Application, as well as points of reference on the coast. The various sea- and aircraft, their characteristics and the activities that they will perform must also be set out. The description in the Application must relate to all of the work that is done, to the installation and set-up of the infrastructure set out above, the production tests, acceptance tests, and to abandonment, dismantling and rehabilitation. The various stages must be set out on a Gantt work plan including milestones and timetables. All of the items of the Application must be set out as examined in Chapter D, and must include subjects, findings or other influences discovered during the course of preparation of the Document.

3.2. **Description of the Application**

All of the facilities, including the infrastructure used by and adjacent to such facilities must be described, as well as the actions involved in setting them up and the auxiliary impacts. The forecast need for future facilities, including compressors, power sources, maintenance and service vessels must also be described.

3.2.1.1. The purpose of the development drillings and the type of drilling (including natural gas or oil, salvage) must be described.

3.2.1.2. The drilling platform, including the type of platform, the name of the platform, title, when it was manufactured, dates of upgrade, previous areas of operation, location of last anchorage (port) prior to reaching the development site, whether the platform has operated within the economic waters of the State of Israel before, and if so where and when, must also be set out. The actions required for approval of the arrival of the platform must be set out with an emphasis on the prevention of invasive species. Set out how the platform will arrive at the drilling site. Set out the platform's fleet specifications. Set out whether more than one drilling platform will operate during each of the stages of development of the field, including the drilling completion stage. If, during the stage of preparation of the Document, there is no information about a particular platform, the type of platform and its principal characteristics must be set out.

3.2.1.3. The water depth must be set out at each of the drilling sites together with the depth of drilling below the seabed (below mud line - BML).

3.2.1.4. The sea- and aircraft involved in the development drillings, production tests and completion thereof must be set out.

3.2.2. **Description of Drilling Process**

3.2.2.1. Describe, in brief, all of the drilling processes and phases including the actions and materials relating all drilling activities. The main operations, depth of drilling under the seabed (BML), under the surface of the water (BWD) and under the platform must be set out in a table for each drilling segment. Set out whether the drilling process in all drillings is identical. If not, then the drilling process as aforesaid must be set out and presented.

3.2.2.2. Attach a schematic sketch showing the depth of the drillings as a function of time, including appropriate reference to the stages of the drilling and drilling data.

3.2.2.3. The various stages of development, including the future development of the Field, the number of drillings planned for each stage, the total number of drillings in the Field and an assessment of the timetable for performance of the various stages of development must be set out.

3.2.2.4. Set out a Gantt Chart setting out the drilling activities done in series and in parallel.

3.2.2.5. Prevention of Oil Blowout

Describe the blowout preventer (BOP) that has proven efficacy and that is designed to prevent oil, gas and/or liquids under the surface such as produced water, saline water from blowing out of the bore into the marine environment. Explain and describe the continuous pressure controls. Set out the standard for periodic testing of all of the means of prevention of blowout or fault. Describe the measures and the alternatives for the BOP that will be available for the purpose of development of the field in the event of a fault in the BOP.

3.2.2.6. Protective pipeline and concretization

3.2.2.6.1. In accordance with the drilling plan, describe the protective pipeline from the seabed to the target strata.

3.2.2.6.2. Describe the concretization of the casement pipelines in the drillings, in order to prevent possible leaks and the transition of liquids from the bore into the seawater or underground.

3.2.2.6.3. Describe the method of construction and concretizing of the bores with reference to the timeframes of the principal stages in drilling the bores.

3.2.2.6.4. Describe the composition of bore concretization materials.

3.2.2.6.5. - Set out the manner in which the quality of concretization is ensured during drilling, the method of testing such and the standard used for testing.

3.2.2.7. Testing of drilling pipelines

Describe the method for testing the drilling pipeline and its accessories, the reports and the references required for ensuring that drilling and protection pipelines are in order and the method of testing such, with all of the components thereof.

3.2.2.8. Production Tests

3.2.2.8.1. Describe the planned production test method, the phases thereof, the order of activities, the equipment and the possible methods thereof, and set out the reasons for such. Set out the various indexes that will be examined such as maximum production of all production components (gas, oil, water, condensate), pressure, gas composition including H^2S, CO_2, etc.

3.2.2.8.2. In cases where use of chemical substances is planned in the production test, set out the substances that will be used in the production tests, the commercial names of such substances, their quantity, concentration, chemical composition and function including chemical formula, CAS (Chemical Abstract System) Number, and MSDS (Material Safety Data Sheet) and include them in the chemical table in section 3.5.

3.2.2.8.3. Set out whether, during the production testing stage, there is a possibility of a presence of H_2S in the reservoir, during which stages of the Application H_2S might appear and the methods of operation and treatment in the event that H_2S does appear.

3.3. Noise Hazards

Set out details of the mechanical equipment and the noise levels from the dominant sources characteristic of each form of technology. Set out details of the duration of the drilling, the hours of work each day, the number of sea vessels that will operate at the same time, throughout the hours of the day, and the aircraft involved in the work. Set out details of the frequency and magnitude of the noise that will be generated during the course of work at various distances from the source of the noise.

3.4. **Air quality**

3.4.1. Describe the sources of emissions of contaminants into the air from the planned operations during the drilling and production testing stages, including: Energy facilities, flare / vents, unfocused emissions and other sources.

3.4.2. For all sources of emissions presented, set out the regime for the activation, the type of fuel, the contaminants emitted and other data necessary for evaluating emission rates. The rates of emissions of contaminants shall be estimated on the basis of manufacturer's data, measurements or calculations on the basis of EPA-AP42 methodologies or on the basis of other methodologies upon prior approval. Address the pollutants SO_2, NO_x, PM_{10}, VOC and methane at least. Air pollutant emissions files and the method of calculation / assessment thereof shall be set out in a table in accordance with sources of emissions during the various stages of operation – drilling and production tests, as well as faults during various stages (including during emergency shutdown).

3.4.3. Faults that might give rise to increase emissions of air contaminants into the environment, the emission of additional contaminants such as H_2S or the generation of odor hazards (at sea and on land) must be addressed.

3.5. Hazardous Materials

Describe and set out all of the hazardous materials planned to be used, including drilling, drilling completion and production testing liquids. The following details must be noted for each material:

The chemical composition, the commercial name, the CAS (Chemical Abstract System) number; the UN number; the Material Safety Data Sheet (MSDS), the quantity, the purpose of use and the method of use of them, their location on the platform (together with a chart), the storage and collection of them, the method of treatment and disposal of them. The data must be set out in a table of chemicals.

3.6. Sources of Discharge into the Sea

General – This Chapter shall set out the sources of discharge into the sea in the context of production drilling, production tests and completion drilling. Approval of the Document shall not constitute a substitute for the approval of the Committee for Grant of Permits for Discharge into the Sea for each of the sources of discharge. The information shall be set out in full for each stage.

3.6.1. Development of the Field – Production Drilling

3.6.1.1. Describe all of the sources of discharge into the sea, and describe, for each source, the processes that give rise to the discharge and a flowchart of the process. The flows that must be presented include: Drilling mud (discharge into the sea depends on the type of drilling mud chosen); cutting discharge, cooling water, desalination concentrate water, organic kitchen waste (at a distance of more than 12 nautical miles from the shore, at a distance of fewer than 12 nautical miles, this must be removed to the shore), sanitary effluent / waste ("black water"), washing water ("gray water"), rinses from oil separation facilities, cement surpluses, bilge water (if any).

The following information will be given for each source of discharge into the sea. For drilling mud and cutting discharge – see also the specific instructions in section 3.6.1.12.

3.6.1.2. Describe the processes that create the flow together with a drawing of the processes.

3.6.1.3. Describe the treatment processes, if any, including physical data of stocking units, engineering and operational data for each treatment facility (the area of the facility, the volume of each unit, capacity, duration of presence, etc.); means of monitoring and control of each process / treatment; attach a schematic drawing for each treatment facility.

3.6.1.4. Set out the list of additives in each production and treatment process, the quantity of each additive, its function and the method of addition of it; attach information sheets (MSDS) for each additive, with an emphasis on ecological information for the marine environment, and possible impacts on fish farming and wild fish. See also reference later on in section 3.6.1.3.5 (Additives).

3.6.1.5. Times of Discharge: Describe the flow times including whether the flow is continuous or interrupted, fixed or variable (hourly / daily / other), and what the conditions and/or processes are that determine the quantity and/or times of flow.

3.6.1.6. Method of Discharge: Describe the method of discharge into the sea of each and every source and whether the discharge is effected separately / separate source or together with other discharges. In describing the source, set out the physical characteristics of the source / source pipe and the depth of the source with respect to the surface of the water / the seabed.

3.6.1.7. Quantities: Set out the quantities of each source, set out the information in accordance with maximum hourly, maximum daily, maximum monthly and total quantity during the course of the drilling. Set out the method of controlling quantities / amounts pumped into the sea (wharf based capacity meters, water meters, other - give details). In the event that there are no capacity meters, check and set out what is required in order to install capacity meters, including storing the pumping data on a data logger. Quantity data shall be presented in cubic meters.

3.6.1.8. With respect to the discharge of sanitary waste (“black water”) and shower / washing / laundry water (“gray water”), set out the quantity in cubic meters / day / person, for each separate source.

3.6.1.9. Bilge water – set out whether the platform contains a facility for the collection of bilge water, the method of collection thereof and the method of removal to an onshore facility. Attach an IOPPC (International Oil Pollution Prevention Certificate) in accordance with Annex 1 to MARPOL.

3.6.1.10. Quality: Describe the composition of each source. Set out the information on the basis of data from similar facilities, including the conduct of laboratory tests. This information shall include contaminant concentration data, and total contaminant load discharged into the sea (in tons) including the provisions set out in section 3.6.1.15 (Qualities). Note, for each source of pumping, the source of the information regarding the composition of it. Set out the nature and frequency of the various tests that must be conducted on the platform and the standards whereby the tests must be performed.

3.6.1.11. Give details as to whether there are land-based alternatives for each pumping source. If not, give reasons and details regarding the way in which this subject was checked.

<u>Cutting discharge, drilling mud and left-over cement</u> (drilling mud relates to any addition of liquids and materials used for drilling purposes).

3.6.1.12. Cuttings:

3.6.1.12.1. Quantities: Set out the quantity (tons) and volume (cubic meters) of cutting discharge generated and/or discharged into the sea (depending on the type of drilling mud) as follows: In each of the drilling segments, by drilling diameter; in the stage in which the drilling takes place without recycling and the cutting discharge is placed around the the wellhead directly on the seabed; in the drilling stage which is done with recycling, when the cutting discharge is brought up to the platform with the drilling mud; total quantity of cutting discharge discharged into the sea.

3.6.1.12.2. Treatment and removal of cutting discharge – describe the method of treatment and removal of cutting discharge.

3.6.1.12.3. If the cutting discharge removal destination is at sea, describe the piling up of cutting discharge and drilling mud on the seabed and estimate the radius and area affected by this process. Also, set out the threshold requirements and the quality criteria for the cutting discharge prior to discharge into the sea, and set out the method of monitoring and control for compliance with such criteria, including the method, frequency and nature of sampling. In the event that the removal destination for the cutting is onshore, the method of collection of the cutting, and the method of transportation and removal of it onshore must also be described.

3.6.1.13. Cement / drilling fluids and muds:

3.6.1.13.1. Quantities of drilling mud: Set out the total quantity and volume of drilling mud (cubic meters and tons), for the stage of the drilling without recycling when the drilling mud is placed near to the drilling bore on the seabed, and for the stage of drilling done when the recycled drilling mud is brought back up to the platform with the cutting discharge and total quantities of the drilling mud discharged into the sea.

3.6.1.13.2. Set out the composition of drilling mud in a table, including: The name of the material, the function of each material, the quantity of each material in each segment of drilling and the total quantity of materials in each segment of the drilling, totals of all materials in each segment of the drilling and total quantities of all materials in the entire drilling process. This data shall be presented in cubic meters, transition units (SG) and tons. Note which of the drilling stages the discharge into the sea takes place in, what quantity is being discharged at each stage, and the total. The data shall be presented in cubic meters and in tons (the data must be attached in an Excel file as well).

3.6.1.13.3. Describe the way in which the various substances are added to the water and to other drilling liquids (creating the drilling mud). In reliance upon the above, please also refer to the quantities of water / other drilling fluid that are added during the course of drilling, due to losses of water / fluids / drilling mud back into the rock strata.

3.6.1.13.4. For each component and material, information sheets (MSDS) must be presented, including ecological information regarding the marine environment (toxicity, biodegradability, bioaccumulation) and concentrations of each component that might be pumped into the sea.

3.6.1.13.5. Chemicals / additives: Set out in a concentrated table data on chemicals, based on source of use (drilling mud, cement, etc.), based on information sheets, including: the name of the chemical, its CAS number, the composition of the chemical (in the event of a compound, set out each substance and composition, and the percentage of it in the compound), ecological information including the results of toxicity tests, biodegradability, bioaccumulation and the level of its impact / toxicity on the marine environment. Wherever there is no information, write "no information"; and note the level of environmental risk according to OSPAR / the Norwegian Method (green, yellow, red, black).

3.6.1.13.6. Describe the method and frequency of the various tests conducted in mud and drilling liquids, including materials pumped into the drilling mud preparation system and the standards under which the tests are conducted.

3.6.1.13.7. Biological toxicity test: Set out the tests conducted for testing biological toxicity in drilling mud / surpluses from the treatment facility pumped into the sea and set out where such tests are performed and the source of the data; examine and present the extent to which the existing toxicity tests accord with the deep sea conditions in the Eastern Mediterranean Deep Sea Basin. Attach an expert opinion regarding the extent to which the tests comply, and his recommendations regarding the conducting of compatibility tests for the deep sea conditions in our region.

3.6.1.13.8. Treatment of drilling mud: Describe the areas and methods of organization and the facility for the treatment of drilling mud, separation of the cutting discharge from it, testing the composition of it and details of the additives planned for the treatment facility, including the list of additives, the function of each substance, the method of placement of it, etc. Losses of drilling mud must be addressed, and estimates given as to the percentage lost, quantities (in tons) and volume (in cubic meters).

3.6.1.13.9. Attach sketches, including notation of physical data of units of production / processes / treatment and return of drilling mud, including work areas, volumes of treatment facilities, durations, etc.

3.6.1.13.10. Describe the stages of drilling in which use is made of cement, and the processes in respect of which left-over cement is discharged into the sea.

3.6.1.14. Cement quantities: Set out the total quantity of cement in each of the stages of drilling and the total quantity in use (tons). Estimate and set out the quantities of cement that are to be discharged into the sea.

3.6.1.15. Information on quality of discharges into the sea:

The information on the quality of discharges into the sea shall include data on chemical composition, as follows: The information will be based on tests from similar facilities and processes from the past five years, subject to details of the source of the information and presentation thereof.

3.6.1.15.1. The information for pumping originating in drilling mud will include the chemical composition of the liquid, including: An extended metal scan (ICP, mercury in AA); GCMS scan for organic materials with probability percentages, half-quantity concentrations and summary; detailed VOC scan (head space) with probability percentages, including half-quantity concentrations and summary; TOC; TSS; BOD; mineral oil (FTIR / GC-MS / GC-FID); general oil (FTIR / GC-MS / GC-FID); PAH; turbidity; free chlorine; phenol; cresol; pH; AOX; DOX; forms of nitrogen (nitrate - NO_3; nitrite - NO_2; ammoniac nitrogen NH_4-N; Kjeldahl nitrogen TKN; total nitrogen - calculated); phosphorus - P; sulfide; TDS; chlorides; the information shall be presented as concentration (mg/L) and as load (weight per unit of time).

3.6.1.15.2. The information on discharges originating in drilling mud shall include The composition of the metals: Ag, As, Cd, Cu, Cr, Hg, Ni, Pb, Zn; organic matter (TOC); radioactive materials Pb-210, Th-228, Ra-226, Ra-228.

3.6.1.15.3. Information on use of barite: Note the source of the barite (the country of manufacture) and attach the results of tests for metal content in barite (raw material) as follows: Cd and Hg content (AA, at a sensitivity of at least 0.1 mg / kg at least) and the content of Ag, As, Cu, Cr, Ni, Pb, Zn.

3.6.1.15.4. The information for discharges from the wash treatment facility will include the chemical composition of the liquid, including: An extended metal scan (ICP, mercury in AA); GCMS scan for organic materials with probability percentages, half-quantity concentrations and summary; detailed VOC scan (head space) with probability percentages, including half-quantity concentrations and summary; TOC; TSS; BOD; DOC; turbidity; phenol; cresol; pH; AOX; DOX; mineral oil (FTIR / GC-MS / GC-FID); general oil (FTIR / GC-MS / GC-FID); forms of nitrogen (nitrate - NO_3; nitrite - NO_2; ammoniac nitrogen NH_4-N; Kjeldahl nitrogen TKN; total nitrogen - calculated); phosphorus - P; sulfide; TDS; chlorides; the information shall be presented as concentration (mg/L) and as load (weight per unit of time).

3.6.1.15.5. The information for discharges from the sanitary effluent treatment facility will include the chemical composition of the liquid, including: BOD; TSS; TOC; turbidity, free chlorine, oils and lipids (FTIR), mineral oil (FTIR), forms of nitrogen; sulphide; detergents (MBAS); pH; fecal coli per 100 mL, fecal enterococci per 100 mL, extended survey of metals (ICP), TDS; the information shall be presented as concentrate (ML) and load (mass per unit of time – mass / month or mass / year).

3.6.1.15.6. Describe the measures and structure of the platform for the purpose of separating clean upper water, in the event of rain, from oily lower water intended for treatment prior to release into the sea or removal to land.

3.7. **Waste**

Describe the quantity of the waste expected to be created, including kitchen waste, dry waste, other waste created as a result of the process of drilling, development and production of the field, except for waste set out in the section regarding sources of discharge into the sea as set out in section 3.6 above.

3.8. **Closure / Abandonment of the Field and Dismantling of the Infrastructure**

Describe the details of the actions required at the time of termination of production in individual drillings and in the entire field, and the order of performance thereof, including temporary abandonment or permanent abandonment.

3.8.1. Describe the measures for closing the wellhead, the target strata, and other conducting strata, abandonment and restoration of the previous condition.

3.8.2. Note the standard under which the closure methods of the well heads are installed.

3.8.3. Set out the list of chemicals planned for use in closing the well and include these in the table of chemicals in section 3.5 together with information sheets.

3.8.4. Attach a schematic drawing of a cross-section of the drilling prior to closure of the drilling and after closure (temporary / permanent).

Chapter D – Evaluation of the Environmental Impacts expected to develop due to Performance of the Application and the Measures to be taken to Prevent / Minimize such

In this Chapter, the various topics expected to have an environmental impact shall be set out graphically and verbally, including impact on moving or stationary species within the areas of the Application and its close and remote environs, in accordance with the provisions of section

1.2.2. This description of the environmental impacts and the sources thereof shall be qualitative and quantitative, and shall refer to all of the actions and impacts set out in Chapter C. The variety of activities expected to take place at the production drilling sites in the Leviathan Field, the production tests, completion thereof, and abandonment of the bores. With respect to each subject, an explanation shall be given as to whether it is necessary to prevent or reduce the negative environmental impacts and what means must be employed in order to prevent or reduce such, if any.

In the event that during the course of preparation of the Application, influences or other findings are found that are not mentioned in this document, these must be addressed and means must be proposed for reducing the impact in the document.

An environmental management plan must be set out, detailing the means for reduction of the hazards for those actions that give rise to environmental impacts that are considered to be undesirable or unacceptable (unacceptable impacts must be prevented permanently or reduced to acceptable levels), and a complete response will be given for the fact that development of the field will not cause unnecessary environmental harm.

4.1. **Assessment of Potential Impact on the Marine Environment of the Production Drillings**

4.1.1. Assess the maximum scope of the impact of the drilling rig, including anchors, on the seawater, the seabed, and the coast, as the case may be, and set out the basis for the information and the method of effecting the assessment.

4.1.2. In the event that the discharge target for the cutting discharge and drilling mud is at sea, assess the extent of impact on the environment in accordance with an evaluation of the radius and the area affected by the process, as set out in section 3.2.2 and set out the tests, actions and frequency thereof in order to minimize harm to the marine environment.

4.1.3. In the event of proximity to natural monuments identified in accordance with section 1.6, existing or proposed nature reserves and cultural and heritage sites as set out in section 1.8, the methods of action and the operations that must be taken in order to remove the cuttings and drilling mud to an alternative offshore and/or onshore site must be examined.

4.1.4. Examine and present the possibility of reducing and minimizing the placement of discharge and drilling mud directly onto the seabed during the course of drilling from the drilling segment prior to installation of the riser, such as by using an RMR SYSTEM.

4.1.5. Assess the maximum scope of the impact of the drilling liquids at the time of effecting the production tests on the seawater in the area of the Application.

4.1.6. Simulation (a digital three-dimensional hydrodynamic contaminant dispersion model) for drilling mud of the dispersion zone of the drilling mud and other mining liquids – each case must be considered on its merits on the basis of environmental data and location relative to the coast, the quantity of mud and discharge and the duration of time of the drilling or discharge into the sea. This matter will be coordinated and approved in advance and in writing. If simulation is required, the model must be approved and is to be presented in a preliminary document which shall contain a description of the type of model, calibration characteristics, commencement conditions, language conditions, the grid of the model and other parameters required in order to activate the model. After approval of the conditions and calibration of the model, the scenarios for modeling the dispersion of contaminants from a hydrodynamic point of view will be set, in various climatic conditions.

4.1.7. The considerations and criteria including the environmental factors taken into account in determining the method of discharge of each source of discharge into the sea (consolidation of discharges, depth of outlet) must be set out in order to ensure optimal dispersion in the sea.

Where necessary, an imaging model will be required.

4.2. Production Tests

Describe all of the means for ensuring that under no circumstances will there be any connection (transfer of liquids or gases) from the area where the production tests are taking place and the water-carrying strata and expansion of the fuel composition (liquid and gas) underground or in the marine environment.

4.3. **Environmental Impacts of Sea Pollution Event by Oil based on Extreme Scenarios**

4.3.1. The change in the current field and in the movement of the oil stain from the place of the leak must be set out in detail and in stages from the production bores along the coast of the Eastern Mediterranean Sea, from the Gaza Strip in the south to the coast of southern Lebanon in the north, and west to the coast of southern Cyprus. This description should rely, inter alia, on the results of activation of a three-dimensional hydrodynamic model, which has been fed with wind data and the other necessary hydrodynamic characteristics. The hydrodynamic model must set out, precisely, the field of currents in accordance with the layout of the local seabed.

4.3.2. Presuming that the oil slick, based on the findings of the hydrodynamic model, is likely to penetrate the shallow portion of the continental shelf off the coast of Israel, describe via the appropriate hydrodynamic model for simulating the hydrodynamic processes in the coastal environment the current regime in the area affected mainly by local winds and waves, and analyze the impact of such currents on dispersal of the oil slick on the coastal environment.

4.3.3. In running the model and in all of the calculations stemming from it, please take into account the worst-case scenario of 30 continuous days of discharge into the marine environment, at a maximum daily capacity in accordance with the drilling data. The type of oil in the model must be the most resilient oil expected in the reservoir and/or in accordance with the worst-case scenario data.

4.3.4. Please run each of the four most common sea conditions on Israeli beaches for a period of 30 days:

4.3.4.1. Extreme winter wave storm: 9.12.2010 - 08.01.2011

4.3.4.2. Winter wave storm: 26.01.2008 - 14.02.2008

4.3.4.3. Summer swell: 17.07.2008 - 16.08.2008

4.3.4.4. Strong North-Easterly wind (Spring and Autumn): 25.09.2007 - 25.10.2007

4.3.5. Please explain in clear detail all of the data and estimates for the maximum daily quantity of oil set out in the document, and the general quantity during the course of the current scenario, without 30 day control, including formulas and calculations. Please clarify the objective difficulties in evaluating the expected quantities and the possible areas of imprecision. Please address the relevance of the modeling method performed and expand, in the explanation, on the relationship between the results of the model and the actual anticipated assessment based on international knowledge and experience from past oil pollution incidents. Explain the nature of the oil spill over the water, including the thickness and expected spread of it, and the environmental significance of the thickness and spread of the spill.

4.3.6. Please analyze, on the basis of the findings of the model, the results of the spread of the oil stain from the drilling bore and give a detailed explanation of the environmental significance of the results of the model. Please refer to the marine environment in general and to the coastal area and the various sites therein in particular. Give details and explain the environmental and other implications that might arise from an oil spill incident at sea under the various scenarios, vis-à-vis the various environments. Including a description of sensitive areas that might be affected by a pollution incident (based on a map of sensitivity of beaches to sea pollution by oil. **The map is accessible on the internet and a copy may be obtained from the Marine and Coastal Division as a** GIS layer). Address the various significances, including:

4.3.6.1. The impact on the ecosystem in general, and on the various species in particular.

4.3.6.2. The impact of the various uses including an assessment of the measures required to remedy the damage and to restore the previous condition, an assessment of the length of time during which uses might be harmed and a general assessment of the costs of restoring the previous condition, all in accordance with open reports of international experiences.

4.3.6.3. Please address the following environments: The open sea environment, including a distinction between deep water and the critical transition zone, the seabed, beaches used for swimming and leisure, rocky beaches and/or sandy beaches that are rich in biota, marinas, moorings, marine anchorages and ports, power station cooling water suction plant and coal terminal, reverse osmosis plants and fish farm cages.

4.3.7. Set out an oil spill spread model (name of model, name of manufacturer and representative calibration data), and output data, for the prior approval of the Ministry for Environmental Protection (Marine and Coastal Division), prior to running the model. For the purpose of approval of the calibration stage, please set out a document describing, in detail, the boundary conditions and the starting conditions of the model, and the various variables and non-variables chosen for the purpose of running the model. The following are the details, variables and conditions that are required for the approval:

4.3.7.1. General

4.3.7.1.1. The name of the model.
4.3.7.1.2. A brief description of the model.
4.3.7.1.3. Reasons for adapting the proposed Eastern Mediterranean Sea (oil) spill simulation model.
4.3.7.1.4. Examples from around the world for use in the proposed spill simulation model.

4.3.7.2. Meteorological-Physical Conditions and Variables

4.3.7.2.1. Conditions of edge of model (boundaries and surface)
4.3.7.2.2. Conditions of commencement of model.
4.3.7.2.3. Resolution of model, both horizontal and vertical.
4.3.7.2.4. Characteristics of starting data for model: winds, currents, sea level, temperature, salinity, etc.
4.3.7.2.5. Bathymetry.

4.3.7.3. Chemical Variables

4.3.7.3.1. Type of oil.
4.3.7.3.2. Quantity of oil emitted per unit of time.
4.3.7.3.3. Calibration and Verification of Model
4.3.7.3.4. Methodological description and explanation of the proposed method of calibration.
4.3.7.3.5. Presentation of the variables required for calibration for the purpose of achieving the requisite model performances.

4.3.7.3.6. Presentation of calibration findings (in figures, tables, and a verbal explanation).
4.3.7.3.7. Methodological description and explanation of the proposed method of verification.
4.3.7.3.8. Presentation of verification findings (in figures, tables, and a verbal explanation).

4.3.7.4. Scenarios for Examination

4.3.7.4.1. Analysis of the usual and extreme hydrodynamic characteristics in the area and environs of the drilling bore.

4.4. **Light Hazards**

The effect of lighting and the planned production tests required for performance of the Application on the environment must be examined and measures proposed for reducing expected light hazards.

4.5. **Noise**

The expected noise impact on fauna in the region of the production drillings and the expected noise impact of the production tests and of production must be assessed. Details must be given of the local species that might be harmed by such noises (with an emphasis on pelagic animals such as fish, whether wild or caged, marine mammals, turtles), and measures for reducing damage.

4.6. **Nature and Ecology**

Assess the level of sensitivity of the animals and the possible impacts of construction of the rig on habitats as described on the habitat map in section 1.6.

4.6.1. Rehabilitation upon abandonment must be described.

4.7. **Culture and heritage sites**

Examine the impact of implementation of the Application on declared sites and on sites that may be discovered and exposed during the performance of the Application, as described in section 1.8.

4.8. **Air Quality**

4.8.1. The impact of the Application on generation of the secondary pollutant ozone (O_3) on the environment of the Application must be assessed via a photochemical model. For this purpose, the Developer shall provide emissions files from all of the sources of emissions of the ozone generating pollutants (NOx, VOC) to the Air Quality Division at the Ministry of Environmental Protection, which has an appropriate model.

4.8.2. Set out the measures and actions planned to be taken to reduce emissions from all sources set out in section 3.4, and the efficacy thereof, and address the best available technology (BAT) for complying with international requirements. For facilities / operations in respect of which there are requirements in TA-Luft 2002, address compliance with such requirements. The ongoing maintenance of these facilities must be described and the processes of rationalization of the manufacture and exploitation of electricity must be set out in order to reduce the emission of pollutants into the atmosphere. In particular, address the treatment of problems relating to H_2S emissions into the air, in routine operations or in the event of faults.

4.9. **Waste**

Describe the methods of treatment and removal of waste, as set out in section 3.7 above.

4.10. **Hazardous Materials**

4.10.1. Set out the measures for reducing risks from hazardous materials in accordance with the details in section 3.5 above.

4.10.2. Describe and set the measures for treatment in the event that hazardous materials are discovered during the course of the drilling, including H_2S.

4.10.3. Set out the method of treatment in emergencies (hazardous material event) and the means for minimizing risks, including passive and active measures such as batches detectors.

4.11. **Measures for Reduction of Geological and Seismic Risks**

4.11.1. Set out the measures and mechanisms, both automatic and manual, which will respond to an early warning of earthquakes or tsunamis.

4.11.2. Prepare emergency procedures or a chapter of existing emergency procedures for the handling of earthquakes. These procedures must address all exceptional situations, including: failure of communications and contact, inability to reach emergency forces, partial emergency team, etc.

4.12. **Fishing**

In accordance with the findings set out in section 1.6.15.6, set out the impact of the production drillings on fishing operations and the methods of reducing such impacts in the event of harm to fishing operations.

4.13. **Safety and Protection**

Estimate the safety range required around the production drillings to protect against harm to existing infrastructure and seacraft during the course of development of the field, installation of production infrastructure, and production.

4.14. **Monitoring and Control Program**

4.14.1. Describe the various means of monitoring and control for air, water, the seabed, waste, mud and cuttings, fluids, production by-products, and all sources that are discharged into the sea, which will ensure that the development of the field is effected in accordance with the plan, that faults or defects are located and that actions are taken to remedy such. Note, inter alia, what tests are planned to be done continuously, which are done visually and which are done in laboratories on the drilling platform, which are done at external laboratories, and at what frequency.

4.14.2. Describe the method of taking samples in order to obtain representative samples, for continuous / visual / laboratory sampling.

4.14.3. Describe the calibration and maintenance actions on monitoring and control instruments.

4.14.4. Present a marine environment background monitoring plan in accordance with the Background Monitoring Plan approved as set out in section 1.1.3.

4.15. **Abandonment of the Field.**

Examine the impact of closure of the production drillings and performance of the actions set out in section 3.8 on the environment and the means required to prevent such impacts, including the removal of materials, equipment and waste.

Chapter E – Proposed Instructions for Plan for Preservation and Prevention of Harm to the Environment of the Application

General:

5.1. This Chapter shall set out all of the proposals for setting the guidelines of the Application, at the level set out as being required for detailing the possible impacts set out in the chapters of this document, and the measures that are to be taken in order to prevent or reduce such.

5.2. The guidelines shall refer to the actions that must be taken or not taken in the entire area of the Application, during the course of and throughout the various phases of the production drilling, the production tests and completion thereof.

5.3. The Instructions shall be for the grant of a drilling permit.

5.4. The guidelines shall relate to the installation and operation of systems to track and monitor the effects that flow or that may flow from this Application.

5.5. The Instructions shall relate to actions that must be taken in the entire area of the Application, upon the making of a decision to effect production drilling, until cessation of such production, closure of the production drilling, abandonment of the field and dismantling of the infrastructure within the area of the Application, and shall include, inter alia, the following matters:

5.5.1. Instructions for the various stages of performance of the Application – the permit for drilling; for production tests; and the completion thereof.

5.5.2. Instructions for the handling of hazardous materials.

5.5.3. Instructions for the reduction and prevention of harm to land and to seawater and the coastline, and including harm to the marine ecology, heritage and cultural sites, fishing and marine farming.

5.5.4. Instructions for preservation of fauna and flora in the area of the Application including instructions for the prevention of harm to habitats, to pelagic species whose presence around the drilling rig might be increased, such as sharks, marine mammals and birds.

5.5.5. Instructions for the collection of data for the purpose of monitoring and follow-up of seawater quality, the form of the seabed, the depth of coverage of the sandy layer above the pipeline, the state of the pipeline, the quality and quantity of the sediment, the current regimen, the flora and fauna and marine agriculture in the environment of the drilling facilities, and actions that will be taken if the data points to deviations or faults that might cause harm to the environment.

5.5.6. Instructions for the construction of the various monitoring systems (air, water, waste, mud and cutting discharge, products of production tests, birds, etc.), which shall be activated at the time of construction and performance of the Application in accordance with a monitoring plan that will enable an assessment of the efficiency of the actions taken and handling of deviations or faults discovered during the course of monitoring.

5.5.7. Instructions for measures for preventing / reducing light hazards.

5.5.8. Instructions for measures for reducing air contaminant emissions and the prevention of odor hazards.

5.5.9. Instructions for measures for preventing or reducing noise.

5.5.10. Instructions for measures for the treatment and removal of cutting discharge and drilling mud.

5.5.11. Instructions for measures for treatment of various sources of discharge including cooling water, sanitary waste, kitchen waste, concentrate water, bilge water, washing water, hydraulic liquids.

5.5.12. Instructions for the definition of safety and protection zones and the management of safety against harm to existing infrastructure and sea vessels.

5.5.13. Instructions for methods of treatment and removal of waste.

5.5.14. Instructions for preparation of emergency procedures in the event of faults or accidents including activation of BOP in emergencies, submission of an emergency factory plan for the treatment of oil spills at sea, fire, earthquake, tsunami.

5.5.15. Instructions for the reduction of geological and seismic risks and reference to up-to-date relevant standards.

5.5.16. Instructions for periodical reporting of faults or exceptional incidents to the Petroleum Commissioner, and of environmental issues to the Ministry for Environmental Protection.

5.5.17. Instructions relating to changes in the development plan and examination of the impact of such on the environment and details of the updates required as a result of such changes.

5.5.18. Instructions for the setting up of a team to accompany the Application, and the composition thereof.

For the purpose of proof of compliance by the members of the proposed team with the conditions of education and experience required under the General Requirements of Section C, please attach, as an Appendix to the Document, the CV of each of the experts and the information required in accordance with the details in Table 1 below:

Table 1: Details of Experts, Experience and Professional Knowledge

References Attached	**Years of Practical Experience**	**Field of Experience**	**Education**	**Name of Expert / Company**	**Function of Expert**

* Fill in the table by typing in on a computer and not by hand.

State of Israel

Ministry of National Infrastructure, Energy and Water
Natural Resources Administration

Oil & Gas

16 Kislev 5775
December 8, 2014
NFT_892_2014

To:
Mrs. Orna Primor, Environmental Engineer oprimor@nobleenergyinc.com
Noble Energy

Dear Orna,

Re: **Instructions for Preparation of Environmental Impact Document for Development of Leviathan Field (Leases I/14 and I/15)**
Ref: Your letter to me of November 12, 2014

Pursuant to your above request, attach please find the response of our Ministry and of the Ministry for Environmental Protection to the questions and remarks provided to us for comment. I apologize for the delay in providing this response.

If you have any questions or require any further clarifications, please contact us.

Yours sincerely,

Ilan Nissim
Head of Environmental Division

CC:
Yossi Wirtzburger, Director, Natural Resources Administration
Alexander Varshavsky, Petroleum Commissioner
Dr. Victor Broidin, Senior Department Head, Engineering Control Department
Rani Amir, Head of the Marine and Coastal Environment Division, Ministry for Environmental Protection
Fred Erzuan, Deputy Head of the Marine and Coastal Environment Division, Ministry for Environmental Protection
Benny First, Head of Planning, Ministry for Environmental Protection
Dr. Dror Zurel, Scientific Coordinator for Maritime Monitoring and Research, Marine and Coastal Division, Ministry for Environmental Protection
Yevgeny Malkin, Director Energy Resources in the Marine Environment, Marine and Coastal Division, Ministry for Environmental Protection.
Reut Rabi, Air Quality Department, Ministry for Environmental Protection
Jacques Zimmerman, Regulation Manager, Noble Energy

Item	Subject of Comment	Comment (pursuant to the above letter)	Ministry Response
1.1.2, 1.1.3, 1.2.1 Area of impact	Requirement to refer to the coastal environment.	The current document (Leviathan Field Drilling) deals with the environmental impact of drilling in the Leviathan field. The environmental impact in the coastal region will be set out in Chapter D, which deals with assessments of the environmental impact in the coastal region, as a result of an event of oil pollution at sea.	Acceptable
1.3.1 Maps and Orthophoto	Requirement to submit maps based on the New Israel Grid and the number of maps required to be submitted	All of the maps submitted to date were submitted on a WGS84 UTM basis. In our opinion, consistency should be maintained in drafting the maps in order to avoid confusion as a result of a change in the basis of the geographic grid. In order to maintain uniformity with respect to all of the information (environmental, geological and engineering) which Noble generated in the past, we would like to submit all maps in WGS84 UTM format. The location of the sites will be reported on the New Israel Grid separately. In addition, see our comment in our comments document of March 6, 2014, regarding the need for consolidation of maps (section 1.3).	Acceptable. You are requested to set out the scale at which you plan to submit, and the resolutions of the maps in the digital copy.
1.3.3 Location of PRMP	Presentation of distance of the PRMP platform from the coast.	As noted above, the document deals with drillings in the Leviathan field. The location of the PRMP platform has not yet been finalized and therefore was not included in the content of the present document.	Acceptable. Please note the approximate location that is known at the time of preparation of the document.
1.5.2	Description of waves	Specific information	Acceptable.

Item	Subject of Comment	Comment (pursuant to the above letter)	Ministry Response
Description of hydrodynamic characteristics	regime	regarding the area of the survey of July 2011 to April 2014 will be provided. Furthermore, see our comments on section 1.5.1 in the comments document of March 6, 2014.	
1.5.3	Impact of waves in extreme storms.	See our comments in the comments document of March 6, 2014	Unacceptable. Please set out the information required in the section, in the environmental document.
1.8	Heritage sites	The document sets out the information in general terms. We would like to avoid submitting maps due to the sensitivity of the information. All of the information will be provided in a separate document, to the competent authorities.	As noted in the instructions, the method of presentation of the information must be coordinated and approved in writing by the Marine Archeology Unit of the Antiquities Authority.
1.9.3	Meteorology and Air Quality	Local information in the area of the Leviathan field is not available. Furthermore, see also our comment (sections 1.9.2-1.9.1) in the comments document of March 6, 2014.	Unacceptable.
1.10.1	Noise	See our comments (section 1.10) in the comments document of March 6, 2014.	Acceptable.
3.2 Description of the Application	Description of Facilities and Infrastructure	A description of the infrastructure will be given in the context of the Leviathan Field Production EIA and not in the present document (Leviathan Field Drilling), which deals with the environmental impacts of drillings in the Leviathan field.	The general section requires only a general description. Details of the requirements appear later on in the section and do not include the field development equipment.
3.3	Noise	The noise levels from the various sources of noise are known from digital sources. Since the drilling platform has not yet been selected, in our opinion a digital survey is sufficient to assess the noise as a result of drilling	Acceptable. However, please address the noise generated by platforms with similar characteristics to those that will be chosen or the results of measurements done on possible platforms that might be chosen. Set out an

Item	Subject of Comment	Comment (pursuant to the above letter)	Ministry Response
		operations.	assessment based on Noble's prior experience in using various kinds of platforms. After the platform is selected, the data must be updated and provided to the Ministries of National Infrastructure Energy and Water, and Environmental Protection.
3.4.2	Air Quality	Air quality data for all emissions sources will be provided prior to digital sources. Emergency shutdown does not take place during the course of these drilling operations but rather, during production operations and therefore, this does not need to be included in this section.	Acceptable with respect to EDS but unacceptable with respect to sources of emissions. Set out an assessment based on Noble's prior experience in using various kinds of platforms. After the platform is selected, the data must be updated and provided to the Ministries of National Infrastructure Energy and Water, and Environmental Protection.
3.6.1	Sources of Discharge into the Sea	The specific drilling platform has not yet been selected and therefore the information that will be supplied is based on the operations of a similar, representative platform.	Acceptable.
3.6.1.9	Bilgewater	The drilling platform has not yet been selected and therefore we cannot provide specific information. However, it is emphasized that the drilling platform will operate in accordance with the MARPOL regulations.	Partially acceptable. The information will be provided based on the operations of a similar, representative platform.
3.6.1.13.6-7	Toxicity tests	To be effected in accordance with the toxicity testing guidelines in the NPDES Permit 2012.	The toxicity test is in accordance with the requirements of the Ministry for Environmental Protection, see Comment 2 on Table 2 of the Discharge Permit that was given, at the time, for the Tamar SW drilling – and present the extent to which the existing toxicity tests accord with the conditions in the deep sea of the Eastern Mediterranean basin. Attach an expert opinion regarding

Item	Subject of Comment	Comment (pursuant to the above letter)	Ministry Response
			the extent to which the tests comply, and his recommendations regarding the conducting of compatibility tests for the deep sea conditions in our region.
3.6.1.15.4	Quality of offshore discharges	Please explain the term "Wash Treatment Facility" on the drilling platform.	A facility for the treatment of liquids originating in drainage from the floor of the platform and/or facilities on the platform, including contaminated upper drainage water.
3.7 Waste Data	Waste data – requirement to set out waste data during the development and production stage	The current document (Leviathan Field Drilling) deals with the environmental impact of drilling in the Leviathan field and not with the development and production stages.	Please assess the dispersion of mud and cutting discharge.

Item	Subject of Comment	Comment (pursuant to the above letter)	Ministry Response
4.1.6	Assessment of Potential Impact on the Marine Environment – Marine Pollutant Dispersion Model.	See our comments in the comments document of March 6, 2014	Partially acceptable. The requirement to set out a dispersion model stems from the need to know where to place the summary survey monitoring points after drilling. That is in order to ensure that the samples are taken in the zone that is exposed to the mud and cutting discharge and not in a clean area. Since it is our understanding that the sampling that was done in the background survey and that which was done after the drilling were done randomly, your assessment that there is no need for a model since real data will be obtained following analysis of the monitoring survey conducted after the drilling is insufficient. If you do not wish to implement a model, please propose an alternative mechanism that will enable definition of the zone that is expected to be most affected, and in which most of the sampling points can be located for the post-drilling monitoring.
4.3.7	Presentation of model data for approval.	The model that will be presented was used in the past in previous services and was approved by the Ministry.	Unacceptable. You may refer to the type of platform and the noises that this type of platform causes, on which the best practices currently employed in the industry are installed.
4.5 Noise	Presentation of measures for reduction of harm	Measures for reducing harm will not be discussed in the document because the environmental impact regarding noise is temporary, minimal and no environmental harm is expected.	Unacceptable. Set out and present, in the environmental document, an assessment based on Noble's prior experience in using various kinds of platforms. After the platform is selected, the data must be updated and provided to the Ministries of National Infrastructure Energy and Water, and Environmental Protection.

Item	Subject of Comment	Comment (pursuant to the above letter)	Ministry Response
			Pursuant to this update, we will discuss the need for measures to reduce or diminish the noise.
4.8.1 Air Quality	Photochemical model	When a specific platform is selected, the data will be provided to the Air Quality Department at the Ministry for Environmental Protection, for examination via the model.	Set out and present, in the environmental document, an assessment based on Noble's prior experience in using various kinds of platforms. After the platform is selected, the data must be updated and provided to the Ministries of National Infrastructure Energy and Water, and Environmental Protection.
4.13 Safety and Protection		The safety range set out in the survey is around the production drillings. The safety range during the course of development of the field, installation of the infrastructure and production shall be set out in the Leviathan Field development survey.	Unacceptable. Set out the safety range around the platform at the time of drilling. It is acceptable that the safety range from production drilling be set out in the environmental impact document for production.
5.5.18 Control and Monitoring Plan	Instructions for the setting up of a team to accompany the Application, and the composition thereof. In our opinion, this matter needs to be submitted in a cover letter and does not need to be included in the environmental impact document.	In our opinion, this matter needs to be submitted in a cover letter and does not need to be included in the environmental impact document.	Unacceptable. A proposal must be included for an accompanying team. It is acceptable in oil exploration applications in territorial waters to set up an accompanying team, and therefore, this should also be done in drillings that are performed in the economic waters.

Appendix B

Cross-Reference Table for Compliance with the "Guidelines for Preparation of Environmental Impact Document"

Table B-1. Cross-reference table for compliance with the Guidelines for Preparation of Environmental Impact Document for Production Drilling, Production Tests and Completion – Development of Leviathan Field (Leases I/14 and I/15).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
A	1		Description of the Current Maritime Environment to which the Application Relates						
	1.1.		General						
		1.1.1.		The existing environmental system is the starting point for forecasting environmental impacts in the future. The environmental areas set out in this Chapter shall be used later on for examining and describing the possible environmental impacts expected to develop due to development of the Leviathan Field and production of the gas therefrom.	Yes	1	--	Description of the Current Maritime Environment	Chapter 1 as a whole addresses this requirement.
		1.1.2.		The current condition of the marine and coastal environment shall be described in detail, including the scientific knowledge in terms of biological, ecological, chemical, sedimentological, atmospheric, geological, hydrodynamic aspects and aspects related to cultural and heritage sites.	Yes	1	--	Description of the Current Maritime Environment	The baseline description focuses on the Leviathan Field (the Application Area for drilling and completion activities). The coastal environment is summarized in Section 1.6.4, but a detailed coastal description is not presented. Details of the nearshore and coastal environment will be presented in the Leviathan Field Development EIA. This was accepted by the MNIEWR in a letter dated December 8, 2015.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.1.3.		The environmental condition of the entire marine and coastal area expected to be affected or likely to be affected as a result of the actions must be described in the Application. The area of impact shall be assessed, inter alia, in accordance with the current regimen at sea in the various areas. For the purpose of preparing the Document, it shall be necessary to rely on the most up-to-date, relevant and focused information that exists in the professional literature and on the Environmental Impact Survey in NOP 37H (Chapters A-B) and the Marine Environment Monitoring Survey for the Development of the Leviathan Field – Production Drilling, Field Development and Offshore Production, which was prepared in accordance with the Leviathan Field Development Background Monitoring Survey Offshore – Scope of Work / Sampling and Analysis Plan, April 2014, Israel), and the documents attached thereto. The Plan was prepared in reliance upon Appendix B1 (Guidelines for Monitoring the Marine Environment due to Oil and Natural Gas Exploration Activity in Israel, Draft for Public Comment – December 2013), and was approved together with comments and conditions for performance on April 9, 2014 (Leviathan Field - FPSO) and on May 18, 2014 (Transmission Pipeline).	Yes	1	--	Description of the Current Maritime Environment	The baseline description focuses on the Leviathan Field (the Application Area for drilling and completion activities). The coastal environment is summarized in Section 1.6.4, but a detailed coastal description is not presented. Details of the nearshore and coastal environment will be presented in the Leviathan Field Development EIA. This was accepted by the MNIEWR in a letter dated December 8, 2015.
		1.1.4.		The level of chemical, physical and biological homogeneity of the seabed must also be examined based on the findings of surveys conducted in the past around the exploration drillings.	Yes	1	--	--	Chapter 1 as a whole addresses this requirement. The survey report prepared according to the referenced Guidelines is provided in Appendix D.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.1.5.		A special survey must also be included with an emphasis on the seabed breached as a result of the exploration activities performed in the Leviathan Field, including a verbal and other description of the nature of the disturbance, including the presence of collections of mud and discharge, bacterial carpets and salt pools as a result of the Leviathan 2 drilling, changes in the nature and composition of the seabed and the content of pollutants and metals on the seabed. Furthermore, the proportion of the area of the Field that has not yet been disturbed must be estimated and the rate of rehabilitation of the injured systems must be assessed based on the findings of the various monitoring plans effected in the area of the Application.	Yes	1	1.13	Leviathan-2 Wellsite Monitoring Summary	A summary of the Leviathan-2 monitoring results is presented in Section 1.13. Detailed methods and results have presented separately in monitoring reports to the MNIEWR.
		1.1.6.		Additional actions currently being taken in the areas covered by the Application such as shipping, trawler fishing and pelagic fishing, sea sport etc., must also be noted, along with the nature of the interface between such actions and the actions under the Application.	Yes	1	1.11	Marine Transportation System and Infrastructure	
							1.12	Marine Farming	
	1.2.		Boundaries of the Document and Area of Influence						
		1.2.1.		The area of the Document marked with a blue line: shall include the marine zone that is up to 2 km away from the production drillings and from the area of the field, including salvage drilling sites if planned. The maritime area will include the water column, seabed and sub-seabed, and the maritime infrastructure and facilities situated at this site.	Yes	1	1.2	Boundaries of Application and Area of Influence	The Application Area includes the entire Leviathan North and Leviathan South lease blocks.
		1.2.2.		The area of influence of the Document shall cover the entire maritime and coastal zones that might be environmentally impacted as a result of ongoing activities or a fault in one of the drilling sites. It is clarified that the area of impact varies and therefore, the author of the Document must consult with the Ministry for Environmental Protection in order to obtain a specific delineation of the various impact boundaries, prior to preparing the Document.	Yes	1	1.2	Boundaries of Application and Area of Influence	Noble Energy consulted with the MoEP to determine the area of the application in accordance with Section 1.2.1 of the Guidelines. The area of impact was determined according to the oil spill discharge model.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	1.3.		Maps and Orthophoto						
		1.3.1.		All of the maps and orthophotos that are to be prepared for the purpose of the Environmental Document shall be on the New Israeli Grid, and in accordance with the regulations of the Israel Mapping Center.	Yes	--	--	--	All figures in the document are prepared on WGS84 UTM Zone 36N geographic grid. New Israeli Grid coordinates are provided in Table 1-1. This was accepted by the MNIEWR in a letter dated December 8, 2015.
		1.3.2.		In addition to the above, the location of all components of the Application must be marked on a geographic grid (Lat, Lon and UTM grid) and must be described in detail in words.	Yes				All figures in the document are prepared on WGS84 UTM Zone 36N geographic grid.
		1.3.3.		The distance between the drilling site and points of reference on the coast (Rosh Hacarmel, Hadera) and the perpendicular distance of the PRMP platform from the coast must also be noted.	Yes	1	1.3	Maps	Table 1-1 provides distances from each drillsite to the points of reference. Distance from the PRMP to the coast is stated in Section 1.3.
		1.3.4.		A general depth map must be presented at a scale of 1:250,000 of the deep sea off the coast of Israel, with the location of all of the components of the Application, including the drilling sites, existing and proposed maritime boundaries and areas, including marine reserves and Defense Regulation lines (the “Defense Regulations of 2005”), existing gas transmission / supply pipelines and shipping routes being noted on it.	Yes	1	1.3	Maps	A bathymetric map showing the required features is provided in Figure 1-3. The 1:250,000 scale version is provided in Appendix E.
		1.3.5.		A series of regional depth maps must be presented at a scale of 1:20,000, at a 2 km distance from each of the drilling sites, with the exposed rocky areas, the seabed, the type of ground (for instance: clay, silt, sand), fractures, channels, land-slides and above- and underwater infrastructures and facilities found in each region being noted on it. The differences between the depth contours on the maps shall be 5 meters and the mapping data shall be the most up-to-date in existence. If there is information at a distance of more than 2 km, it should be presented too.	Yes	1	1.4.2	Bathymetry and Seafloor Morphology	Bathymetric and seafloor feature maps for each of the initial wellsites is presented in Figures 1-7 through 1-14. Appendix E provides the 1:20,000 scale maps addressing the Guideline requirements

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.3.6.		Detailed depth maps of the Application area (blue line) are to be set out at a scale of 1:5,000 around each of the sites, and mark on them the exposed rocky areas, the seabed, the type of ground (for instance: clay, silt, sand), sensitive ecological systems (seaweed carpets, cold springs), and above- and underwater infrastructures and facilities existing in any area. The differences between the depth contours on the maps shall be 1 meter and the mapping data shall be updated to the last decade. The sedimentological characteristics of the seabed shall be based on a granulometric and mineralogical survey which faithfully represents the sediment in the area of the Application on the basis of the background survey, as set out in section 1.1.3.	Yes	1	1.4.2	Bathymetry and Seafloor Morphology	Bathymetric and seafloor feature maps for each of the initial wellsites is presented in Figures 1-7 through 1-14. Appendix E provides the 1:5,000 scale maps addressing the Guideline requirements.
		1.3.7.		Maritime transportation and infrastructure systems, electricity infrastructure and facilities, communications and energy lines, corridors, pipelines and terminals for various infrastructures (gas, petrol, hazardous materials, desalination, etc.) in the area of the Application must be set out on a maritime map at a scale of 1:100,000.	Yes	1	1.3	Maps	Figures 1-3, 1-4, and 1-38 address this requirement for the Application Area (i.e. Leviathan Field). Appendix E provides the 1:100,000 scale map addressing the Guideline requirements.
							1.11	Marine Transportation System and Infrastructure	
	1.4.		Geological, Seismic and Sedimentological Characteristics An exhaustive and detailed geo-hydrological description of the site, including:						
		1.4.1.		Describe, in words, the general geographical location of the production drilling sites, their proximity to seismically active areas and the rock foundations upon which they will be constructed.	Yes	1	1.4	Geological, Seismic, and Sedimentological Characteristics	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.4.2.		A general geological / geomorphological / bathymetric map must be set out at a scale of 1:250,000 of the sea off the coast of Israel, and mark thereupon the location of the production drilling sites. On this map, mark geological fractures, with an emphasis on fractures that are active or that are suspected of being active. Fractures described as being “suspected of being active” by the Israel Geological Institute or similar entities shall be deemed to be active unless it is proven that they are not active using the usual methods (conduct of research and geophysical cross-sections, and paleoseismological analysis). Likewise, mark locations of historical earthquakes of a magnitude of more than 2.5, areas liable to landslides and other geological and morphological phenomena which are notable.	Yes	1	1.4.2 1.4.5	Bathymetry and Seafloor Morphology Seismicity	Figure 1-16 shows historical earthquakes and fault zones (from USGS). Figures 1-7 through 1-14 show strike-slip faults and seafloor channels near the initial wellsites. Appendix E provides the 1:250,000 scale map addressing the Guideline requirements.
		1.4.3.		A series of regional geological / geomorphological / bathymetric maps at a scale of 1:20,000, of the seabed around all of the planned drilling sites must be prepared with geological fractures being marked upon them, with an emphasis on active (young) fractures or fractures suspected of being active, including the Or Yehuda Fracture and the average rate of their movement. Furthermore, the location of historical earthquakes of a magnitude of more than 2.5 must be marked, along with areas slated for landslides, instability, exposed rocky infrastructure on the surface of the seabed, and the age thereof, and other geological and morphological phenomena that need to be noted including transportation of sediment, previous sediment slides and activity, shallow gas springs, channels and depressions in the seabed. The distance at which the data from the planned production drilling sites will be presented shall be 2 km at least.	Yes	1	1.4.2 1.4.5	Bathymetry and Seafloor Morphology Seismicity	Figures 1-7 through 1-14 show maps of the seafloor around the initial wellsites, including active faults and seafloor channels. Appendix E provides the 1:20,000 scale version of these maps. There are no historical earthquakes with magnitude greater than 2.5 near the wellsites (see Figure 1-16), so these are not shown on the individual wellsite maps.
		1.4.4.		If there is an intention to discharge or dump drilling mud and cutting discharge into the sea, set out the area of dispersal of the muds and other cuttings on a geophysical survey conducted via side-scan sonar and underwater information, physical changes in the seabed due to the effects of anchoring and excavation, the build-up of waste, etc.	Yes	4	4.6.2	Impacts of Drilling Discharges	These requirements are addressed in the “impact” discussion in Chapter 4 and are not part of the baseline chapter.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.4.5.		Describe in detail the rock infrastructure at each of the production drilling sites. Set out detailed information that might clarify the characteristics of the land (for instance: the speed of shear stress waves, the depth to the bedrock, characteristics that affect non-linear conduct, etc.).	Yes	1	1.4.2 1.4.3	Bathymetry and Seafloor Morphology; Sub-seabed conditions	Section 1.4 describes the geological environment at the drillsites, but the "speed of shear stress waves" and "characteristics that affect non-linear conduct" are not discussed. Noble Energy does not consider this information necessary or relevant for the impact assessment.
		1.4.6.		The potential existence of active geological fractures or of fractures that are suspected of being active, and geological phenomena with a risk potential as set out in sections 1.4.2 and 1.4.3 within the area of the Application and its immediate environs must also be addressed.	Yes	1	1.4	1.4.5 Seismicity	
	1.5.		Hydrodynamic Regime						
		1.5.1.		The information regarding the various zones must be set out in accordance with the depth range in each zone.	Yes	1	1.5.3	Currents	
		1.5.2.		Describe the characteristic wave regime within the area of the Application. This description shall be based on wave characteristics measured in the south eastern Mediterranean in general, and off the coast of Israel over the last 20 years in particular.	Yes	1	1.5	Hydrodynamic Regime	Site-specific data from the Leviathan Field are summarized from July 2011 to April 2014. This was accepted by the MNIEWR in a letter dated December 8, 2015.
				Set out the statistical breakdown of wave characteristics within the timeframe of one year (significant and maximum height, direction, cycle time at the top of the spectrum, and average cycle time), and within a longer timeframe of 5, 10, 20, 50 and 100 years, statistics of storm durations for various maritime conditions.	Yes	1	1.5	Hydrodynamic Regime	A statistical breakdown is presented based on data from July 2011 to April 2014. The EIA also presents data on storm frequency from 1962 to 2001. This was accepted by the MNIEWR in a letter dated December 8, 2015.
		1.5.3.		Refer to the affect of waves in extreme storms and the possibility of the development of killer waves, including due to a seismic source, on the stability of the marine structures within the area of the Application.	Yes	1	1.4.5 1.5.2 4.11	Seismicity Extreme Storms Preparation for Earthquakes	Section 1.4.5 discusses tsunamis from seismic sources. Section 1.5.2 discusses the frequency of extreme storms; effects on the stability of marine structures are discussed in Section 4.11 (Preparation for Earthquakes).

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.5.4.		Describe the regime of the currents in the area of the Application, created due to the winds, and other oceanic variables (for instance: astronomic tides, Coriolis force, jet streams along the edge of the continental shelf, seasonal changes of seawater mass, temperature, salinity, etc.). This description shall be based on meteorological-oceanographic information collected since the mid-20th Century, in the Eastern Mediterranean in general and along the coast of Israel in particular.	Yes	1	1.5.3	Currents	Site-specific data from the Leviathan Field are summarized from January 2013 to April 2014. This was accepted by the MNIEWR in a letter dated December 8, 2015.
		1.5.5.		Set out the statistical division of the wind regime in the Eastern Mediterranean, including the annual frequency of wind directions, wind magnitude (including gusts), seasonal effects, and extreme winds. The minimum resolution shall be 22.5° for wind direction and 2 m/s for speed.	Yes	1	1.5.4	Winds	Data are presented from a marine atmospheric model that includes the annual and monthly frequency of wind speed and direction. The text addresses seasonal effects.
	1.6.		Nature and Ecology						
		1.6.1.		Set out the various habitats that exist in the body of water, and in the various seabed environments including hard and soft bed zones, sponge gardens, deep coral reefs, seaweed carpets, cold springs. A detailed description must be provided of fauna and flora societies in each of these habitats, including coverage percentages, and taxonomic information regarding the identity of species in the region. A map of the various habitats in the area of the Application must be included.	Yes				The baseline description focuses on the Leviathan Field, which is the Application Area for drilling and completion activities. There are no coral reefs, seaweed beds, or similar habitats. A habitat map and coverage percentages are not provided as the seafloor is exclusively soft bottom.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.6.2.		The species within the area of the Application and within the area of its impact (as described in section 1.2.2) must be described including micro and macro algae, seaweeds, seabed dwelling fauna, sedentary or territorial. In addition, describe the coastal natural monuments, as the case may be, situated within the area of the Application and within the area of its impact. The information regarding natural phenomena will be in reliance upon a detailed biological survey (as set out in the approved Background Monitoring Plan – section 1.1.3) which will be conducted within the area of the Application and impact, and on information, if such exists in this area, from prior surveys. The information included shall be set out in tables, maps, graphs, pictures, video, and shall be accompanied by a detailed verbal description of the findings and with lists of inventory, including scientific names based on taxonomic classification. Note the presence of rare, unique or delicate organisms.	Yes	1	1.6.1	Benthic Communities	A summary of benthic communities is presented based on the Background Monitoring Survey. The detailed survey report is provided in Appendix D. The baseline description focuses on the Leviathan Field, which is the Application Area for drilling and completion activities. There are no coral reefs, seaweed beds, or similar habitats.
		1.6.3.		The condition of marine mammals, sea turtles, permanent sea birds, migrating birds (based on seasons and hourly distribution), and species of pelagic fish located in the region of the planned infrastructure, must be presented in accordance with information from the most up-to-date professional literature and from field surveys and population sizes must be estimated.	Yes	1	1.6.2	Marine Mammals, Sea Turtles, Birds, and Fishes	A literature review is presented. In general, population sizes are not available for marine mammals, sea turtles, birds, and fishes.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
				Pursuant to the above sections, a detailed analysis must be conducted of the information including on the basis of the following issues:	Yes	1	1.6.1	Benthic Communities	
		1.6.4.		1.6.4.1. Identification of the creatures to a species level or to the most detailed taxonomical level possible. 1.6.4.2. Density of individuals. 1.6.4.3. Richness of species (in the various taxonomic groups). 1.6.4.4. Variety, the appropriate index must be chosen from the acceptable variety indexes such as: Shanon-Wiener, Simpson (2004), Magurran, and give reasons for the choice. 1.6.4.5. Fixed and mobile species. 1.6.4.6. "Target species": key species, species of commercial value, most common species (breeding season, egg-laying season, area in which drilling operations will be tolerable, heavy metals and organic contaminants in target species). 1.6.4.7. Classification of species based on origin: Mediterranean-Atlantic, species with broad geographical distribution, invasive species.	Yes	1	1.6.1	Benthic Communities	The specific information requested for benthic communities is presented in Section 1.6.2. Key species and their geographical origin and distribution are also noted for other faunal groups in Section 1.6.2 (Marine Mammals, Sea Turtles, Birds, and Fishes).
		1.6.5.		Fishing areas within the area of the Application must be set out. Set out trawler fishing routes, fishing (note the kind of fishing - rod fishing, etc.), and the quantities of fish collected over a monthly and annual cross-section. This data must be set out on a map at a scale of 1:50,000 and in a GIS layer.	Yes	1	1.6.3	Fishing Areas	There are no known fishing areas within the Application Area, and therefore a map is not provided. A regional description is presented.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	1.7.		Sea Water and Sediment Quality						
		1.7.1.		Set out the characteristics of the sea water and sediment quality within the area of impact, around each of the planned drillings and the zone planned for development of the field. The information regarding the quality of the seawater and sediment shall be based on a seawater and sediment quality survey (Section 1.1.3) conducted in the area of impact of the Application and on additional relevant information if any in this area, from the monitoring plan and previous surveys. The information included shall be set out in maps, graphs and shall be accompanied by a detailed verbal description of the findings.	Yes	1	1.7	Seawater and Sediment Quality	The EIA addresses this requirement, focusing on the planned locations of drilling and completion activities.
		1.7.2.		Set out the quantity of floating material in the water column, in a variety of marine climatic conditions (winds, waves, currents). The presentation of this data shall be based on sediment samples in accordance with Section 1.1.3 and on additional relevant information if such exists in this area. The turbidity of the water shall be measured at the surface, in the center of the water column and near to the seabed at each of the sites. Likewise, set out the climatic conditions at the time of taking the samples.	Yes	1	1.7.1.1	Hydrography	A summary of hydrography is presented based on the Background Monitoring Survey. The detailed survey report is provided in Appendix D.
		1.7.3.		Set out the levels of chlorophyll in the water column, within the area of the Application. Likewise, an assessment of the dispersion of chlorophyll must be conducted over the entire area of impact, using remote sensing methods.	Yes	1	1.7.1.1 1.7.1.2	Hydrography Seawater Quality	A summary of hydrography and seawater quality is presented based on the Background Monitoring Survey. The detailed survey report is provided in Appendix D.
		1.7.4.		Describe, in detail, the chemical characteristics of the water column (dissolved oxygen, pH, salinity, temperature, nutrients), within the area of the Application, around each of the sites.	Yes	1	1.7.1.1 1.7.1.2	Hydrography Seawater Quality	A summary of hydrography and seawater quality is presented based on the Background Monitoring Survey. The detailed survey report is provided in Appendix D.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		1.7.5.		Describe, in detail, the chemical characteristics of the sediment within the above area of the Application. The description shall focus on toxic substances, on chemical derivatives of heavy metals, TOC, PAH, SBF and their derivatives (including the results of decomposition), oxygen concentration in sediments. The sediment sampling system (the number of stations and their location) will be approved prior to performance as is set out in Section 1.1.3.	Yes	1	1.7.2	Sediment Quality	A summary of sediment quality is presented based on the Background Monitoring Survey. The detailed survey report is provided in Appendix D.
		1.7.6.		Likewise, describe the characteristics as set out in section 1.7.5 of the fauna on the hard bed (if any) and of the fauna on the soft bed and of the fauna within the bed (in filtering animal tissue such as clams, snails, worms, polychaetes and crabs and fishes). The extent of the sampling shall be approved in advance prior to performance, as set out in section 1.1.3.	Yes	1	1.6.2	Benthic Communities	A summary of benthic communities is presented based on the Background Monitoring Survey. The detailed survey report is provided in Appendix D.
	1.8.		Culture and heritage sites						
				The information regarding antiquities and cultural heritage sites shall be based on a detailed archeological survey or as a result of processing of a visual survey, a geo-hazard survey, a remote sensing survey (side sonar scanner, multi-beam, ROV movies, etc.) which shall be conducted within the area of the Application and on information that exists regarding the area from prior surveys. The sites known to the Antiquities Authority (both declared and as yet undeclared sites) and other sites containing information about archeological findings or sunken ships from must be included. The total raw data shall be presented on maps at a scale of 1:20,000, near to the planned drilling sites, and 1:100,000 at a depth of more than 1,000 m for the entire Field and shall be provided to the Marine Archeology Unit at the Antiquities Authority, and shall include the archeological sites, pictures, video and be accompanied by detailed verbal description of the findings in the area of the Application and in its immediate environs. The information presented in the Document shall be determined following consultation with the Antiquities Authority, Marine Archeology Unit. The approval of the Marine Archeology Unit at the Antiquities Authority shall be attached to the Document as an appendix.	Yes	1	1.8	Culture and Heritage Sites	An approval letter from the Antiquities Authority is provided as Appendix F. Based on consultation with the Marine Archeology Unit of the Antiquities Authority as required in the Guidelines, the location of specific sonar contacts (potential archaeological resources) is not shown and detailed descriptions of individual sites are not provided. Section 1.8 summarizes the findings of the archaeological assessment and provides a general map showing the region where sonar contacts were found. A 1:100,000 scale version of the map is included in Appendix E.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	1.9.		Meteorology and Air Quality						
		1.9.1.		Describe the existing meteorological conditions in the area of the Application and its environs.	Yes	1	1.9.1	Existing Meteorological Conditions	
		1.9.2.		Special meteorological conditions that might cause conditions of dispersal that will give rise to high air pollution concentrations in the environment must be noted.	Yes	1	1.9.1 1.9.2	Existing Meteorological Conditions Air Quality	There are no known special meteorological conditions affecting dispersal.
		1.9.3.		The status of the air quality in the area of the Application and in the onshore areas that will be affected by the planned activity must be described. Up-to-date monitoring data regarding the pollutants NOx, SO2 PM10 and other relevant pollutants must be addressed if relevant. The monitoring data will be from the past five years, and will be examined on the basis of the environment and target values (Air Quality Value Regulations, 2011) and if there is no target value, on the basis of the reference value. The availability of the data will not be less than 95% over a period of five years.	Yes	1	1.9.2	Air Quality	Site-specific monitoring data do not exist for the Application Area; a regional description is provided. This change was approved by the MNIEWR.
	1.10.		Noise						
		1.10.1.		Set out the magnitude of the sub-marine noise at a number of representative points near to each of the components of the Application (as set out in section 1.6).	Yes	1	1.10	Noise	Site-specific data are not available on underwater noise from "representative points near to each of the components of the Application." A general description is presented based on available data. This change was accepted by the MNIEWR in a letter dated December 8, 2015.
	1.11.		Marine Transportation System and Infrastructure						
				On the basis of section 1.3.7, describe, in words, the marine transportation and infrastructure system in the chosen area of the Application (the Leviathan Field). Set out the current operations of the system: Traffic volumes, entry and exit directions of vessels in accordance with the various classes of vessel, fuel containers, fishing boats, maritime farming service boats, yachts, tugboats and small operations vessels, etc.	Yes	1	1.11	Marine Transportation System and Infrastructure	There are no shipping lanes within the Application Area; therefore, a discussion of traffic volumes etc. is not presented. Existing infrastructure is limited to telecommunications cables and existing wellsites. A map of the existing infrastructure is presented.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
B	2		Reasons for Preference of the Location of the Proposed Plan and Possible Alternatives						
	2.1.		General	This Chapter must contain all of the reasons for choosing the proposed sites in the Application for production drilling. In addition, please refer to geological and seismic, environmental, planning, engineering and economic aspects, such as proximity to existing and planned infrastructure, exploitation of additional natural resources, impact on natural monuments, air quality, noise, etc. Data from drilling operations and development plans effected in the past near to the area of the Application, if any, must also be addressed.	Yes	2	2.2	Well Location Alternatives	
	2.2.		Location Alternatives	Give details of and explain the various reasons that led to the determination of the proposed site of the exploratory drilling as set out in section 2.1. Set out the location alternatives examined, the preferred alternative and the reasons that gave rise to the choice of it. -For each location alternative, the following criteria at least will be examined: Structural analysis issues, the size of the field and the location of the target stratum; landslides and liquefaction; marine reserves; regions defined as special regions such as ridges, canyons or deep coral reefs, sponges, clams or other sedentary organisms; habitats of animals in danger of extinction; shipping lanes; infrastructure, communications and energy lines; current regime; fish reproduction zones and times; fishing lanes and zones.	Yes	2	2.2	Well Location Alternatives	All of the specific criteria are addressed. Table 2-2 summarizes the role of the criteria in selecting drillsite locations.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	2.2.	2.2.1.	Technological Alternatives	Set out the various technological alternatives examined and the various considerations that gave rise to the decision to use the technology set out in the Application, including the drilling technology (including vertical, angular, horizontal); the type of platform; BOP; drilling mud and liquids – composition, treatment, cutting discharge and drilling mud disposal targets. If use is planned to be made of mineral / oil based drilling mud, set out the criteria and limitations for use of one kind as opposed to another. Including reference to relevant regulations from around the world. Furthermore, set out alternatives to the method of treatment and discharge into the sea of the various fluids. In summary of this Chapter, the alternatives shall be set out in a comparison table, with each topic under examination being ranked, according to weight, together with the professional reasons for selecting it. An example of a criteria table is attached in Appendix B2 on the website of the Ministry of National Infrastructure, Energy and Water.	Yes	2	2.3 2.4	Technological Alternatives Summary	All of the specific criteria are addressed. Table 2-3 summarizes the evaluation of location and technological alternatives.
C			Description of Actions Stemming from Performance of the Application						
	3.1.		General	This Chapter shall set out the drilling plan in accordance with the various planned stages of work and development, including production drillings, production testing, completion of production drilling, construction, running and operation. The distance between the production drillings must be noted. The Application must be presented on simulation photographs, on a bathymetric map, noting the distances between the various drillings (both existing and planned) on the Application, as well as points of reference on the coast. The various sea- and aircraft, their characteristics and the activities that they will perform must also be set out. The description in the Application must relate to all of the work that is done, to the installation and set-up of the infrastructure set out above, the production tests, acceptance tests, and to abandonment, dismantling and rehabilitation. The various stages must be set out on a Gantt work plan including milestones and timetables. All of the items of the Application must be set out as examined in Chapter D, and must include subjects, findings or other influences discovered during the course of preparation of the Document.	Yes	3	3.2	Description of the Application	This EIA is limited to drilling and completion activities. The operation of the wells and set up of the production infrastructure will be discussed in the Field Development EIA. Because no subsea infrastructure is included in this EIA, simulation photographs are not presented. This general approach was approved by the MNIEWR in a letter dated December 8, 2015

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	3.2.		Description of the Application						
				All of the facilities, including the infrastructure used by and adjacent to such facilities must be described, as well as the actions involved in setting them up and the auxiliary impacts. The forecast need for future facilities, including compressors, power sources, and maintenance and service vessels must also be described.	Yes	3	3.2.2 3.2.3	Drilling Rigs and Strategy Support Vessels and Helicopters	This EIA is limited to drilling and completion activities and does not include any subsea infrastructure. Facilities and infrastructure for production are analyzed in the Field Development EIA. This general approach was approved by the MNIEWR in a letter dated December 8, 2015
		3.2.1.1		The purpose of the development drillings and the type of drilling (natural gas or oil; salvage) must be described.	Yes	3	3.1	General	
		3.2.1.2.		Describe the drilling platform including the type of platform, the name of the platform, title, when it was manufactured, dates of upgrade, previous areas of operation, location of last anchorage (port) prior to reaching the development site, whether the platform has operated within the economic waters of the State of Israel before, and if so where and when, must also be set out. The actions required for approval of the arrival of the platform must be set out with an emphasis on the prevention of invasive species. Set out how the platform will arrive at the drilling site. Set out the platform's fleet specifications. Set out whether more than one drilling platform will operate during each of the stages of development of the field, including the drilling completion stage. If, during the stage of preparation of the Document, there is no information about a particular platform, the type of platform and its principal characteristics must be set out.	Yes	3	3.2.2	Drilling Rigs and Strategies	Specific drilling rigs have not been selected. However, the type of drilling rigs and Noble Energy's specifications are presented.
		3.2.1.3.		The water depth must be set out at each of the drilling sites together with the depth of drilling below the seabed (below mud line - BML).	Yes	3	3.2.1	General	
		3.2.1.4.		The sea- and aircraft involved in the development drillings, production tests and completion thereof must be set out.	Yes	3	3.2.2 3.2.3	Drilling Rigs and Strategy Support Vessels and Helicopters	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		3.2.2.	Description of Drilling Process						
		3.2.2.1.		Describe, in brief, all of the drilling processes and phases including the actions and materials relating all drilling activities. The main operations, depth of drilling under the seabed (BML), under the surface of the water (BWD) and under the platform must be set out in a table for each drilling segment. Set out whether the drilling process in all drillings is identical. If not, then the drilling process as aforesaid must be set out and presented.	Yes	3	3.2.4	Drilling Schedule	
		3.2.2.2.		Attach a schematic sketch showing the depth of the drilling as a function of time, including appropriate reference to the stages of the drilling and drilling data.	Yes	3	3.2.4	Drilling Schedule	
		3.2.2.3.		The various stages of development, including the future development of the Field, the number of drillings planned for each stage, the total number of drillings in the Field and an assessment of the timetable for performance of the various stages of development must be set out.	Yes	3	3.1	General	
		3.2.2.4.		Set out a Gantt Chart setting out the drilling activities done in series and in parallel.	Yes	3	3.2.4	Drilling Schedule	
		3.2.2.5.		Prevention of Oil Blowout - Describe the blowout preventer (BOP) that has proven efficacy and that is designed to prevent oil, gas and/or liquids under the surface such as produced water, saline water from blowing out of the bore into the marine environment. Explain and describe the continuous pressure controls. Set out the standard for periodic testing of all of the means of prevention of blowout or fault. Describe the measures and the alternatives for the BOP that will be available for the purpose of development of the field in the event of a fault in the BOP.	Yes	3	3.2.5	Blowout Preventer	
		3.2.2.6.		Protective pipeline and concretization	Yes	3	3.2.6	Protective Casing and Cementing	
				3.2.2.6.1 In accordance with the drilling plan, describe the protective pipeline from the seabed to the target strata	Yes	3	3.2.6	Protective Casing and Cementing	
				3.2.2.6.2 Describe the concretization of the casement pipelines in the drillings, in order to prevent possible leaks and the transition of liquids from the bore into the seawater.	Yes	3	3.2.6	Protective Casing and Cementing	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
				3.2.2.6.3. Describe the method of construction and concretizing of the bores with reference to the timeframes of the principal stages in drilling the bores.	Yes	3	3.2.6	Protective Casing and Cementing	
				3.2.2.6.4. Describe the composition of bore concretization materials.	Yes	3	3.2.6	Protective Casing and Cementing	
				3.2.2.6.5 Set out the manner in which the quality of concretization is ensured during drilling, the method of testing such and the standard used for testing.	Yes	3	3.2.6	Protective Casing and Cementing	
		3.2.2.7.		Testing of drilling pipelines – Describe the method for testing the drilling pipeline and its accessories, the reports and the references required for ensuring that drilling and protection pipelines are in order and the method of testing such, with all of the components thereof.	Yes	3	3.2.6.2	Testing of the Casing	
		3.2.2.8.		Production Tests	Yes	3	3.3	Production Tests	
				3.2.2.8.1 Describe the planned production test method, the phases thereof, the order of activities, the equipment and the possible methods thereof, and set out the reasons for such. Set out the various indexes that will be examined such as maximum production of all production components (gas, oil, water, condensate), pressure, gas composition including H_2S, CO2, etc.	Yes	3	3.3	Production Tests	
				3.2.2.8.2. In cases where use of chemical substances is planned in the production tests, the commercial names of such substances, their quantity, concentration, chemical composition and function including chemical formula, CAS (Chemical Abstract System) Number, and MSDS (Material Safety Data Sheet) and include them in the chemical table in section 3.5.	Yes	3	3.3.2	Chemical Substances	A tabulated list of chemicals is provided in Appendix H along with Safety Data Sheets.
				3.2.2.8.3 Set out whether, during the production testing stage, there is a possibility of a presence of H_2S in the reservoir, during which stages of the Application H_2S might appear and the methods of operation and treatment in the event that H_2S does appear.	Yes	3	3.3.3 5.2.1.10	Hydrogen Sulfide Hydrogen Sulfide Contingency Plan	H_2S is not expected. Noble Energy has developed an H_2S Contingency Plan.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	3.3.		Noise Hazards						
				Set out details of the mechanical equipment and the noise levels from the dominant sources characteristic of each form of technology. Set out details of the duration of the drilling, the hours of work each day, the number of sea vessels that will operate at the same time, throughout the hours of the day, and the aircraft involved in the work. Set out details of the frequency and magnitude of the noise that will be generated during the course of work at various distances from the source of the noise.	Yes	3	3.4	Noise Hazards	Specific drilling rigs have not been selected; representative data are provided for a modeled sound source spectrum for a DP drillship. Details of "the frequency and magnitude of noise that will be generated… at various distances from the source" will depend on the specific equipment selected. Representative data on noise sources is presented in sufficient detail to evaluate impacts. This approach was approved by the MNIEWR in a letter dated December 8, 2015.
	3.4.		Air Quality						
		3.4.1.		Describe the sources of emissions of contaminants into the air from the planned operations during the drilling and production testing stages, including: Energy facilities, flare / vents, unfocused emissions and other sources.	Yes	3	3.5	Air Quality	
		3.4.2.		For all sources of emissions presented, set out the regime for the activation, the type of fuel, the contaminants emitted and other data necessary for evaluating emission rates. The rates of emissions of contaminants shall be estimated on the basis of manufacturer's data, measurements or calculations on the basis of EPA-AP42 methodologies or on the basis of other methodologies upon prior approval. Address the pollutants SO2, NOx, PM10, VOC and methane at least. Air pollutant emissions files and the method of calculation / assessment thereof shall be set out in a table in accordance with sources of emissions during the various stages of operation – drilling and production tests, as well as faults during various stages (including during emergency shutdown).	Yes	3	3.5	Air Quality	The emissions data are presented as required. However, emissions during emergency shutdown are not addressed as this applies to production operations, which are not included this EIA.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		3.4.3.		Faults that might give rise to increase emissions of air contaminants into the environment, the emission of additional contaminants such as H_2S or the generation of odor hazards (at sea and on land) must be addressed.	Yes	3 4	3.5 4.8.2	Air Quality Impacts of Accidental Spills	A fuel spill and condensate spill are addressed in Chapter 4 as sources of additional emissions during upset conditions. H_2S is not expected, but Noble Energy has developed an H_2S Contingency Plan.
	3.5.		Hazardous Materials						
				Describe and set out all of the hazardous materials planned to be used, including drilling, drilling completion and production testing liquids. The following details must be noted for each material: Chemical composition, commercial name, CAS identification number, UN number and MSDS - Material Safety Data Sheet, the quantity, purpose of use and method of use of them, their location on the platform (together with a chart), the storage and collection of them, the method of treatment and disposal of them. The data must be set out in a table of chemicals.	Yes	3	3.6	Hazardous Materials	Chemicals to be used during drilling and completion are tabulated in Section 3.7.2, including quantities and purpose of use. A table listing all chemicals is provided in Appendix H along with Safety Data Sheets. Specific details of storage and use locations will depend on the specific drilling rig selected.
	3.6.		Sources of Discharge into the Sea						
		General – This Chapter shall set out the sources of discharge into the sea in the context of production drilling, production tests and completion drilling. Approval of the Document shall not constitute a substitute for the approval of the Committee for Grant of Permits for Discharge into the Sea for each of the sources of discharge. The information shall be set out in full for each stage.			Yes	3	3.7	Discharges	Section 3.7 as a whole addresses this requirement through completion of completion drilling and testing.
		3.6.1.	Development of the Field – Production Drilling	3.6.1.1. Describe all of the sources of discharge into the sea, and describe, for each source, the processes that give rise to the discharge and a flowchart of the process. The flows that must be presented include: Drilling mud (discharge into the sea depends on the type of drilling mud chosen), cutting discharge, cooling water, desalination concentrate water, organic kitchen waste (at a distance of more than 12 nautical miles from the shore, at a distance of fewer than 12 nautical miles, this must be removed to the shore), sanitary effluent / waste ("black water"), washing water ("gray water"), rinses from the oil separation facility, cement surpluses, bilge water (if any).	Yes	3	3.7	Discharges	Discharge processes and flowcharts will depend on the specific drilling rigs selected. The *Atwood Advantage* is used as a representative example. This was accepted by the MNIEWR in a letter dated December 8, 2015.
			The following information will be given for each source of discharge into the sea. For drilling mud and cutting discharge – see also the specific instructions in section 3.6.1.12.						

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		3.6.1.2.		Describe the processes that create the flow together with a drawing of the processes.	Yes	3	3.7	Discharges	
		3.6.1.3.		Describe the treatment processes, if any, including physical data of stocking units, engineering and operational data for each treatment facility (the area of the facility, the volume of each unit, capacity, duration of presence, etc.); means of monitoring and control of each process / treatment; attach a schematic drawing for each treatment facility.	Yes	3	3.7	Discharges	The details of treatment processes, including schematic diagrams, will depend on the specific drilling rigs selected and therefore details are not presented. This was accepted by the MNIEWR in a letter dated December 8, 2015.
		3.6.1.4.		Set out the list of additives in each production and treatment process, the quantity of each additive, its function and the method of addition of it; attach information sheets (MSDS) for each additive, with an emphasis on ecological information for the marine environment, and possible impacts on fish farming and wild fish. See also reference later on in section 3.6.1.3.5 (Additives).	Yes	3	3.7.2	Drilling and Completion Discharges	Additives used during drilling and completion are tabulated. Safety Data Sheets are presented in Appendix H.
		3.6.1.5.		Times of Discharge: Describe the flow times including whether the flow is continuous or interrupted, fixed or variable (hourly / daily / other), and what the conditions and/or processes are that determine the quantity and/or times of flow.	Yes	3	3.7	Discharges	
		3.6.1.6.		Method of Discharge: Describe the method of discharge into the sea of each and every source and whether the discharge is effected separately / separate source or together with other discharges. In describing the source, set out the physical characteristics of the source / source pipe and the depth of the source with respect to the surface of the water / the seabed.	Yes	3	3.7	Discharges	
		3.6.1.7.		Quantities: Set out the quantities of each source, set out the information in accordance with maximum hourly, maximum daily, maximum monthly and total quantity during the course of the drilling. Set out the method of controlling quantities / amounts pumped into the sea (wharf based capacity meters, water meters, other - give details). In the event that there are no capacity meters, check and set out what is required in order to install capacity meters, including storing the pumping data on a data logger. Quantity data shall be presented in cubic meters.	Yes	3	3.7	Discharges	Estimated discharge rates and quantities are presented based on data from drilling the Leviathan-4 well. No capacity meters are needed to control discharge rates; all discharge quantities are monitored and reported in accordance with permit requirements.
		3.6.1.8.		With respect to the discharge of sanitary waste ("black water") and shower / washing / laundry water ("gray water"), set out the quantity in cubic meters / day / person, for each separate source.	Yes	3	3.7	Discharges	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		3.6.1.9.		Bilge water – set out whether the platform contains a facility for the collection of bilge water, the method of collection thereof and the method of removal to an onshore facility. Attach an IOPPC (International Oil Pollution Prevention Certificate) in accordance with Annex 1 to MARPOL.	Yes	3	3.7.3	Other Routine Discharges	No bilge water discharges are planned. The drilling rigs will be equipped with an oil/water separator that complies with MARPOL Annex I requirements. An IOPPC cannot be provided at this time because the drilling rigs have not been selected. This was accepted by the MNIEWR in a letter dated December 8, 2015.
		3.6.1.10.		Quality: Describe the composition of each source. Set out the information on the basis of data from similar facilities, including the conduct of laboratory tests. This information shall include contaminant concentration data, and total contaminant load discharged into the sea (in tons) including the provisions set out in section 3.6.1.15 (Qualities) Note, for each source of pumping, the source of the information regarding the composition of it. Set out the nature and frequency of the various tests that must be conducted on the platform and the standards whereby the tests must be performed.	Yes	3	3.7.2 3.7.2.5 3.7.3	Drilling and Completion Discharges Drilling Mud Testing Other Routine Discharges	Data from the Tamar Field are presented and are considered representative.
		3.6.1.11.		Give details as to whether there are land-based alternatives for each pumping source. If not, give reasons and details regarding the way in which this subject was checked.	Yes	3	3.7.5	Alternatives to Onsite Discharge	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		3.6.1.12.		Cuttings discharge, drilling mud and left-over cement (drilling mud relates to any addition of liquids and materials used for drilling purposes). Cuttings: *3.6.1.12.1.* Quantities: Set out the quantity (tons) and volume (cubic meters) of cutting discharge generated and/or discharged into the sea (depending on the type of drilling mud) as follows: In each of the drilling segments, by drilling diameter; in the stage in which the drilling takes place without recycling and the cutting discharge is placed around the wellhead directly on the seabed; in the drilling stage which is done with recycling, when the cutting discharge is brought up to the platform with the drilling mud; total quantity of cutting discharge discharged into the sea.	Yes	3	3.7.2	Drilling and Completion Discharges	
				3.6.1.12.2. Treatment and removal of cutting discharge – describe the method of treatment and removal of cutting discharge.	Yes	3	3.7.2	Drilling and Completion Discharges	
				3.6.1.12.3. If the cutting discharge removal destination is at sea, describe the piling up of cutting discharge and drilling mud on the seabed and estimate the radius and area affected by this process. Also, set out the threshold requirements and the quality criteria for the cutting discharge prior to discharge into the sea, and set out the method of monitoring and control for compliance with such criteria, including the method, frequency and nature of sampling. In the event that the removal destination for the cutting is onshore, the method of collection of the cutting, and the method of transportation and removal of it onshore must also be described.	Yes	3 4	3.7.2 4.6.2	Drilling and Completion Discharges Impacts of Drilling Discharges	The radius and area affected by cuttings discharges is addressed in Chapter 4 (Impacts) not Chapter 3. The analytical method for ensuring <1% MOBM retention on cuttings has not been specified, but two examples are given (method from USEPA general permit and GC method ISO 16703).
		3.6.1.13.		Cement / drilling fluids and muds when the drilling mud is placed near to the drilling bore on the seabed, and for the stage of drilling done when the recycled drilling mud is brought back up to the platform with the cutting discharge and total quantities of the drilling mud discharged into the sea.	Yes	3	3.7.2	Drilling and Completion Discharges	
				3.6.1.13.1 Quantities of drilling mud – set out the total quantity and volume of drilling mud (cubic meters and tons), for the stage of the drilling without recycling.	Yes	3	3.7.2	Drilling and Completion Discharges	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
				3.6.1.13.2 Set out the composition of drilling mud in a table, including: The name of the material, the function of each material, the quantity of each material in each segment of drilling and the total quantity of materials in each segment of the drilling, totals of all materials in each segment of the drilling and total quantities of all materials in the entire drilling process. This data shall be presented in cubic meters, transition units (SG) and tons. Note which of the drilling stages the discharge into the sea takes place in, what quantity is being discharged at each stage, and the total. This data shall be presented in cubic meters and tons. (the data must be attached in an Excel file as well).	Yes	3	3.7.2	Drilling and Completion Discharges	Excel spreadsheets will be provided separately to the MNIEWR (not part of EIA)
				3.6.1.13.3 Describe the way in which the various substances are added to the water and to other drilling liquids (creating the drilling mud). In reliance upon the above, please also refer to the quantities of water / other drilling fluid that are added during the course of drilling, due to losses of water / fluids / drilling mud back into the rock strata.	Yes	3	3.7.2	Drilling and Completion Discharges	
				3.6.1.13.4 For each component and material, information sheets (MSDS) must be presented, including ecological information regarding the marine environment (toxicity, biodegradability, bioaccumulation) and concentrations of each component that might be pumped into the sea.	Yes	3	3.7.2	Drilling and Completion Discharges	
				3.6.1.13.5 Chemicals / additives: Set out in a concentrated table data on chemicals, based on source of use (drilling mud, cement, etc.), based on information sheets, including: the name of the chemical, its CAS number, the composition of the chemical (in the event of a compound, set out each substance and composition, and the percentage of it in the compound), ecological information including the results of toxicity tests, biodegradability, bioaccumulation and the level of its impact / toxicity on the marine environment. Wherever there is no information, write "no information"; and note the level of environmental risk according to OSPAR / the Norwegian Method (green, yellow, red, black).	Yes	3	3.7.2	Drilling and Completion Discharges	Chemicals and additives to be used during drilling and completion are listed in Section 3.7.2. A table listing all of the required information will be provided in Appendix H along with Safety Data Sheets.
				3.6.1.13.6 Describe the method and frequency of the various tests conducted in mud and drilling liquids, including materials	Yes	3	3.7.2.5	Drilling Mud Testing	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
				pumped into the drilling mud preparation system and the standards under which the tests are conducted.					
				3.6.1.13.7 Biological toxicity test – set out the tests conducted for testing biological toxicity in drilling mud / surpluses from the treatment facility pumped into the sea and set out where such tests are performed and the source of the data; examine and present the extent to which the existing toxicity tests accord with the deep sea conditions in the Eastern Mediterranean Deep Sea Basin. Attach an expert opinion regarding the extent to which the tests comply, and his recommendations regarding the conducting of compatibility tests for the deep sea conditions in our region.	Yes	3	3.7.2.5	Drilling Mud Testing	Toxicity tests are proposed as required. An expert opinion evaluating the applicability of the toxicity tests to the deep sea conditions in the region is attached as Appendix L.
				3.6.1.13.8 Treatment of drilling mud: describe the areas and methods of organization and the facility for the treatment of drilling mud, separation of the cutting discharge from it, testing the composition of it and details of the additives planned for the treatment facility, including the list of additives, the function of each substance, the method of placement of it, etc. Losses of drilling mud must be addressed, and estimates given as to the percentage lost, quantities (in tons) and volume (in cubic meters).	Yes	3	3.7.2	Drilling and Completion Discharges	
				3.6.1.13.9 Attach sketches, including notation of physical data of units of production / processes / treatment and return of drilling mud, including work areas, volumes of treatment facilities, durations, etc.	Yes	3	3.7.2	Drilling and Completion Discharges	A general description of the drilling process is presented. However, sketches of equipment are not included as these will depend on the specific drilling rigs selected. This was accepted by the MNIEWR in a letter dated December 8, 2015.
				3.6.1.13.10 Describe the stages of drilling in which use is made of cement, and the processes in respect of which left-over cement is discharged into the sea.	Yes	3	3.7.2	Drilling and Completion Discharges	
		3.6.1.14.		Cement quantities: Set out the total quantity of cement in each of the stages of drilling and the total quantity in use (tons). Estimate and set out the quantities of cement that are to be discharged into the sea.	Yes	3	3.7.2	Drilling and Completion Discharges	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		3.6.1.15.		Information on quality of discharges into the sea: The information on the quality of discharges into the sea shall include data on chemical composition as follows: The information will be based on tests from similar facilities and processes from the past five years, subject to details of the source of the information and presentation thereof.	Yes	3	3.7.2.6 3.7.3.3	Analytical Test Results for Drilling Mud and Cuttings Quality of Other Routine Discharges	Data presented from the Tamar Field are considered representative.
				3.6.1.15.1 The information for pumping originating in the drilling mud will include the chemical composition of the liquid, including: An extended metal scan (ICP, mercury in AA); GCMS scan for organic materials with probability percentages, half-quantity concentrations and summary; detailed VOC scan (head space) with probability percentages, including half-quantity concentrations and summary; TOC; TSS; BOD; mineral oil (FTIR); PAH; turbidity; free chlorine; phenol; cresol; pH; AOX; DOX; species of nitrogen (nitrate - NO3; nitrite - NO2; ammoniac nitrogen NH4-N; Kjeldahl nitrogen TKN; total nitrogen - calculated); phosphorus - P; sulfide; TDS; chlorides; the information shall be presented as concentration (mg/L) and as load (weight per unit of time).	Yes	3	3.7.2.6	Analytical Test Results for Drilling Mud and Cuttings	Data presented from the Tamar Field are considered representative.
				3.6.1.15.2 The information on discharges originating in drilling mud shall include the composition of the metals: Ag, As, Cd, Cu, Cr, Hg, Ni, Pb, Zn; organic matter (TOC); radioactive materials Pb-210, Th-228, Ra-226, Ra-228.	Yes	3	3.7.2.6	Analytical Test Results for Drilling Mud and Cuttings	Data presented from the Tamar Field are considered representative.
				3.6.1.15.3 Information on use of barite: Note the source of the barite (the country of manufacture) and attach the results of tests for metal content in barite (raw material) as follows: Cd and Hg content (AA, at a sensitivity of at least 0.1 mg / kg at least) and the content of Ag, As, Cu, Cr, Ni, Pb, Zn.	Yes	3	3.7.2.6	Analytical Test Results for Drilling Mud and Cuttings	The source of barite varies and cannot be specified in advance. This information can be provided to the MNIEWR in post-drilling monitoring reports. Data from the Tamar Field are presented and considered representative.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
				3.6.1.15.4 The information for discharges from the wash treatment facility will include the chemical composition of the liquid, including: An extended metal scan (ICP, mercury in AA); GCMS scan for organic materials with probability percentages, half-quantity concentrations and summary; detailed VOC scan (head space) with probability percentages, including half-quantity concentrations and summary; TOC; TSS; BOD; DOC; turbidity; phenol; cresol; pH; AOX; DOX; mineral oil (FTIR / GC-MS / GC-FID); general oil (FTIR / GC-MS / GC-FID); forms of nitrogen (nitrate - NO3; nitrite - NO2; ammoniac nitrogen NH4-N; Kjeldahl nitrogen TKN; total nitrogen - calculated); phosphorus - P; sulfide; TDS; chlorides; the information shall be presented as concentration (mg/L) and as load (weight per unit of time).	Yes	3.7	3.7.3.3	Quality of Other Routine Discharges	Data presented from the Tamar Field are considered representative.
				3.6.1.15.5 The information for discharges from sanitary effluent treatment facility will include the chemical composition of the water, including: BOD; TSS; TOC; turbidity, free chlorine, oils and lipids (FTIR), mineral oil (FTIR), forms of nitrogen; sulphide; detergents (MBAS); pH; fecal coli per 100 mL, fecal enterococci per 100 mL, extended survey of metals (ICP), TDS; the information shall be presented as concentrate (ML) and load (mass per unit of time - mass / month or mass / year).	Yes	3	3.7.3.3	Quality of Other Routine Discharges	Data presented from the Tamar Field are considered representative.
				3.6.1.15.6 Describe the measures and structure of the platform for the purpose of separating clean upper water, in the event of rain, from oily lower water intended for treatment prior to release into the sea or removal to land.	Yes	3	3.7.3	Other Routine Discharges	
	3.7.		Waste						
				Describe the quantity of the waste expected to be created, including kitchen waste, dry waste, other waste created as a result of the drilling process, development and production of the field, except for waste set out in the section regarding sources of discharge into the sea as set out in section 3.6 above	Yes	3	3.8	Waste	The EIA is limited to drilling and completion activities. Wastes created during production will be addressed in the Leviathan Field Development EIA. This general approach was approved by the MNIEWR in a letter dated December 8, 2015

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	3.8.		Closure/Abandonment of the Field and Dismantling of the Infrastructure						
				Describe the details of the actions required at the time of termination of production in individual drillings and in the entire field, and the order of performance thereof, including temporary abandonment or permanent abandonment.	Yes	3	3.9	Well Closure (Temporary Abandonment)	The EIA is limited drilling and completion activities and includes only the temporary abandonment of the wells prior to completion. Abandonment of the field and dismantling of the infrastructure will be addressed in the Leviathan Field Development EIA. This general approach was approved by the MNIEWR in a letter dated December 8, 2015
		3.8.1.		Describe the measures for closing the wellhead, the target strata, and other conducting strata, abandonment and restoration of the previous condition.	Yes	3	3.9	Well Closure (Temporary Abandonment)	
		3.8.2.		Note the standard under which the closure methods of the well heads are installed.	Yes	3	3.9	Well Closure (Temporary Abandonment)	Temporary abandonment will be conducted in accordance with MNIEWR guidelines for "Abandonment of Offshore Oil and Gas Wells" which are based on sections 30 CFR§250.1710-1722 and 250.1740-1742 of the U.S. regulations and on the API BULL E3 standard.
		3.8.3.		Set out the list of chemicals planned for use in closing the well and include these in the table of chemicals in section 3.5 together with information sheets.	Yes	3	3.7.2	Drilling and Completion Discharges	The chemicals to be used in well completions are reference in Section 3.7.2; a table of chemicals is provided in Appendix H.
		3.8.4.		Attach a schematic drawing of a cross-section of the drilling prior to closure of the drilling and after closure (temporary / permanent).	Yes	3	3.9	Well Closure (Temporary Abandonment)	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
D			Evaluation of the Environmental Impacts expected to develop due to Performance of the Application and the Measures to be taken to Prevent / Minimize such						
				In this Chapter, the various topics expected to have an environmental impact shall be set out graphically and verbally, including impact on moving or stationary species within the areas of the Application and its close and remote environs, in accordance with the provisions of section 1.2.2. This description of the environmental impacts and the sources thereof shall be qualitative and quantitative, and shall refer to all of the actions and impacts set out in Chapter C. The variety of activities expected to take place at the production drilling sites in the Leviathan Field, the production tests, completion thereof, and abandonment of the bores. With respect to each subject, an explanation shall be given as to whether it is necessary to prevent or reduce the negative environmental impacts and what means must be employed in order to prevent or reduce such, if any. In the event that during the course of preparation of the Application, influences or other findings are found that are not mentioned in this document, these must be addressed and means must be proposed for reducing the impact in the document.	Yes	4	--	Evaluation of Environmental Impacts	Chapter 4 as a whole addresses these requirements. Table 4-1 provides a matrix showing the activities to be conducted, the potential impacts, and the sections in which they are addressed.
				An environmental management plan must be set out, detailing the means for reduction of the hazards for those actions that give rise to environmental impacts that are considered to be undesirable or unacceptable (unacceptable impacts must be prevented permanently or reduced to acceptable levels), and a complete response will be given for the fact that development of the field will not cause unnecessary environmental harm.	Yes	5	--		Chapter 5, the Oil Spill Contingency Plan, Emergency Response Plan, H_2S Contingency Plan, and bridging (interface) documents will constitute Noble Energy's environmental management plan (EMP). A separate EMP document is not provided.
	4.1.		Assessment of Potential Impact on the Marine Environment of the Production Drillings						
		4.1.1.		Assess the maximum scope of the impact of the drilling rig, including anchors, on the seawater, the seabed, and the coast, as the case may be, and set out the basis for the information and the method of effecting the assessment.	Yes	4	4.6.1	Evaluation of Environmental Impacts	Because DP drilling rigs will be used, there will be no anchoring. Seafloor disturbance is discussed in Section 4.6.1

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		4.1.2.		In the event that the discharge target for the cutting discharge and drilling mud is at sea, assess the extent of impact on the environment in accordance with an evaluation of the radius and the area affected by the process, as set out in section 3.2.2 and set out the tests, actions and frequency thereof in order to minimize harm to the marine environment.	Yes	4	4.6.2	Impacts of Drilling Discharges	
		4.1.3.		In the event of proximity to natural monuments identified in accordance with section 1.6, existing or proposed nature reserves, culture and heritage sites as set out in section 1.8, the methods of action and the operations that must be taken in order to remove the cuttings and drilling mud to an alternative offshore and/or onshore site must be examined.	Yes	4	4.6.2	Impacts of Drilling Discharges	No reefs or hard bottom areas have been identified in the Leviathan Field, and there are no existing or proposed nature reserves. Archaeological sites in the field are not near the drillsites and are not expected to be affected. Therefore, alternative offshore or onshore disposal sites were not evaluated.
		4.1.4.		Examine and present the possibility of reducing and minimizing the placement of discharge and drilling mud directly onto the seabed during the course of drilling from the drilling segment prior to installation of the riser, such as by using an RMR SYSTEM.	Yes	2	2.3.3.3	Riserless Mud Recovery System	The potential use of a riserless mud recovery system was evaluated under Alternatives in Section 2.3.3.3.
		4.1.5.		Assess the maximum scope of the impact of the drilling liquids at the time of effecting the production tests on the seawater in the area of the Application.	Yes	4	4.6.2	Impacts of Drilling Discharges	

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		4.1.6.		Simulation (a digital three-dimensional hydrodynamic contaminant dispersion model) for drilling mud of the dispersion zone of the drilling mud and other mining liquids – each case must be considered on its merits on the basis of environmental data and location relative to the coast, the quantity of mud and discharge and the duration of time of the drilling or discharge into the sea. This matter will be coordinated and approved in advance and in writing. If simulation is required, the model must be approved and is to be presented in a preliminary document which shall contain a description of the type of model, calibration characteristics, commencement conditions, language conditions, the grid of the model and other parameters required in order to activate the model. After approval of the conditions and calibration of the model, the scenarios for modeling the dispersion of contaminants from a hydrodynamic point of view will be set, in various climatic conditions.	Yes	4	4.6.2	Impacts of Drilling Discharges	Simulation modeling of mud and cuttings dispersion has been conducted. The modeling methodology was approved by the MoEP in a letter dated July 29, 2015.
		4.1.7.		The considerations and criteria including the environmental factors taken into account in determining the method of discharge of each source of discharge into the sea (consolidation of discharges, depth of outlet) must be set out in order to ensure optimal dispersion in the sea.	Yes	3	3.7.3	Other Routine Discharges	The discharge depths and consolidation of discharges will depend on the specific drilling rigs selected by Noble Energy. Section 3.7.3 presents this information using the *Atwood Advantage* as an example. All discharges will comply with MARPOL and permit requirements.
	4.2.		Production Tests						
				Describe all of the means for ensuring that under no circumstances will there be any connection (transfer of liquids or gases) from the area where the production tests are taking place and the water-carrying strata and expansion of the fuel composition (liquid and gas) underground or in the marine environment.	Yes	4	4.2 5.2.1	Production Tests Drilling and Production Test Performance	Section 4.2 addresses impacts of production testing as described in Section 3.3 (i.e., flowback and flaring of production liquids). Well control and spill prevention issues are discussed in Sections 3.2.5, 3.2.6, and 5.2.1, which are cross-referenced.
	4.3.		Environmental Impacts of Sea Pollution Event by Oil based on Extreme Scenarios						
		4.3.1.		The change in the current field and the movement of the oil stain from the place of the leak must be set out in detail and in stages from the production bores along the coast of the Eastern Mediterranean Sea, from the Gaza Strip in the south to the coast of southern	Yes	4	4.3	Accidental Pollution Events	The spill modeling was conducted in accordance with the Guidelines.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
				Lebanon in the north, and west to the coast of southern Cyprus. This description should rely, inter alia, on the results of activation of a three-dimensional hydrodynamic model, which has been fed with wind data and the other necessary hydrodynamic characteristics. The hydrodynamic model must set out, precisely, the field of currents in accordance with the layout of the local seabed.					
		4.3.2.		Presuming that the oil slick, based on the findings of the hydrodynamic model, is likely to penetrate the shallow portion of the continental shelf off the coast of Israel, describe via the appropriate hydrodynamic model for simulating the hydrodynamic processes in the coastal environment the current regime in the area affected mainly by local winds and waves, and analyze the impact of such currents on dispersal of the oil slick on the coastal environment.	Yes	4	4.3.3 4.3.4.11	Condensate Spill Modeling Results Impacts on Coastal Habitats and Infrastructure	This section complies with the Guidelines. Potential impacts on the coastal environment are analyzed.
		4.3.3.		In running the model and in all of the calculations stemming from it, please take into account the worst-case scenario of 30 continuous days of discharge into the marine environment, at a maximum daily capacity in accordance with the drilling data. The type of oil in the model must be the most resilient oil expected in the reservoir and/or in accordance with the worst-case scenario data.	Yes	4	4.3.3	Condensate Spill Model Results	The worst-case scenarios were developed in accordance with the Guidelines.
		4.3.4.		Please run each of the four most common sea conditions on Israeli beaches for a period of 30 days:	Yes	4	4.3	Accidental Pollution Events	The spill modeling was conducted in accordance with the Guidelines.
				4.3.4.1. Extreme winter wave storm: 9.12.2010 - 08.01.2011 4.3.4.2. Winter wave storm: 26.01.2008 - 14.02.2008 4.3.4.3. Summer swell: 17.07.2008 - 16.08.2008 4.3.4.4. Strong North-Easterly wind (Spring and Autumn): 25.09.2007 - 25.10.2007	Yes	4	4.3	Accidental Pollution Events	The spill modeling was conducted in accordance with the Guidelines.
		4.3.5.		Please explain in clear detail all of the data and estimates for the maximum daily quantity of oil set out in the document, and the general quantity during the course of the current scenario, without 30 day control, including formulas and calculations. Please clarify the objective difficulties in evaluating the expected quantities and the possible areas of imprecision. Please address the relevance of the modeling method performed and expand, in the explanation, on the relationship between the results of the model and the actual	Yes	4	4.3	Accidental Pollution Events Appendix N: Worst-Case Discharge Scenario	A detailed presentation of the worst-case spill scenario (including supporting information and calculations) is provided in Appendix N.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		4.3.5. (cont'd)		anticipated assessment based on international knowledge and experience from past oil pollution incidents. Explain the nature of the oil spill over the water, including the thickness and expected spread of it, and the environmental significance of the thickness and spread of the spill.					
		4.3.6.		Please analyze, on the basis of the findings of the model, the results of the spread of the oil stain from the drilling bore and give a detailed explanation of the environmental significance of the results of the model. Please refer to the marine environment in general and to the coastal area and the various sites therein in particular. Give details and explain the environmental and other implications that might arise from an oil spill incident at sea under the various scenarios, vis-à-vis the various environments. Including a description of sensitive areas that might be affected by a pollution incident (based on a map of sensitivity of beaches to sea pollution by oil. The map is accessible on the internet and a copy may be obtained from the Marine and Coastal Division as a GIS layer). Address the various significances, including:	Yes	4	4.3 4.3.4.11	Accidental Pollution Events Impacts on Coastal Habitats and Infrastructure	This section complies with the Guidelines. For the coastal analysis, Noble Energy used its ESI Atlas, which incorporates information from the referenced sensitivity map.
				4.3.6.1. The impact on the ecosystem in general, and on the various species in particular.	Yes	4	4.3.4	Potential Impacts	This section complies with the Guidelines.
				4.3.6.2. The impact of the various uses including an assessment of the measures required to remedy the damage and to restore the previous condition, an assessment of the length of time during which uses might be harmed and a general assessment of the costs of restoring the previous condition, all in accordance with open reports of international experiences.	Yes	4	4.3.5	Mitigation Measures	An assessment of restoration costs is not presented because there are too many variables that could influence the actual impacts. A worst-case spill is a highly unlikely event and Noble Energy expects that significant impacts will be avoided through its well control, spill prevention, and spill response measures.
				4.3.6.3. Please address the following environments: The open sea environment, including a distinction between deep water and the critical transition zone, the seabed, beaches used for swimming and leisure, rocky beaches and/or sandy beaches that are rich in biota, marinas, moorings, marine anchorages and ports, power station cooling water suction plant and coal terminal, reverse osmosis plants and fish farm cages.	Yes	4	4.3.4	Potential Impacts	This section complies with the Guidelines.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		4.3.7.		Set out an oil spill spread model (name of model, name of manufacturer and representative calibration data), and output data, for the prior approval of the Ministry for Environmental Protection (Marine and Coastal Division), prior to running the model. For the purpose of approval of the calibration stage, please set out a document describing, in detail, the boundary conditions and the starting conditions of the model, and the various variables and non-variables chosen for the purpose of running the model. The following are the details, variables and conditions that are required for the approval:	Yes	4	4.3	Accidental Pollution Events	This section complies with the Guidelines. The modeling methodology was approved by the MoEP.
			4.3.7.1 General		Yes	--	--	Appendix M	Spill modeling details are presented in Appendix M.
				4.3.7.1.1. The name of the model. 4.3.7.1.2. A brief description of the model. 4.3.7.1.3. Reasons for adapting the proposed Eastern Mediterranean Sea (oil) spill simulation model. 4.3.7.1.4. Examples from around the world for use in the proposed spill simulation model.					
			4.3.7.2. Meteorological-Physical Conditions and Variables		Yes	--	--	Appendix M	Spill modeling details are presented in Appendix M.
				4.3.7.2.1. Conditions of edge of model (boundaries and surface) 4.3.7.2.2. Conditions of commencement of model. 4.3.7.2.3. Resolution of model, both horizontal and vertical. 4.3.7.2.4. Characteristics of starting data for model: winds, currents, sea level, temperature, salinity, etc. 4.3.7.2.5. Bathymetry.					

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
			4.3.7.3. Chemical Variables		Yes	--	--	Appendix M	Spill modeling details are presented in Appendix M.
				4.3.7.3.1. Type of oil. 4.3.7.3.2. Quantity of oil emitted per unit of time. 4.3.7.3.3 Calibration and Verification of Model 4.3.7.3.4 Methodological description and explanation of the proposed method of calibration. 4.3.7.3.5 Presentation of the variables required for calibration for the purpose of achieving the requisite model performances. 4.3.7.3.6 Presentation of calibration findings (in figures, tables, and a verbal explanation). 4.3.7.3.7 Methodological description and explanation of the proposed method of verification. 4.3.7.3.8 Presentation of verification findings (in figures, tables, and a verbal explanation).					
			4.3.7.4. Scenarios for Examination		Yes	--	--	Appendix M	
				4.3.7.4.1. Analysis of the usual and extreme hydrodynamic characteristics in the area and environs of the drilling bore.	Yes	--	--	Appendix M	The hydrodynamic scenarios evaluated in the spill modeling are those specified in Section 4.3.4 of the Guidelines and include both "typical" and extreme scenarios.
	4.4.		Light Hazards						
				The effect of lighting and the planned production tests required for performance of the Application on the environment must be examined and measures proposed for reducing expected light hazards.	Yes	4	4.4	Light Hazards	This section complies with the Guidelines. No specific mitigation measures for light hazards are recommended as the residual risk is low.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	4.5.		Noise						
				The expected noise impact fauna in the region of the production drillings and the expected noise impact of the production tests and of production must be assessed. Details must be given of the local species that might be harmed by such noises (with an emphasis on pelagic animals such as fish, whether wild or caged, marine mammals, turtles), and measures for reducing damage.	Yes	4	4.5	Noise	The noise impact assessment is limited to drilling and completion activities. Noise from production activities will be assessed in the Field Development EIA. No mitigation measures are recommended as the residual risk is low.
	4.6.		Nature and Ecology						
				Assess the level of sensitivity of the animals and the possible impacts of construction of the rig on habitats as described on the habitat map in section 1.6.	Yes	4	4.6	Nature and Ecology	All potential impacts to nature and ecology are discussed in this section. However, no rehabilitation is recommended for impacts of routine activities.
		4.6.1.		Rehabilitation upon abandonment must be described.					
	4.7.		Culture and Heritage Sites						
				Examine the impact of the Application on declared sites and on sites that may be discovered and exposed during the performance of the Application as described in section 1.8.	Yes	4	4.7	Culture and Heritage Sites	This section complies with the Guidelines.
	4.8.		Air Quality						
		4.8.1.		The impact of the Application on generation of the secondary pollutant ozone (O_3) on the environment of the Application must be assessed via a photochemical model. For this purpose, the Developer shall provide emissions files from all of the sources of emissions of the ozone generating pollutants (NOx, VOC) to the Air Quality Division at the Ministry of Environmental Protection, which has an appropriate model.	Yes	--	--	--	Noble Energy will provide emissions files to the MNIEWR for modeling.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		4.8.2.		Set out the measures and actions planned to be taken to reduce emissions from all sources set out in section 3.4, and the efficacy thereof, and address the best available technology (BAT) for complying with international requirements. For facilities/operations in respect of which there are requirements in TA-Luft 2002, address compliance with such requirements. The ongoing maintenance of these facilities must be described and the processes of rationalization of the manufacture and exploitation of electricity must be set out in order to reduce the emission of pollutants into the atmosphere. In particular, address the treatment of problems relating to H2S emissions into the air, in routine operations or in the event of faults.	Yes	4	4.8 4.8.3	Air Quality Mitigation Measures	The EIA states that the drilling rigs and supply vessels will comply with applicable MARPOL Annex VI regulations, including the use of low sulfur fuels and meeting the applicable NO_x emission limits under Regulation 13 of Annex VI. No specific requirements were identified in TA-Luft 2002 that are applicable to drilling and completion activities. Regarding possible H_2S emissions, H_2S is not expected; the H_2S Contingency Plan is referenced.
	4.9.		Waste	Describe the methods of treatment and removal of waste, as set out in section 3.7 above.	Yes	3 4	3.8 4.9	Waste Waste	This section refers to Section 3.8 rather than repeating methods for waste treatment and removal.
	4.10.		Hazardous Materials						
		4.10.1.		Set out the measures for reducing risks from hazardous materials in accordance with the details in section 3.5 above.	Yes	4	4.10	Hazardous Materials	This section generally describes hazardous materials management and emergency response. Detailed procedures are provided in Noble Energy's Emergency Response Plan and H_2S Contingency Plan.
		4.10.2.		Describe and set the measures for treatment in the event that hazardous materials are discovered during the course of the drilling, including H_2S.					
		4.10.3.		Set out the method of treatment in emergencies (hazardous material event) and the means for minimizing risks, including passive and active measures such as batches detectors.					
	4.11.		Measures for Reduction of Geological and Seismic Risks						
		4.11.1.		Set out the measures and mechanisms, both automatic and manual, which will respond to an early warning of earthquakes or tsunamis.	Yes	4	4.11	Measures for Reduction of Geological and Seismic Risks	This section summarizes the requested measures, mechanisms, and procedures. Detailed procedures are provided in Noble Energy's Emergency Response Plan.
		4.11.2.		Prepare emergency procedures or a chapter of existing emergency procedures for the handling of earthquakes. These procedures must address all exceptional situations, including: failure of communications and contact, inability to reach emergency forces, partial emergency team, etc.					

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	4.12.		Fishing						
				In accordance with the findings set out in section 1.6.15.6, set out the impact of the production drillings on fishing operations and the methods of reducing such impacts, in the event of harm to fishing operations.	Yes	4	4.12	Fishing Activities and Marine Farming	This section complies with the Guidelines.
	4.13		Safety and Protection						
				Estimate the safety range required around the production drillings to protect against harm to existing infrastructure and seacraft during the course of development of the field, installation of production infrastructure, and production.	Yes	4	4.13	Safety and Protection Zones	This section complies with the Guidelines but includes only drilling and completion activities. Safety and protection zones for production infrastructure will be addressed in the Development EIA. This general approach was approved by the MNIEWR in a letter dated December 8, 2015
	4.14		Monitoring and Control Programs						
		4.14.1.		Describe the various means of monitoring and control for air, water, the seabed, waste, mud and cuttings, fluids, production by-products, and all sources that are discharged into the sea which will ensure that the development of the field is effected in accordance with the plan, that faults or defects are located and that actions are taken to remedy such. Note, inter alia, what tests are planned to be done continuously, which are done visually and which are done in laboratories on the platform, which are done at external laboratories, and at what frequency.	Yes	4	4.14	Monitoring and Control Program	Plans for monitoring are summarized and the reader is referred to the detailed methods used in the Background Monitoring Survey (Appendix D). No routine monitoring of air quality is planned.
		4.14.2.		Describe the method of taking samples in order to obtain representative samples, for continuous / visual / laboratory sampling.	Yes	4	4.14	Monitoring and Control Program	For sampling methods, the reader is referred to the methods used in the Background Monitoring Survey (Appendix D).
		4.14.3.		Describe the calibration and maintenance actions on monitoring and control instruments.	Yes	4	4.14	Monitoring and Control Program	For calibration and maintenance actions on monitoring and instruments, the reader is referred to the methods used in the Background Monitoring Survey (Appendix D).

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		4.14.4.		Present a marine environment background monitoring plan in accordance with the Background Monitoring Plan approved as set out in section 1.1.3.	Yes	--	--	Appendix D	A separate background monitoring plan is not presented but the reader is referred to the detailed methods used in the Background Monitoring Survey (Appendix D).
	4.15		Abandonment of the Field						
				Examine the impact of closure of the production drillings and performance of the actions set out in section 3.8 on the environment and the means required to prevent such impacts, including the removal of materials, equipment and waste.	Yes	4	4.15	Well Closure (Temporary Abandonment)	Noble Energy will conduct post-drilling ROV surveys to ensure that the seafloor around each drillsite is clear of equipment and debris.
E			Proposed Guidelines for Plan for Preservation and Prevention of Harm to the Environment of the Application						
	5.1		General	This Chapter shall set out all of the proposals for setting the guidelines of the Application, at the level set out as being required for detailing the possible impacts set out in the chapters of this document, and the measures that are to be taken in order to prevent or reduce such.	Yes	5	--	Proposed Guidelines for Plan of Preservation and Prevention of Harm to the Environment	Chapter 5 as a whole addresses this requirement.
	5.2.			The guidelines shall refer to the actions that must be taken or not taken in the entire area of the Plan, during the course of and throughout the various phases of the production drilling, the production tests and completion thereof.					
	5.3.			The guidelines shall be for the grant of a drilling permit.					
	5.4.			The guidelines shall relate to the installation and operation of systems to track and monitor the effects that flow or that may flow from this Application.					

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
	5.5.			The guidelines shall relate to the actions that must be taken in the entire area of the Application, upon the making of a decision to effect production drilling, until cessation of such production, closure of the production drilling, abandonment of the field and dismantling of the infrastructure within the area of the Application, and shall include, inter alia, the following matters:	Yes	5	--	Proposed Guidelines for Plan of Preservation and Prevention of Harm to the Environment	Chapter 5 as a whole addresses this requirement for activities related to production drilling and completion. The Leviathan Field Development EIA will address the remaining activities, including cessation of production, closure of the production drilling, abandonment of the field and dismantling of the infrastructure within the Application Area.
		5.5.1.		Guidelines for the various stages of performance of the Application – the permit for drilling; for production tests; and the completion thereof.	Yes	5	5.2.1	Drilling, Completion, and Production Test Performance	This section complies with the Guidelines.
		5.5.2.		Guidelines for the handling of hazardous materials.	Yes	5	5.2.2	Handling of Hazardous Materials	This section complies with the Guidelines.
		5.5.3.		Guidelines for the reduction and prevention of harm to land and to seawater and the coastline, and including harm to the marine ecology, heritage and cultural sites, fishing and marine farming.	Yes	5	5.2.3	Reduction and Prevention of Harm including Land, Seawater, and the Coastline	This section complies with the Guidelines.
		5.5.4.		Guidelines for preservation of fauna and flora in the Application including guidelines for the prevention of harm to habitats, to pelagic species whose presence around the drilling rig might be increased, such as sharks, marine mammals and birds.	Yes	5	5.2.3	Preservation of Fauna and Flora including Pelagic Species	This section complies with the Guidelines.
		5.5.5.		Guidelines for the collection of data for the purpose of monitoring and follow-up of seawater quality, the form of the seabed, the depth of coverage of the sandy layer above the pipeline, the state of the pipeline, the quality and quantity of the sediment, the current regimen, the flora and fauna and marine agriculture in the environment of the drilling facilities, and actions that will be taken if the data points to deviations or faults that might cause harm to the environment.	Yes	5	5.2.5	Monitoring	Combined requirements 5.5.5 and 5.5.6 into a single Monitoring section. The highlighted "pipeline" items are not applicable. Monitoring plans are summarized but a separate, detailed background monitoring plan is not presented. The reader is referred to the methods used in the Background

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		5.5.6.		Guidelines for the construction of various monitoring systems (air, water, waste, mud and cutting discharge, products of production tests, birds, etc.), which shall be activated at the time of construction and performance of the Application in accordance with a monitoring plan that will enable an assessment of the efficiency of the actions taken and handling of deviations or faults discovered during the course of monitoring.					Monitoring Survey (Appendix D). No routine monitoring or air quality or birds is planned.
		5.5.7.		Guidelines for measures for preventing / reducing light hazards.	Yes	5	5.2.6	Preventing/ Reducing Light Hazards	This section complies with the Guidelines.
		5.5.8.		Guidelines for measures for reducing air contaminant emissions and the prevention of odor hazards.	Yes	5	5.2.7	Reducing Air Contaminant Emissions	This section complies with the Guidelines.
		5.5.9.		Guidelines for measures for preventing or reducing noise.	Yes	5	5.2.8	Preventing or Reducing Noise	This section complies with the Guidelines.
		5.5.10.		Guidelines for measures for the treatment and removal of cutting discharge and drilling mud.	Yes	5	5.2.9	Drilling Mud and Cuttings	This section complies with the Guidelines.
		5.5.11.		Guidelines for measures for treatment of various sources of discharge including cooling water, sanitary waste, kitchen waste, concentrate water, bilge water, washing water, hydraulic liquids.	Yes	5	5.2.10	Other Discharges	This section complies with the Guidelines.
		5.5.12.		Guidelines for the definition of safety and protection zones and the management of safety against harm to existing infrastructure and sea vessels.	Yes	5	5.2.11	Safety and Protection Zones	This section complies with the Guidelines.
		5.5.13.		Guidelines for methods of treatment and removal of waste.	Yes	5	5.2.12	Waste Treatment and Removal	This section complies with the Guidelines.
		5.5.14.		Guidelines for preparation of emergency procedures in the event of faults or accidents including activation of BOP in emergencies, submission of an emergency factory plan for the treatment of oil spills at sea, fire, earthquake, tsunami.	Yes	5	5.2.13	Emergency Procedures	This section complies with the Guidelines. Details to be provided in Noble Energy's Emergency Response Plan.
		5.5.15.		Guidelines for the reduction of geological and seismic risks and reference to up-to-date relevant standards.	Yes	5	5.2.14	Geological and Seismic Risks	This section complies with the Guidelines. Details to be provided in Noble Energy's Emergency Response Plan.
		5.5.16.		Guidelines for periodical reporting of faults or exceptional incidents to the Petroleum Commissioner, and of environmental issues to the Ministry for Environmental Protection.	Yes	5	5.2.15	Periodical Reporting of Faults or Exceptional Incidents	This requirement is addressed at a general level.

Table B-1. (Continued).

Guidelines for Preparation of Environmental Impact Document					Addressed in Leviathan Drilling EIA				
Chapter	Section	Sub-Section	Heading	Clause/Requirement	Status	Chapter	Section Number	Section Name	Comments
		5.5.17.		Guidelines relating to changes in the development plan and examination of the impact of such on the environment and details of the updates required as a result of such changes.	Yes	5	5.2.16	Changes in Development Plan	This requirement is addressed at a general level
		5.5.18.		Guidelines for the setting up of a team to accompany the Application, and the composition thereof.	Yes	5	5.2.17	Team and Reporting	This requirement is addressed at a general level. The MNIEWR accepted that this section will summarize the organizations that are part of the team, but does not need to identify individuals or provide CVs.

Appendix C

List of Preparers and Qualifications

Name	Position, Affiliation	Qualifications	Responsibilities
Neal W. Phillips, Ph.D.	Senior Scientist CSA Ocean Sciences Inc.	Experience: 31 years Education: • Ph.D., Ecology, University of Georgia, 1983 • M.S., Marine Studies, University of Delaware, 1978	Author, all chapters
Larry Reitsema, Ph.D.	Senior Scientist CSA Ocean Sciences Inc.	Experience: 39 years Education: • Ph.D., Marine Biology/Toxicology, Texas A&M University, 1981 • M.S., Fisheries, Texas A&M University, 1975	Science/Technical Reviewer
Nathan D. Vinhaterio, Ph.D.	Oceanographer RPS ASA (Consultant)	Experience: 13 years Education: • Ph.D., Oceanography, University of Rhode Island, Graduate School of Oceanography, 2012 • B.S. Geosciences, University of Rhode Island,	RPS ASA Project Manager; Primary Modeler, Muds and Cuttings Discharge
Shelley Wachsmann, Ph.D.	Meadows Professor of Biblical Archaeology, Nautical Archaeology Program, Texas A&M University (Consultant)	Experience: 38 years Education: • Ph.D., Near Eastern Archaeology, Institute of Archaeology, Hebrew University, Jerusalem, 1990 • M.A., Near Eastern Archaeology, Institute of Archaeology, Hebrew University, Jerusalem, 1984 • B.A. Near Eastern and Classical Archaeology, Institute of Archaeology, Hebrew University, Jerusalem, 1974	Marine archaeological assessment of sonar contacts
Steve Brenner, Ph.D.	Full Professor at Bar Ilan University (Consultant)	Experience: 35 years Education: • Ph.D., Meteorology, Massachusetts Institute of Technology, 1982 • B.S., Meteorology and Physical Oceanography, City College of New York, 1975	Modeling the dispersion of a continuous oil spill
Deborah K. Fawcett	Project Scientist CSA Ocean Sciences Inc.	Experience: 11 years Education: • M.S., Marine Science, University of South Alabama, 2003 • B.A., Biology, Wittenberg University, 2000	CSA Project Manager; Co-author, Chapter 1; Author, Appendix E (Survey Report)
Chris J. Kelly, Ph.D.	Senior Scientist CSA Ocean Sciences Inc.	Experience: 15 years Education: • Ph.D., Ecology, University of Maryland, 2011 • B.S. Biology, Florida Institute of Technology, 2001	Co-author, Chapter 1; Author, Appendix E (Survey Report)

Name	Position, Affiliation	Qualifications	Responsibilities
Kathleen T. Gifford	Project Scientist CSA Ocean Sciences Inc.	Experience: 5 years Education: • M.S., Chemical Oceanography, Florida Institute of Technology, 2009 • B.S. Marine Sciences, Richard Stockton College of New Jersey, 2007	Co-author, Chapter 1; Author, Appendix E (Survey Report)
Yossi Azov, Ph.D.	Senior Scientist CSA Ocean Sciences Inc.	Experience: 34 years Education: • Ph.D., Environmental & Water Resources Engineering, Technion – Israel Institute of Technology, 1979 • Master of Human Environmental Sciences, Hebrew University of Jerusalem, Israel, 1975 • Bachelor in Biology, Hebrew University of Jerusalem, Israel, 1973	MVI Project Manager; Co-author, Chapter 1
Elad Mills	Project Scientist CSA Ocean Sciences Inc.	Experience: 3 years Education: • M.S., Environmental Studies, Tel-Aviv University, 2012 • B.S., Marine Sciences & Biotechnology, Ruppin Academic Center, 2009	Co-author, Chapter 1
Kevin Noack	Geospatial Coordinator CSA Ocean Sciences Inc.	Experience: 2 years Education: • M.S., Geographic Information Science, Florida State University 2012 • B.S., Geography and Economics, Florida State University	GIS, maps, and figures
Brent R. Gore	Geospatial Analyst CSA Ocean Sciences Inc.	Experience: 3 years Education: • Master of Arts in Geography, East Carolina University, in process • B.A., Geography, University of North Carolina, 2009	GIS, maps, and figures
Natalie C. Kraft	Senior Technical Editor CSA Ocean Sciences Inc.	Experience: 6 years Education: • Master of Environmental Management in Coastal Environmental Management, Duke University, 2013 • B.S. in Marine Science and Biology, University of Miami, 2011	Technical editor
Stephanie Urquhart	Support Services Manager CSA Ocean Sciences Inc.	Experience: 5 years	Document production
Deborah Murray	Word Processor CSA Ocean Sciences Inc.	Experience: 7 years	Document formatting

NEAL W. PHILLIPS, Ph.D.

Senior Scientist

Education

Doctor of Philosophy in Ecology, University of Georgia, 1983

Master of Science in Marine Studies, University of Delaware, 1978

Bachelor of Arts in Biological Sciences, University of Delaware, 1975

Dr. Phillips is an experienced marine ecologist, impact analyst, technical writer, and editor. Since joining CSA Ocean Sciences Inc. (CSA) in 1983, he has been responsible for analysis, interpretation, and synthesis on numerous multidisciplinary projects for government and industry clients. These include environmental impact assessments, monitoring programs to evaluate pollutant effects, and baseline studies of the marine environment. Dr. Phillips has extensive experience in evaluating environmental impacts, primarily associated with oil and gas industry programs in the United States and internationally.

Dr. Phillips has prepared over 50 Environmental Impact Analyses (EIAs) for oil and gas exploration and development activities in the Gulf of Mexico, including post-Macondo EIAs for Chevron, Shell, Marathon, and Murphy as well as EIA-related environmental baseline updates for Noble Energy, Inc. The EIAs were prepared according to the specifications of the Bureau of Ocean Energy Management (BOEM) and its predecessor, the Minerals Management Service (MMS). The post-Macondo EIAs meet the requirements of Notice-to-Lessees (NTL) 2008-G04 and NTL 2010-N06 and will be used by the agency for its National Environmental Policy Act (NEPA) review of the operators' exploration and development plans. Dr. Phillips previously co-authored an Environmental Report for the Outer Continental Shelf Oil and Gas Leasing Program that served as the basis for a nationwide Programmatic EIS prepared by the MMS.

Dr. Phillips is also an experienced scientific editor. He has edited several major literature reviews for CSA, including a synthesis of environmental and socioeconomic information for the deepwater Gulf of Mexico, the South Florida area, and the Texas and Louisiana continental shelf. He has prepared computerized annotated bibliographies for several projects.

Prior to joining CSA, Dr. Phillips conducted research on the ecology, energetics, population dynamics, and feeding of estuarine benthic invertebrates, and he has since published several papers on these topics. He has also published papers concerning benthic communities of the southwest Florida shelf, the northeastern Gulf of Mexico, and the South Atlantic Bight.

EXPERIENCE

1983 to Present: CSA Ocean Sciences Inc. – Senior Scientist

- Primary author and impact analyst for Environmental Impact Analyses (EIAs) for Exploration Plans (EPs) and Development Operations Coordination Documents (DOCD) for various prospects in the Gulf of Mexico Planning Areas. The EIAs were prepared in accordance with BOEM requirements in effect at the time of contract award as specified in Notice to Lessees (NTL) 2008-G04 (Various Clients, 2010 to Present).
- Principal author of a key issues study for potential petroleum exploration in the Bahamas (Client Confidential, 2009).
- Impact analyst and principal author of Environmental Impact Assessments for proposed exploratory drilling offshore Sierra Leone, Nigeria, and São Tomé (Anadarko, 2008 to 2009).
- Principal author of a study summarizing the U.S. regulatory framework and recent monitoring programs evaluating impacts of synthetic-based drilling fluids (Jacques Whitford Limited, 2008).

- Impact analyst and report co-author for an Environmental and Social Impact Assessment for petroleum development offshore Ghana (Kosmos Energy LLC, 2008).
- Impact analyst and report co-author for an Environmental Impact Assessment for seismic surveys offshore Cabinda, Angola (Chevron, 2006 to 2008).
- Impact analyst and report co-author for an Environmental Impact Assessment for seismic surveys offshore Mozambique (Anadarko, 2007).
- Editor and report co-author for a study of *Lophelia* coral communities in the northern Gulf of Mexico (Minerals Management Service, 2006 to 2007).
- Impact analyst for an Environmental Evaluation and associated permitting documents for a proposed deepwater LNG port offshore Tampa, Florida (Port Dolphin Energy LLC, 2006 to 2009).
- Impact analyst and report editor for an Environmental Impact Assessment for LNG terminal expansion in Equatorial Guinea (Marathon, 2006).
- Impact analyst and principal author of an Environmental Impact Assessment for proposed exploratory drilling offshore Palau (Palau Pacific Energy, 2005 to 2006).
- Impact analyst and report author of over 35 Environmental Impact Analyses for exploration and development activities in the Gulf of Mexico (Various petroleum companies, 2002 to 2008).
- Editor and report co-author for a study concerning effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico (Minerals Management Service, 2001 to 2006).
- Impact analyst and co-author of Environmental Review in support of Deepwater Port Act application to the U.S. Coast Guard for an offshore LNG terminal in the Gulf of Mexico (ExxonMobil, 2003 to 2004).
- Co-author and technical reviewer of Environmental Review in support of Deepwater Port Act application to the U.S. Coast Guard for an offshore LNG terminal in the Gulf of Mexico (Shell, 2003).
- Impact analyst and report co-author of an Environmental Impact Assessment and Oil Spill Contingency Plan for exploratory drilling offshore Gabon, West Africa (Anadarko Petroleum, 2002 to 2003).
- Impact analyst and report co-author of an Environmental and Social Impact Assessment for exploratory drilling offshore Equatorial Guinea, West Africa (ChevronTexaco, 2002 to 2003).
- Impact analyst, co-author and editor of an Environmental Impact Statement for the shock trial of the Winston S. Churchill (Department of the Navy, 1999 to 2001).
- Report editor and co-author of Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Ecosystem Monitoring, Mississippi/Alabama Shelf (U.S. Geological Survey and Minerals Management Service, 1997 to 2001).
- Report editor and co-author of Deepwater Gulf of Mexico Environmental and Socioeconomic Data Search and Literature Synthesis (Minerals Management Service, 1998 to 2000).
- Impact analyst and report editor for an Environmental Impact Assessment for exploratory drilling in Block 4(b) offshore Trinidad (Conoco Trinidad B.V., 1998).
- Impact analyst and report editor for an Environmental Impact Assessment for exploratory drilling in Block 5(b) offshore Trinidad (Amoco Energy, 1997 to 1998).

- Impact analyst and report editor for an Environmental Impact Study for exploratory drilling in the Red Sea offshore Eritrea (Anadarko Eritrea Company, 1997 to 1998).
- Impact analyst, co-author and editor of an Environmental Impact Statement for shock testing the *SEAWOLF* submarine (Department of the Navy, 1996 to 1998).
- Impact analyst and report editor for an Environmental Impact Assessment for the Amoco Trinidad LNG Upstream Development Project (Amoco Trinidad Oil Company, 1997).
- Impact analyst and report co-author (marine environment) for an Environmental Impact Assessment for a petroleum development/production project in the Arabian Sea (Qatar Liquefied Gas Company Ltd and Ras Laffan LNG Company Ltd., 1995 to 1996).
- Data analyst and report author for an oil and gas monitoring program in Viosca Knoll Block 202 (Mobil Exploration and Producing U.S. Inc., 1995).
- Editor and co-author of a Water Quality Protection Program Document and Action Plan for the Florida Keys National Marine Sanctuary. This multidisciplinary document integrated task reports from eight authors and was incorporated in the Environmental Impact Statement for the Sanctuary (U.S. Environmental Protection Agency, 1992 to 1993).
- Editor and report co-author of a synthesis of environmental and socioeconomic data for the South Florida area. A total of 25 authors, including scientists from seven universities, contributed to the report (Minerals Management Service, 1988 to 1991).
- Editor and report co-author of a synthesis report and computerized annotated bibliography of environmental literature for the Texas-Louisiana continental shelf (Minerals Management Service, 1987 to 1988).
- Marine Biology Task Leader for four Environmental Impact Reports concerning exploratory drilling in the Santa Barbara Channel (California State Lands Commission, 1984 to 1988).
- Report co-author of a multidisciplinary, benthic study of the continental shelf off southwest Florida (Minerals Management Service, 1984 to 1987).
- Data analyst and report author for a program to monitor benthic impacts of dredged material disposed on the continental shelf off Tampa, Florida (U.S. Environmental Protection Agency, 1984 to 1987).
- Editor and report co-author of a reconnaissance survey of seagrass beds in the Florida Big Bend Region and a follow-up survey of hurricane effects on the seagrass beds (Minerals Management Service, 1985 to 1986).
- Editor and report co-author of a simulation modeling and prediction of the long-term fate of drilling discharges on the California outer continental shelf (Minerals Management Service, 1985).

1983: Skidaway Institute of Oceanography – Consulting Assistant

- Synthesized and reported previously collected data on benthic macroinvertebrate assemblages of the Georgia continental shelf.

1980 to 1983: Skidaway Institute of Oceanography – Research Assistant

- Conducted research on the energetics and nutrition of detritus-feeding marine invertebrates.

1977 to 1979: University of Georgia – Teaching Assistant

- Taught general courses in biology and ecology at the Institute of Ecology.

1976 to 1977: University of Delaware – Research Assistant

- Worked at the College of Marine Studies under a National Oceanic and Atmospheric Administration grant. Collected, processed, and analyzed field samples for the study of marshgrass productivity. Assisted in data analysis and sampling design.

PUBLICATIONS (Corporate)

CSA International, Inc. (N.W. Phillips, co-author). 2009. Environmental Impact Assessment: Exploration Drilling in Joint Development Zone Block 3, Nigeria – São Tomé e Príncipe. Report for Anadarko Petroleum Corporation.

CSA International, Inc. (N.W. Phillips, co-author). 2009. Key Issues Study – Petroleum Exploration: Cay Sal Bank, The Bahamas. (Client confidential.)

CSA International, Inc. (N.W. Phillips, co-author). 2009. Environmental Impact Assessment: Exploration Drilling Offshore Sierra Leone. Report for Anadarko Petroleum Corporation.

CSA International, Inc. (N.W. Phillips, co-author). 2008. Environmental and Social Impact Assessment: Jubilee Field, Phase 1 Development, Offshore Ghana, West Africa. Report for Kosmos Energy, LLC.

CSA International, Inc. (N.W. Phillips, co-author). 2008. Offshore Drilling Mud and Cuttings Study. Report for Jacques Whitford Limited.

CSA International, Inc. (N.W. Phillips, editor and co-author). 2007. Characterization of northern Gulf of Mexico deepwater hard bottom communities with emphasis on *Lophelia* coral. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2007-044.

CSA International, Inc. (N.W. Phillips, co-author). 2007. Environmental impact report for a proposed seismic survey in Rovuma offshore Area 1. Report for Anadarko Moçambique Area 1, Lda.

CSA International, Inc. (N.W. Phillips, co-author). 2007. Environmental impact study for the Block 0 ocean bottom cable/transition zone seismic surveys. Report for Chevron/Cabinda Gulf Oil Company Limited.

CSA International, Inc. (N.W. Phillips, co-author). 2007. Environmental impact assessment/Block 22 exploration drilling programme. Final Report submitted to Petro-Canada Trinidad and Tobago Block 22 Inc. Port of Spain, Trinidad. 8 secs + app.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 2006. Deepwater program: 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; and Volume III: Appendices. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Studies MMS 2006-044, 2006-045, and 2006-046.

Continental Shelf Associates, Inc. (N.W. Phillips, principal author). 2006. Environmental impact analysis, Perdido Developments. Report for Shell Offshore Inc., Houston, TX.

Continental Shelf Associates, Inc. (N.W. Phillips, principal author). 2006. Environmental assessment: proposed oil and gas exploration project at Velasco Reef in Kayangel State, Republic of Palau. Report for Palau Pacific Energy, Inc.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 2003. Environmental review, deepwater port license application for proposed offshore liquefied natural gas terminal in the Gulf of Mexico, Gulf Landing Project. Report for Gulf Landing LLC, Houston, TX.

Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group (N.W. Phillips, editor and co-author). 2001. Northeastern Gulf of Mexico coastal and marine ecosystem program: ecosystem monitoring, Mississippi/Alabama shelf; final synthesis report. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, USGS BSR 2001-0007 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 2001-080. 415 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 2001. Final environmental impact statement: Shock trial of the *WINSTON S. CHURCHILL*. Department of the Navy, Naval Facilities Engineering Command, North Charleston, SC.

Continental Shelf Associates, Inc. and LGL Alaska Research Associates, Inc. (N.W. Phillips, co-author). 2001. Environmental report for the outer continental shelf oil & gas leasing program: 2002-2007. U.S. Department of the Interior, Minerals Management Service, Environmental Division, Herndon, VA. OCS Studies MMS 2001-0029 and 2001-0030.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 2000. Deepwater Gulf of Mexico environmental and socioeconomic data search and literature synthesis: Narrative report (Volume I) and annotated bibliography (Volume II). U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Studies MMS 2000-049 and 2000-050.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1999. Northeastern Gulf of Mexico coastal and marine ecosystem program: Ecosystem monitoring, Mississippi/Alabama shelf; third annual interim report. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0005 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 99-0055. 211 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 1999. Ecology of live bottom habitats of the northeastern Gulf of Mexico: A community profile. U.S. Geological Survey, Biological Resources Division and Minerals Management Service, Gulf of Mexico OCS Region. MMS 99-0004. 84 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1998. Northeastern Gulf of Mexico coastal and marine ecosystem program: Ecosystem monitoring, Mississippi/Alabama shelf; second annual interim report. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR-1998-0002 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 98-0044. 198 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1998. Northeastern Gulf of Mexico coastal and marine ecosystem program: Ecosystem monitoring, Mississippi/Alabama shelf; first annual interim report. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division, USGS/BRD/CR-1997-0008 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA, OCS Study MMS 97-0037. 133 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1998. Environmental impact study for exploratory drilling in the Zula and Edd blocks, offshore Eritrea. Report for Anadarko Eritrea Company, Asmara, Eritrea.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1998. Final environmental impact statement: Shock testing the Seawolf submarine. Department of the Navy, Naval Facilities Engineering Command, North Charleston, SC.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1997. Offshore environmental impact assessment, Amoco Trinidad LNG upstream development project. Report for Amoco Trinidad Oil Company, Port of Spain, Trinidad.

CH2M Hill International Ltd. and Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 1996. Environmental impact assessment. Report for Qatar Liquefied Gas Company Ltd. and Ras Laffan LNG Company Ltd., Doha, Qatar.

Continental Shelf Associates, Inc. (N.W. Phillips, principal author). 1995. Monitoring program report for Viosca Knoll Block 202, Well No. 1. Report for Mobil Exploration & Producing U.S. Inc., New Orleans, LA.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and co-author). 1995. Synthesis of available biological, geological, chemical, socioeconomic, and cultural resource information for the South Florida area. Supplemental report: A comparison of seagrass beds in Panama and South Florida. OCS Study MMS 95-0029. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA.

Continental Shelf Associates, Inc. (N.W. Phillips, editor and principal author). 1993. Water quality protection program for the Florida Keys National Marine Sanctuary: Program document. Report prepared for Battelle Ocean Sciences under contract to the U.S. Environmental Protection Agency, Washington, DC.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 1993. Water quality protection program for the Florida Keys National Marine Sanctuary: Phase II report. Report prepared for Battelle Ocean Sciences under contract to the U.S. Environmental Protection Agency, Washington, DC.

Continental Shelf Associates, Inc. (N.W. Phillips, principal author). 1992. Environmental monitoring to assess the fate of drilling fluids discharged into Alabama state waters of the Gulf of Mexico: Final summary report. Report prepared for the Offshore Operators Committee, New Orleans, LA. 59 pp. + app.

Continental Shelf Associates, Inc. (N.W. Phillips, author). 1991. Synthesis of available biological, geological, chemical, socioeconomic, and cultural resource information for the south Florida area. Executive Summary. OCS Study MMS 91-0016. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA.

Continental Shelf Associates, Inc. (N.W. Phillips and K.S. Larson, editors). 1990. Synthesis of available biological, geological, chemical, socioeconomic, and cultural resource information for the South Florida area. OCS Study MMS 90-0019. U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, Herndon, VA.

Continental Shelf Associates, Inc. (N.W. Phillips and B.M. James, editors). 1988. Offshore Texas and Louisiana marine ecosystems data synthesis. OCS Studies MMS 88-0066, 88-0067, and 88-0068. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 1988. Field surveys report. Environmental impact report for exploratory drilling for oil and gas resources, Parcel 1, Pt. Conception area, Santa Barbara County. Report for the California State Lands Commission, Sacramento, CA. 96 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author and editor). 1987. Southwest Florida shelf regional biological communities survey, Year 3 final report. Report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, New Orleans, LA. Contract No. 14-12-0001-29036. OCS Studies MMS 86-0108, 86-0109, and 86-0110. 3 vol.

Continental Shelf Associates, Inc. (N.W. Phillips, principal author and editor). 1987. Synthesis report, Tampa Harbor dredged material disposal monitoring study. Report for Battelle Ocean Sciences and Technology Department under contract to the U.S. Environmental Protection Agency. 146 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 1987. Administrative draft environmental impact report for exploratory drilling operations proposed by Atlantic Richfield Company on state oil and gas lease PRC 2726. Report for the California State Lands Commission, Sacramento, CA. 302 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author). 1987. Administrative draft environmental impact report for exploratory drilling operations proposed by Phillips Petroleum Company on state oil and gas lease PRC 2955. Report for the California State Lands Commission, Sacramento, CA. 327 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author and editor). 1987. Assessment of hurricane damage in the Florida Big Bend seagrass beds. Report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, New Orleans, LA. Contract No. 14-12-0001-30188. 39 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, principal author and editor). 1985. Environmental impact report for exploratory drilling operations proposed by Chevron U.S.A., Inc. on state oil and gas lease PRCs 2199, 2894, 3150, and 3184. Volume II, Field benthic survey report. Report for the California State Lands Commission, Sacramento, CA. 112 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author and co-editor). 1985. Assessment of the long-term fate and effective methods of mitigation of California outer continental shelf platform particulate discharges. Report for the U.S. Department of the Interior, Minerals Management Service Pacific OCS Region, Los Angeles, CA. Contract No. 14-12-0001-30056. 241 pp.

Continental Shelf Associates, Inc. (N.W. Phillips, co-author and editor). 1985. Florida Big Bend seagrass habitat study. Report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, New Orleans, LA. Contract No. 14-12-0001-30188. OCS Study MMS-85-0088. 47 pp.

PUBLICATIONS (Individual)

Viada, S.T., R.M. Hammer, R. Racca, D. Hannay, M.J. Thompson, B.J. Balcom, and N.W. Phillips. 2007. Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. Environmental Impact Assessment Review and Science Direct (in press). http://www.sciencedirect.com.

Gettleson, D.A., A.D. Hart, S.T. Viada, and N.W. Phillips. 2004. Effects of oil and gas exploration and development at selected continental slope sites in the Gulf of Mexico. Paper presented at the Seventh SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production held in Calgary, Alberta, Canada, 29-31 March 2004. SPE 86773. Society of Petroleum Engineers, Richardson, TX.

Thompson, M.J., W.W. Schroeder, N.W. Phillips, and B.D. Graham. 1999. Ecology of live bottom habitats of the northeastern Gulf of Mexico: A community profile. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Division. USGS/BRD/CR-1999-0001 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study 99-0044.

Phillips, N.W., D.A. Gettleson, and K.D. Spring. 1990. Benthic biological studies of the southwest Florida shelf. Am. Zool. 30:65-75.

James, B.M. and N.W. Phillips. 1989. Offshore Texas and Louisiana marine ecosystems data synthesis, pp. 280-283. In: Proceedings, Ninth Annual Information Transfer Meeting. U.S. Department of the Interior, Minerals Management Service, New Orleans, LA.

Deis, D.R. and N.W. Phillips. 1988. Biological monitoring of beach restoration at Jupiter Island, Florida. In: Proceedings of the Conference on Shore and Beach Preservation Technology.

Thompson, M.J. and N.W. Phillips. 1987. Resource inventory of the Florida Big Bend region, pp. 775-780. In: Estuarine and Coastal Management--Tools of the Trade. Proceedings of the Tenth National Conference of the Coastal Society, 12-15 October 1986. New Orleans, LA.

Phillips, N.W. 1986. Southwest Florida Shelf Studies Years 1, 2, and 3, pp. 252-253. In: Proceedings, Sixth Annual Information Transfer Meeting, 22-24 October 1985. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 86-0073.

Putt, R.E., D.A. Gettleson, and N.W. Phillips. 1986. Fish assemblages and benthic biota associated with natural hard-bottom areas in the northwestern Gulf of Mexico. N.E. Gulf Sci. 8:51-63.

Gettleson, D.A., N.W. Phillips, and R.M. Hammer. 1985. Dense polychaete (*Phyllochaetopterus socialis*) mats on the South Carolina continental shelf. N.E. Gulf Sci. 7:167-170.

Phillips, N.W. 1984. Compensatory intake can be consistent with an optimal-foraging model. Am. Nat. 123:867-873.

Phillips, N.W. and K.R. Tenore. 1984. Effects of food-particle size and pelletization on individual growth and larval settlement of the deposit feeding polychaete *Capitella capitata* Type I. Mar. Ecol. Prog. Ser. 16:241-247.

Phillips, N.W. 1984. Role of different microbes and substrates as potential suppliers of specific, essential nutrients to marine detritivores. Bull. Mar. Sci. 35:283-298.

Phillips, N.W. 1983. Effects of food quality on food preference, ingestion, growth and survival of the marine detritus-feeding amphipod *Mucrogammarus mucronatus* (Say). Ph.D. dissertation, University of Georgia. 171 pp.

Tenore, K.R., L.M. Cammen, S.E.G. Findlay, and N.W. Phillips. 1982. Perspectives of research on detritus: Do factors controlling availability of detritus to macroconsumers depend on its source? J. Mar. Res. 40:473-490.

Phillips, N.W. 1980. A comment on energy maximization by deposit feeders. Limnol. Oceanogr. 25:1,143-1,145.

Phillips, N.W. 1978. Spatial distribution and population dynamics of *Orchestia* spp. (Amphipoda: Talitridae) in the Canary Creek salt marsh, Delaware. M.S. thesis, University of Delaware. 186 pp.

HONORS AND AWARDS

2001 Team Award for Excellence, DDG 81 Shock Trial Environmental Impact Statement Team. Awarded by the Department of the Navy, Program Executive Office for Theater Surface Combatants.

2000 Environmental Award, USS Winston S. Churchill Environmental Impact Statement Team. Awarded by the Secretary of the Navy.

2000 Environmental Award, Winston S. Churchill (DDG 81) Environmental Impact Statement Team. Awarded by the Department of the Navy, Chief of Naval Operations.

LAWRENCE A. REITSEMA, Ph.D.

HSE Professional and Manager

Education

Doctor of Philosophy in Marine Biology/Toxicology, Texas A&M University, 1981

Master of Science in Fisheries, Texas A&M University, 1975

Bachelor of Science in Biology, Calvin College, 1969

Dr. Reitsema is an experienced Health, Safety, and Environment (HSE) professional and manager who has worked with environmental consulting and oilfield service companies prior to joining Marathon in 1990. His areas of expertise include management of HSE issues in the U.S. and international operations, primarily for upstream activities; due diligence and risk assessment activities for U.S. and international facilities and projects; environmental, social, and health impact assessments and associated studies; environmental damage assessments and remediation; marine discharges and spill response; ecological studies related to oil and gas operations in a wide range of environments; international HSE operations and project management; environmental and safety management system development and implementation; training and standards program management; and environmental surveys, sampling, and analyses.

EXPERIENCE

2014 to Present: CSA Ocean Sciences Inc. – HSE Professional and Manager

- Develops EIAs and other environmental assessments and reports for offshore projects for clients worldwide.
- Serves as the lead for the development and implementation of the CSA Health, Safety Environment and Quality Management System.

1990 to 2013: Marathon Oil Corporation – HES Corporate Support Advisor

- Active in the development and support of Marathon's HSE and Major Project Management Systems. Managed HSE Management System implementation throughout the company and supervised corporate staff dedicated to the Management System program. Integrated the Management System with other corporate programs including quality control, major projects, new ventures, emergency response, and other management system / corporate functions.
- Technical support for offshore platform permitting issues, representing Marathon to regulatory agencies overseeing discharge permits and requirements, managed the Technical Environmental Support Team for Emergency Response, and prepared a corporate Natural Resources Damage Assessment Process.
- Served as HSE Manager for several large international projects and consortiums, including an assignment seconded to Sakhalin Energy (1995 to 2001) as HSE Manager and HSE Technical Support Manager. Sakhalin Energy was required to comply with World Bank stipulations as well as those of Russia and required intensive negotiations and studies to complete the permitting process for production. Developed and implemented an HES Management System for Sakhalin Energy.
- Responsible for oversight for all new international projects and provided technical support throughout Marathon with significant involvement in projects in Canada, Equatorial Guinea, Russia, Indonesia, Poland, Libya, Gabon, Kurdistan, the UK, Norway, and others as Manager of New Ventures and Business Support.
- Led a project to develop corporate ESHIA and HSE risk assessment programs.
- Served as an industry representative to numerous trade associations in the U.S. and worldwide, taking various leadership roles and working with the leadership groups to represent industry's interests to government agencies and regulatory bodies.
- Supported environmental personnel throughout the company and provided environmental expertise to international projects and due diligence activities.
- Served as HSE team member for project peer reviews and new country entries.

LGL Ecological Research Associates – Project Manager

- Project Manager for ecologic studies in the Gulf of Mexico focused on platforms, coral reefs, marsh reclamation, and the response of marine organisms to brine discharges.

Newpark Environmental Services – Regulatory Affairs and Government Relations Manager

- Managed permitting program for all operations, including handling, treating, and disposing of waste drilling fluids. Permits and activities included non-hazardous oilfield waste management, hazardous waste treatment and disposal, emergency response, facility permits, transportation permits, and facility siting and operations. Represented the company at public hearings and permit negotiations.

Southern Petroleum Laboratories – Environmental Lab Director

- Responsible for all activities for SPL's Houston full-service environmental sample analysis laboratory, including staffing, equipment, sales, and quality control. Led the laboratory into the EPA's certified lab program, supervised the transition to an electronic laboratory management system, and oversaw growth from 11 to over 50 employees.

ENSR – Project Manager

- Project manager for RCRA projects, site remediation, and due diligence for domestic and international real estate transactions.

PROFILE

Nathan D. Vinhateiro, Ph.D. – Oceanographer

B.S. Geosciences – University of Rhode Island

Ph.D. Oceanography – University of Rhode Island, Graduate School of Oceanography

nathan.vinhateiro@rpsgroup.com

Areas of Expertise:

Dr. Vinhateiro has a background in oceanography and marine geology. He received a Ph.D. from the University of Rhode Island in 2012 where his dissertation examined morphological responses of Rhode Island's barrier-headland coastline to long-term changes in sea level and storm frequency. He has a multidisciplinary background that includes experience in geographic information systems, shoreline change analysis, remote sensing, paleoceanography, and marine geophysics. He has extensive field experience in coastal, and nearshore environments and has spent over 7 years collecting coastal elevation data and applying these datasets to understand shoreline dynamics. At RPS ASA, his work has primarily focused sediment dispersion modeling for a range of industry and government clients. He is the project lead for drilling discharges and sediment transport modeling studies in support of offshore EIAs.

Experience Includes:

RPS ASA **2012-present**
Oceanographer

- Modeling of drilling discharges and produced water in support of environmental risk assessments for offshore exploration wells using ASA's MUDMAP model to assess sediment transport and deposition
- Sediment dispersion modeling to evaluate water column concentrations and deposition of suspended sediment from proposed dredging projects using ASA's SSFATE model in nearshore, estuarine, and riverine environments
- Technical reporting and EIS development for energy infrastructure projects in coastal marine environments; primary focus on sediment transport modeling
- Coastal hazard assessments, including analysis of sea level rise, and numerical modeling of storm surge, and wave run-up for industrial (nuclear) facilities along the US East Coast
- Analysis of surf zone dynamics and natural sediment dispersion processes by breaking waves and alongshore currents for validation / comparison with numerical modeling techniques
- Mapping and inundation analysis of coastal protection infrastructure (groins, seawalls, bulkheads) using high resolution (LiDAR) digital terrain data

University of Rhode Island Graduate School of Oceanography, Narragansett, RI **2004-2012**
Graduate Research Assistant
Dissertation: *Mechanisms of shoreline change on the Rhode Island south coast: Past, present, and future*

- 2010-2012: Research Assistant - GSO Beach Survey Program
- 2007-2010: National Science Foundation Coastal Institute IGERT Project Fellow
- 2009: Project Intern - USGS Coastal and Marine Geology Program, Santa Cruz, CA
- 2008: White Paper Intern - RI Coastal Resources Management Council Internship, Wakefield, RI
- 2004-2007: Research Assistant - Rhode Island Sea Grant/URI Coastal Resources Center

URS Corporation, Honolulu, HI **2002-2003**

Staff Geologist

- Organized and executed field operations required for hazardous waste and geotechnical consulting, including due diligence site assessments, engineering evaluations, remediation, compliance, and site monitoring
- Employed standard operating procedures for field projects (site reconnaissance, soil and ground water sampling, well development, borehole drilling and logging)

Town of South Kingstown, Wakefield, RI **2002**

GPS Technician

- Developed and executed a comprehensive field survey of a municipal storm-water system
- Supported GIS analyst in management and maintenance of town geospatial layers and databases

Shipboard and Field Experience:

- RI Ocean SAMP – RV McMaster. Geophysical surveying and surface grab sampling, 2008-present
- Expedition EN418 – RV Endeavor. Geophysical/archaeological survey - Sea of Crete, May 2006
- BayMap. Geophysical studies for RI Sea Grant Narragansett Bay mapping program, 2005-2008
- Lake Malawi Drilling Project. Field logging of sediment cores in support of international paleoclimate drilling campaign on east African rift lakes, Jan.-Feb. 2005
- Cook Expedition 21 – RV Melville. Tectonic evolution of the southwest Pacific Basin, Mar. 2002

Publications:

Vinhateiro, N., Himmelstoss, E.A., Robinson, R.S., King, J.W. (2014). Shoreline position and rate of change from long-term beach profile measurements: Rhode Island south shore. *Manuscript submitted for publication.*

Vinhateiro, N., Sullivan, K.A., & McNally, C.G. (2012). Expanding the toolbox: Training for the next generation of coastal management practitioners. Journal of Coastal Research, 28(5): 1297-1302.

Anthony, A., Atwood, J., August, P., Byron, C., Cobb, S., Foster, C., Fry, C., Gold, A., Hagos, K., Heffner, L., Kellog, Q., Lellis, K., Opaluch, J., Oviatt, C., Pfeiffer-Herbert, A., Rohr, N., Smith, L., Smyth, T., Swift, J., & Vinhateiro, N. (2009). Coastal lagoons and climate change: ecological and social ramifications in U.S. Atlantic and Gulf Coast ecosystems. Ecology and Society, 14(1): 8

Vinhateiro, N.D., et al. (2008). Lagoons and climate change: ecological and social ramifications in temperate ecosystems. Abstracts of papers, ISSRM 2008, Burlington, VT.

Rubinoff, P., Vinhateiro, N.D., & Piecuch, C. (2008). Summary of coastal program initiatives that address sea level rise as a result of global climate change. Technical report. Rhode Island Sea Grant/URI Coastal Resources Center, Narragansett, RI.

Vinhateiro, N. (2008, Sept. 25). Mapping technology needed to assess risk of sea level rise (Op-Ed). South County Independent, p. A8.

Vinhateiro, N. (2008). Sea level rise and the current status of digital terrain data for the south shore of Rhode Island (White Paper). Wakefield, RI: Rhode Island Coastal Resources Management Council.

Vinhateiro, N.D., King, J.W., Robinson, R.S., & Reddy, C.M. (2007). Holocene stratigraphy and environmental history of a shallow water embayment in Narragansett Bay, RI. Abstracts of papers, ERF 2007, Providence, RI

Coastal Resources Center, & Florida International University. (2006). Fisheries opportunities assessment. Washington, D.C.: U.S. Agency for International Development.

Vinhateiro, N.D., Veeger, A., Nakoa, M., & Craft, P. (2002). Water-use and availability on Block Island, RI. GSA Abstracts with Programs, 34(1).

Curriculum Vitae

Shelley Wachsmann

PERSONAL DATA

Address Nautical Archaeology Program
Department of Anthropology
Texas A&M University
College Station, TX 77843-4352

Phone (979) 847-9257

E-mail swachsmann@tamu.edu

HIGHER EDUCATION

1984 to 1990 Ph.D. in Near Eastern Archaeology, at the Institute of Archaeology, Hebrew University, Jerusalem. Dissertation: *Seagoing Ships and Seamanship in the Late Bronze Age Levant.* Dissertation advisors: Professor Trude Dothan and Professor George F. Bass.

1974 to 1984 MA in Near Eastern Archaeology, *cum laude*, the Institute of Archaeology, Hebrew University, Jerusalem. Thesis: *Toward a Better Understanding of the Historical Significance of Aegeans Depicted in the Theban Tombs.* Thesis advisor: Professor Trude Dothan.

1970 to 1974 BA in Near Eastern and Classical Archaeology, *cum laude*, at the Institute of Archaeology, Hebrew University, Jerusalem.

HISTORY OF PRIOR ACADEMIC AND RELATED APPOINTMENTS

2010-present Meadows Professor of Biblical Archaeology, Nautical Archaeology Program, Texas A&M University.

2009-2012 Coordinator, Nautical Archaeology Program.

1999-2010 Meadows Associate Professor of Biblical Archaeology, Nautical Archaeology Program, Texas A&M University.

1993-1999 Meadows Assistant Professor of Biblical Archaeology, Nautical Archaeology Program, Texas A&M University.

1990-1993 Meadows Visiting Assistant Professor of Biblical Archaeology, Nautical

Archaeology Program, Texas A&M University.

1990 Archaeologist/Researcher: Israel Antiquities Authority (formerly Israel Department of Antiquities and Museums [IDAM])

1976-1989 Inspector of Underwater Antiquities, IDAM.

1975 Assistant to Dr. Amos Kloner, Field Archaeologist in charge of Jerusalem region for IDAM.

____ Assistant to Professor Yigael Yadin preparing excavation material from Tel Hazor for publication (Institute of Archaeology, Hebrew University, Jerusalem).

1974 Tel Lahav excavation, directed by Mr. David Alon (IDAM); Assistant Excavator.

1972 Office of the Staff Officer in Charge of Archaeology in Judea and Samaria (Director: Dr. Zeev Yeivin); Inspector of Antiquities.

ARCHAEOLOGICAL/ANTHROPOLOGICAL FIELD EXPERIENCE

2014 The 2014 Ioppa Maritima Project. Reconstructing the maritime aspects of ancient Jaffa, Israel. Geoarchaeological/geophysical survey of Greonigen Park, Jaffa, and regional deep-water survey (50-250 meters). Principal Investigator.

2013 Easter Island. Reconstructing the Palaeoenvironment of the Moai Quarry inside Rano Raraku. March 07-20, 2013. In collaboration with Dr. Jo Anne Van Tilburg, Cotson Institute, UCLA.

2012 2012 INA/EISP Rano Raraku Crater Lake Survey, Easter Island. Sidescan and bottom-penetrating sonar survey. March 09-26, 2012. In collaboration with Dr. Jo Anne Van Tilburg, Cotson Institute, UCLA.

2010 The 2010 Eratosthenes Seamount Expedition (Geological survey of the seamount located between Cyprus and Egypt led by Dr. Robert D. Ballard; Archaeological observer.)

2007-2009 The Danaos Project (Deep-water survey of the ancient sea route between Crete to Egypt); Project Archaeological Principal Investigator.

2003-2006 The Persian War Shipwreck Survey; Canadian Team Archaeological Principal Investigator.

2005 Documented Gurob ship-cart model at the Petrie Museum of Egyptology, London.

2002 The 2002 INA/CNANS Joint Expedition: (Study of maritime aspects of Phoenician penetration into Portugal in the 7th-6th centuries BC.); Principal Investigator.

1999 The ROBO Israel Deep-Water Shipwreck Survey: (Sidescan Sonar Survey opposite Tantura Lagoon); Principal Investigator.

____ The 1999 Ashkelon Deep-Water Shipwreck Survey: (Survey of two 8th-century BC Phoenician Shipwrecks, directed by Dr. Robert Ballard and Professor Lawrence E. Stager; member of the archaeological team.

1998 Abu-el Haggag Festival in Luxor, Egypt; recorded the festival and carried out interviews.

1997 The Leon Levy Shipwreck Survey, Ashkelon Israel: (Sidescan Sonar and Diving Survey). In cooperation with the Leon Levy Expedition to Ashkelon and Haifa University's Center for Maritime Studies; Principal Investigator.

1996 To the Sea of the Philistines: (Sidescan Sonar Survey Opposite Ashkelon). In cooperation with the Leon Levy Expedition to Ashkelon; Principal Investigator.

1994-1996 INA/CMS Joint Expedition to Tantura Lagoon, Israel; Principal Investigator.

1992 Sea of Galilee Archaeological Research Project (sub-bottom profiling sonar survey); Principal Investigator.

1986 Excavation of the Galilee Boat; Principal Investigator.

1985 Probe excavation of fifth-century BC Ma'agan Mikhael; Principal Investigator.

____ Land excavation in the Crusader city of Caesarea; Principal Investigator.

____ Excavation of a Byzantine wreck at Dor; Principal Investigator.

1980 Excavation of a Late Bronze Age cargo found underwater near Kibbutz Hahotrim; Principal Investigator.

1978-1985 Survey for Napoleonic remains jettisoned into the sea at Tantura during Bonaparte's retreat from Acre; Principal Investigator.

MILITARY SERVICE (ISRAEL DEFENSE FORCE)

Final rank	First Sergeant (Rav Samal). (Ret.)
1973-1990	Active reservist (55th Paratrooper Reserve Brigade, 28th Battalion, Company A).
1969-1970	MAHA'L (Mitnadvei Chutz L'Aretz: Foreign Volunteers Unit) Completed paratrooper training.
Ribbons	Yom Kippur War Ribbon, Lebanese War Ribbon.

FIELDS QUALIFIED TO TEACH, INCLUDING AREAS OF SPECIAL INTEREST

ANTH/RELS 317	Introduction to Biblical Archaeology
ANTH/RELS 489	Ancient Egypt
ANTH 612	Preclassical Seafaring
ANTH 613	Classical Seafaring
ANTH 633	Deep-Submergence Archaeology
ANTH 660	Field Archaeology
ANTH 689	Near Eastern Seafaring

RECORD OF PUBLICATIONS

BOOKS

2013 *The Gurob Ship-Cart Model and Its Mediterranean Context.* College Station, Texas A&M University Press.

1998 *Seagoing Ships and Seamanship in the Bronze Age Levant.* College Station & London, Texas A&M University Press & Chatham Publishing. Second printing, 2009.

1995 *The Sea of Galilee Boat: An Extraordinary 2000 Year Old Discovery*. New York, Plenum. Second edition, 2000 by Perseus Press, Cambridge. Third edition, 2009 by Texas A&M University Press.

1990 *The Excavations of an Ancient Boat from the Sea of Galilee (Lake Kinneret).* (ᶜ*Atiqot* 19). Jerusalem, Israel Antiquities Authority. With contributors.

1987 *Aegeans in the Theban Tombs.* (*Orientalia Lovaniensia Analecta* 20). Leuven, Uitgeverij Peters.

BOOK AWARDS

2013 Joint winner of the Nautical Archaeology Society's Keith Muckelroy Award for published works on maritime archaeology for *The Gurob Ship-Cart Model and Its Mediterranean Context* with Professor Sir Barry Cunliffe's *Britain Begins.* Oxford, Oxford University Press.

2000 The Irene Levi-Sala Book Prize in the Archaeology of Israel in the popular book category for 1998-1999 for *Seagoing Ships and Seamanship in the Bronze Age Levant*.

1997 The Biblical Archaeology Society's Award for Best Popular Book on Archaeology for 1995-1996 for *The Sea of Galilee Boat: An Extraordinary 2000 Year Old Discovery*.

REFEREED CHAPTERS IN BOOKS

2011 Deep-Submergence Archaeology. In *The Oxford Handbook of Marine Archaeology.* A. Catsambis, B. Ford and D. Hamilton, ed. New York: Oxford University Press: 202-231.

2009 On Drawing the Bow. In *Eretz-Israel* 29 (In Honor of Ephraim Stern). J. Aviram, A. Ben-Tor, I. Ephàl, S. Gitin and R. Reich, eds. Jerusalem, Israel Exploration Society: 238*-257*.

2000 To the Sea of the Philistines. In *The Sea Peoples and Their World: A Reassessment. (University Museum Monograph 108. University Museum Symposium Series* 11). Ed. E.D. Oren. The University Museum, University of Pennsylvania, Philadelphia: 103-143.

1990 Concerning Syro-Canaanite Sea Trade in the Late Bronze Age. In *Commerce in Palestine Throughout the Ages: Studies.* Eds. B.Z. Kedar, T. Dothan and S. Safrai. Yad Yitzchak Ben Zvi, Jerusalem: 42-66. (in Hebrew)

INVITED CHAPTERS IN BOOKS

in press The 2012 INA/EISP Rano Raraku Crater Lake Survey. In *Easter Island Statue Quarry Excavations: From Stone to Sculpture.* J. Van Tilburg and C. Arévalo Pakarati, eds. Los Angeles, The Cotsen Institute of Archaeology Press, University of California, Los Angeles. (5 pages and 8 figures) With J. Morris. (Submitted July 17, 2013).

2008 Underwater Survey, 1996-1997. In *Ashkelon Excavation Report* I: *Introduction and Overview* (*1985-2006*). L. E. Stager, J. D. Schloen and D.

M. Master, eds. Winona Lake, Eisenbauns: 97-100.

2005 The Graveyard of Ships: Tantura Lagoon, Israel. In *Beneath the Seven Seas.* Ed. G.F. Bass. Thames & Hudson, London: 98-99.

2002 Nautical Archaeology in Israel. In *International Handbook of Underwater Archaeology*. Eds. C.V. Ruppé and J.F. Barstad. *(Plenum Series of Underwater Archaeology*, General ed., J.B. Arnold III). Plenum, New York: cover, 499-517. With D. Davis. First author.

1995 Earliest Mediterranean Paddled and Oared Ships to the Beginning of the Iron Age. In *Conway's History of the Ship: The Age of the Galley*. Conway, London: 10-35.

1987 The Galilee Boat. In *History from the Sea.* Ed. P. Throckmorton. Mitchell Beazley International, Ltd., London: 81-83.

____ Napoleon's Guns. In *History from the Sea.* Ed. P. Throckmorton. Mitchell Beazley International, Ltd., London: 202-205.

1985 Finds from the Late Canaanite (Bronze) Period. In *From the Depths of the Sea. (Israel Museum Catalogue no.* 263, *Summer 1985*). Israel Museum, Jerusalem: 7-11 and pls. 1-7. With O. Misch-Brandl and E. Galili. Third author.

n.d. Some remarks on Archery. In *In the Footsteps of Early Hunters: Arrowheads from the Collection of F. Burian and E. Friedman* (*Israel Museum Catalogue*, no. 151). Israel Museum, Jerusalem.

REFEREED ARTICLES

2012 Panathenaic Ships: The Iconographic Evidence. *Hesperia* 81: 237-266.

2010 Ahhotep's Silver Ship Model: The Minoan Context. *Journal of Ancient Egyptian Interconnections* 2/3: 31-41.

2009 The Paleoenvironmental Contexts of Three Possible Phoenician Anchorages in Portugal. *International Journal of Nautical Archaeology* 38(2): 221-253. First author, with R.K. Dunn, J. Hale, R.L. Hohlfelder, L.B. Conyers, E.G. Ernenwein, P. Sheets, M.L. Pienheiro Blot, F. Castro, D. Davis.

1995 Zeevarders in Het Oude Nabije Oosten. *Phœnix* (*Bulletin uitgegeven door het Vooraziatsch-Egyptisch Genootschap, Ex Oriente Lux.* Leiden.) 41/2: 72-80.

1987 The Kinneret Boat Project: Part I. The Excavation and the Conservation of the Kinneret Boat. *International Journal of Nautical Archaeology* 16: 233-245. Primary author, with K. Raveh and O. Cohen.

1984 A Concise Nautical History of Dor/Tantura. *International Journal of Nautical Archaeology* 13: 223-241. Primary author, with K. Raveh.

1982 The Ships of the Sea Peoples (IJNA 10.3: 187-220). *International Journal of Nautical Archaeology* 11: 297-304.

1981 The Ships of the Sea Peoples. *International Journal of Nautical Archaeology* 10: 187-220.

1980 The Thera Waterborne Procession Reconsidered. *International Journal of Nautical Archaeology* 9: 287-295.

1978 A Ship Graffito from Khirbet Rafi. International Journal of Nautical Archaeology 7: 227-232. Secondary author, with A. Kloner.

NON-REFEREED ARTICLES

In press The 2014 Ioppa Maritima, Part I: Introduction & The Land Survey. INA Quarterly. (9 pages and 10 illustrations.) (Submitted November 6, 2014)

2011 Which Way Forward? On the Directionality of Minoan/Cycladic Ships. *Skyllis* (*Deutsche Gesellschaft zur Förderung der Unterwasserarchäeologie e.V.*) (*Proceedings of In Poseidons Reich* XII) 11(2): 12-18.

2011 Wachsmann, S., 2011. Innovations in Ship Construction at Tantura Lagoon, Israel: Results of the INA/CMS Joint Expeditions (1994-1996). *Skyllis* Deutsche Gesellschaft zur Förderung der Unterwasserarchäeologie e.V.) (Proceedings of In Poseidons Reich XV) 11(1): 83-93.

____ Archaeological Discoveries on Eratosthenes Seamount. In New Frontiers in Ocean Exploration: The E/V Nautilus 2010 Field Season. *Oceanography* 24(1), Supplement: 30. First author, with S. Demesticha, I. Chryssoheri, and K.L. Croff Bell.

2007-2008 Deep Submergence Archaeology: The Final Frontier. *Skyllis* (*Deutsche Gesellschaft zur Förderung der Unterwasserarchäeologie e.V.*) (*Proceedings of In Poseidons Reich* XII) 8(1-2): 130-154.

2002 Sailing into Egypt's Past: Does a Celebration of Luxor's Patron Saint Echo Ancient Pharaonic Traditions? *Archaeology Magazine* 55/4: 36-39.

1997 Shipwreck Fall: The 1995 INA/CMS Joint Expedition to Tantura Lagoon, Israel. *INA Quarterly* 24/1: cover, 3-18. First author, with Y. Kahanov.

____ The Tantura B Shipwreck: The 1996 INA/CMS Joint Expedition to Tantura Lagoon, Israel. *INA Quarterly* 24/4: cover, 3-15. First author, with Y.

Kahanov and J. Hall.

1996 Technology Before its Time: A Byzantine Shipwreck from Tantura Lagoon. *The Explorers Journal* 74/1: 19-23.

1995 The 1994 INA/CMS Joint Expedition to Tantura Lagoon. *INA Quarterly* 22/2: 3-9.

1991 Ancient Seafaring on the Sea of Galilee. *INA Newsletter* 18/3: cover, 4-9, 12. Reprinted in *Seaways'* 4/1(1993): 16-21.

1990 On Sea-Going Vessels Depicted in Egyptian Art. *Qadmoniot* 23 (89-90): 2-20, back cover. (in Hebrew)

____ Una barca nel Mare di Galilea. *Archeologia Viva* 9/11 (N.S.): 10-17.

____ Ships of Tarshish to the Land of Ophir: Seafaring in the Bible. *Oceanus* 33/1: 70-82.

1988 The Galilee Boat: 2,000-Year-Old Hull Recovered Intact. *Biblical Archaeology Review* 14/5: 18-33. Reprinted in 1990 as a chapter in *Archaeology in the World of Herod, Jesus and Paul* II (*Archaeology and the Bible: The Best of BAR*). Eds. H. Shanks and D.P. Cole. Biblical Archaeology Society, Washington: 208-223. Reprinted in 2006 as a chapter (The "Jesus" Boat: Sunk in the Sea of Galilee) in *Where Christianity was Born.* Ed. H. Shanks. Biblical Archaeology Society, Washington: 48-65.

1986 Is Cyprus Ancient Alashiya? New Evidence from an Egyptian Tablet. *Biblical Archaeologist* 49: 37-40.

1984 A Bronze Napoleonic Mortar from the Tantura/Dor Coast. *Qadmoniot* 17: 33-34. With K. Raveh. First author. (in Hebrew)

____ In the Footsteps of Napoleon at Tantura, Israel. *Archaeology Magazine* 37/5: 58-59, 76 and 17. With K. Raveh. First author.

1981 Graffito of a War Galley from Horvat Rafi. *Qadmoniot* 14: 43-46. With A. Kloner. First author. (in Hebrew)

____ The Search for Napoleon's Lost Ordnance in the Sea of Tantura/Dor. *Qadmoniot* 15: 87-91. With K. Raveh. First author. (in Hebrew)

CHAPTERS IN PROCEEDINGS OF PROFESSIONAL MEETINGS

In press In Search of Lost Fleets: A Preliminary Report on the Persian War Shipwreck Survey, 2003-2005 Expeditions. In *Tropis IX. (IXth International Symposium on Ship Construction in Antiquity, Agia Napa, Cyprus, August 25-30, 2005).*

Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens. (21 pages and 13 illustrations) (Submitted October 2005) With J.R. Hale, R.L. Hohlfelder, D. Yoerger, D. Davis and D. Bartoli. First author.

____ Phoenicians in Portugal: The 2002 INA/CNANS Joint Expedition. In *Tropis* VIII. *(VIIIth International Symposium on Ship Construction in Antiquity, Hydra, August 26-31, 2002).* Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens. (21 pages and 15 illustrations) (Submitted June 2004)

2009 The Danaos Project, 2008: Reconstructing the Crete to Egypt Route. In *Proceedings of the 9th Hellenic Symposium on Oceanography & Fisheries, May 13-16, 2009, Patras, Greece,* Vol. I.). Athens, Association of Employees of the Hellenic Centre for Marine Research: 146-151. With V. Tsoukala, D. Sakellariou, D. Davis, C. Smith, B. Buxton, S. Maroulakis, G. Rousakis, P. Georgiou, J. Hale, R. Hohlfelder, D. Griffin, D. Theodoridou, E. Chyssocheri and P. Fix. First author.

____ Deep Coral Environments South of Crete. *Symposium on Oceanography & Fisheries, May 13-16, 2009, Patras, Greece,* Vol. I.). Athens, Association of Employees of the Hellenic Centre for Marine Research: 665-668. With C. Smith, D. Sakellariou and F. McCoy. Fourth author.

2002 The Moulid of Abu el Haggag: A Contemporary Boat Festival in Egypt. In *Tropis* VII. *(VIIth International Symposium on Ship Construction in Antiquity, Pylos, August 25-30, 1999).* Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens: 821-835.

2001 The INA/CMS Joint Expedition to Tantura Lagoon, Israel: Report on the 1994-1995 Seasons of Excavation. In *Tropis* VI. *(6th International Symposium on Ship Construction in Antiquity, Lamia, August, 1996).* Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens: 601-603.

2000 Some Notes on Mediterranean Seafaring During the Second Millennium B.C. In *Proceedings of the First International Symposium "The Wall Paintings of Thera" (Petros M. Nomikos Conference Centre, Thera, Hellas, 30 August - 4 September 1997).* Ed. S. Sherratt. Thera Foundation – Petros M. Nomikos and The Thera Foundation, Athens: 803-824.

1999 The Pylos Rower Tablets Reconsidered. In *Tropis V. (Vth International Symposium on Ship Construction in Antiquity, Nauplion, August 26-28, 1993).* Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens: 491-504.

1997 Were the Sea Peoples Mycenaeans? The Evidence of Ship Iconography. In *Res Maritimae: Cyprus and the Eastern Mediterranean from Prehistory to Late Antiquity. (Proceedings of the Second International Symposium "Cities on the Sea," Nicosia, Cyprus, October 18-22, 1994, Nicosia, Cyprus). (Cyprus American Archaeological Research Institute Monograph Series* 1). Eds. S. Swiny, R. Hohlfelder and H. Wylde Swiny. Scholars Press, Atlanta: 339-356.

1996 Bird-Head Devices on Mediterranean Ships. In *Tropis IV (IVth International Symposium on Ship Construction in Antiquity, Athens, August, 28-31, 1991).* Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens: 539-572.

1995 The Kinneret Boat: The Excavation Report. In *Tropis III (IIIrd International Symposium on Ship Construction in Antiquity, Athens 24th-27th August, 1989).* Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens: 471-483.

1991 La scoperta e gli scavi della barca di Kinneret. In *Atti, IV rassegna di archeologia subacquea, IV premio Franco Papò, (Giardini Naxos 13th-15th October, 1989).* Ed. P.A. Gianfrotta. Edizioni P&M Associati s.r.l., Messina: 161-170.

1990 The Kinneret Boat: Discovery and Excavation. In *Tropis* II. (*IInd International Symposium on Ship Construction in Antiquity, Delphi, August 27-29, 1987)*. Ed. H. Tzalas. Hellenic Institute for the Preservation of Nautical Tradition, Athens: 371-384.

1986 *Shfifons*—Early Bronze Age Anchor-Shaped Cult Stones from the Sea of Galilee Region. In *Thracia Pontica III (Troisième symposium international, Thème génerale "Les Thraces et les colonies grecques, VII-V s.av.n.é.," Table ronde sur les ancres anciennes, Sozopol, 6-12 octobre 1985).* Eds. A. Fol, M. Lazarov, V. Popov, C. Angelova and K. Porojanov. Institut de Thracologie de l'Académie Bulgare des Sciences, Sofia**:** 395-403, 542-554 figs. 1-554.

NOTES AND COMMENTS

2010 The Danaos Project, 2007-2008. *CMAC News.* 2/1: 6-8.

2008 The Danaos Project (2007). In *Nautical Archaeology, 2006-2007 Seasons.* J. Delgado, ed. *American Journal of Archaeology* 112: 311-313, 314 figs. 4-5, 315 figs. 6-7.

____ Milestones: J. Richard ("Dick") Steffy. *Biblical Archaeology Review* 34/2: 20.

2007 The Persian War Shipwreck Survey (PWSS). In Archaeology in Greece 2006-2007. Archaeological Reports for 2004-2005. Vol. 53.) J. Whitley, S. Germanidou, D. Urem-Kotsouet al, eds. (Published by the Council of the Society for the Promotion of Hellenic Studies, London): 44-45.

2006 The Persian War Shipwreck Survey. In J. Whitley, ed., *Archaeology in Greece 2005-2006. Archaeological Reports for 2005-2006,* Vol. 52. Council of the Society for the Promotion of Hellenic Studies and the Council of the British School at Athens, London: 94.

____ Archaeological View: Archaeology Under the Sea. *Biblical Archaeology Review* 32/6: 26, 80.

____ Alashia Redux, Was it Cyprus: Yes. *Archaeology Odyssey* 9/1: 26-27.

2005 The Persian War Shipwreck Survey. In J. Whitley, ed., *Archaeology in Greece 2004-2005. Archaeological Reports for 2004-2005,* Vol. 51. Council of the Society for the Promotion of Hellenic Studies and the Council of the British School at Athens, London: 80-81 fig. 128.

2004 The Forum: Minoan Oarsmen. *Archaeology Odyssey* 7/4: 9 and 7/6: 8.

2003 Ancient Ships: An Iconographical Tale. *Archaeology Odyssey* 6/1: 24-25.

____ Response: A Complex Migration: Did the Philistines Get to Canaan by Land or by Sea? *Biblical Archaeology Review* 29/6: 22, 64.

____ The Forum: Hatshepsut’s Journey to Punt. *Archaeology Odyssey* 6/3: 10-11.

1996 A Cove of Many Shipwrecks: The 1995 INA/CMS Joint Expedition to Tantura Lagoon. *C.M.S. News* 23 (December 1996): cover, 17-21.

1995 Return to Tantura Lagoon. *C.M.S. News* 22: 9-11.

1992 Notes: IVth International Symposium on Ship Construction in Antiquity. *International Journal of Nautical Archaeology* 21: 159-161.

1987 An Ancient Workboat From the Sea of Galilee. *Mariners Mirror* 73: 375-376.

1986-1987 The Excavation of the Kinneret Boat. *Bulletin of the Anglo-Israel Archaeological Society* 6: 50-52.

1986 Ginosar, Ancient Boat. *Excavations and Surveys in Israel* 5: 42-44. (Published in Hebrew as: Ginosar Coast: An Ancient Boat. *Hadashot Archeologiot* 88[1986]: 6-7.) With K. Raveh and O. Cohen. First author.

____ Ma’agan Mikhael, Ancient Shipwreck. *Excavations and Surveys in Israel* 5: 61-62. (Published in Hebrew as: Ma'agan Mikhael Coast: Remains of a Ship. *Hadashot Archeologiot* 88[1986]: 13-14.) With K. Raveh. First author.

1985 A Square Sail at Cairo. *Mariners Mirror* 71: 230-232.

1984-1985 Nautical Archaeological Inspection of the Israel Department of Antiquities. *Bulletin of the Anglo-Israel Archaeological Society* 4: 24-29, pls. 1-2.

1984 Concerning a Lead Ingot Fragment from ha-Hotrim, Israel. *International Journal of Nautical Archaeology* 13: 169-176, 340. With K. Raveh. First author.

____ Hahotrim Coast, Shipwreck. *Excavations and Surveys in Israel* 3: 37. (Published in Hebrew as: A Shipwreck on the ha-Hotrim Coast. *Hadashot Archeologiot* 85[1984]: 19.) With K. Raveh. First author.

____ Dor, Underwater Find. *Excavations and Surveys in Israel* 3: 25. (Published in Hebrew as: Dor, Coast. *Hadashot Archeologiot* 84 [1984]: 26.) With K. Raveh. First author.

1982 Haifa—Underwater Discovery. *Excavations and Surveys in Israel 1982* 1: 33. (Published in Hebrew as: Haifa Area, Underwater Find. *Hadashot Archeologiot* 78-79: 17.)

____ Megadim Coast—Stone Anchors. *Excavations and Surveys in Israel* 1: 71-72. (Published in Hebrew as: Stone Anchors from the Megadim Coast. *Hadashot Archeologiot* 80-81: 9-10.) With E. Galili and K. Raveh. Third author.

1981 An Underwater Salvage Excavation near Kibbutz Hahotrim, Israel. *International Journal of Nautical Archaeology* 10: 160. With K. Raveh. First author.

____ Hahotrim. *Hadashot Archeologiot* 76: 16. With K. Raveh. First author. (in Hebrew)

____ Underwater Salvage Excavation at Hahotrim, 1980. *Israel Exploration Journal* 31: 116-117 and pl. 24: E. With K. Raveh. First author.

1980 Underwater Work Carried out by the Israel Department of Antiquities. *International Journal of Nautical Archaeology* 9: 256-264. With K. Raveh. First author.

1978 Underwater Investigations by the Department of Antiquities and

Museums. *Israel Exploration Journal* 28: 281-283, pl. 56. With K. Raveh. First author.

1977 Letters to the Editor. *International Journal of Nautical Archaeology* 6: 266-267.

BOOK REVIEWS

2014 Review: *The Oxford Handbook of the Bronze Age Aegean*. Ed. Eric Cline. *International Journal of Nautical Archaeology* 43: 203-206.

2005 Review: *Sailors in the Holy Land: The 1848 American Expedition to the Dead Sea in Search of Sodom and Gomorrah.* By Andrew C.A. Jampoler. *The Northern Mariner* 15/2: 66-67.

2002 Review: *Seafaring and the Jews.* Ed. N. Kashtan. *International Journal of Maritime History* 14: 334-336.

2000 Review: *Phoenicians.* "Peoples of the Past" series. By Glenn E. Markoe. *International Journal of Maritime History* 12: 233-234.

1992 Review: *The Athlit Ram.* Eds. L. Casson and J. Richard Steffy. *American Neptune* 52: 204-206.

1985 Review: *Stone Anchors in Antiquity: Coastal Settlements and Maritime Trade Routes in the Eastern Mediterranean ca. 1600-1050 BC.* By Dan E. McCaslin. *Mariners Mirror* 71: 483-485.

ENCYCLOPEDIA ENTRIES

In press Ships. In *Encyclopedia of the Material Culture of the Biblical World.* A. Berlejung, ed. Tübingen, Mohr Siebeck. (15 pages and 4 illustrations.) (Submitted December 2007)

2009 Ships and Seafaring in the New Testament. In *The New Interpreter's Dictionary of the Bible S-Z.* Vol. 5. K. D. Sakenfeld, ed. Nashville, Abington Press: 237-239.

2008 Sea of Galilee. In *Encyclopedia of the Historical Jesus.* C. Evans, ed. New York, Routledge: 557-560.

2007 Minoan Seafaring. In *The Oxford Encyclopedia of Maritime History*. Vol. II. Ed. J.B. Hattfield. Oxford University Press, New York: 575-576.

1997 Anchors. In *The Oxford Encyclopedia of Near Eastern Archaeology* I. Ed. E.M. Meyers. Oxford University Press, New York: 137-140. With D. Haldane.

(First author.)

____ Galilee Boat. In *The Oxford Encyclopedia of Near Eastern Archaeology* II. Ed. E.M. Meyers. Oxford University Press, New York: 377-379.

____ Seafaring. In *The Oxford Encyclopedia of Near Eastern Archaeology* IV. Ed. E.M. Meyers. Oxford University Press, New York: 505-509.

____ *Shfifonim.* In *The Oxford Encyclopedia of Near Eastern Archaeology* V. Ed. E.M. Meyers. Oxford University Press, New York: 27-28.

____ Ships and boats. In *The Oxford Encyclopedia of Near Eastern Archaeology* V. Ed. E.M. Meyers. Oxford University Press, New York: 30-34. Secondary author, with G.F. Bass.

____ Sea of Galilee Boat. In *Encyclopedia of Underwater and Maritime Archaeology*. Ed. J.P. Delgado. British Museum Press, London: 364-365.

1996 Galilee Boat. In *Dictionary of Judaism in the Biblical Period* I. Eds. J. Neusner and W.S. Green. Macmillan Library Reference USA and Simon & Schuster and Prentice Hall International, New York and London: 241.

1993 Ginnosar. In *The New Encyclopedia of Archaeological Excavations in the Holy Land* II. Israel Exploration Society and Carta, Jerusalem: 520. First author, with K. Raveh.

ARTICLES IN POPULAR MAGAZINES

1991 Hatshepsut's Guide to Red Sea Marine Life. *IsraEl Al* 40: 19-20, 22.

1990 The Ancient Hiding Systems: *And Men Shall Enter the Caves of the Rocks and the Holes of the Ground*... (Isaiah 2: 19). *IsraEl Al* 32: 22-28.

____ The Island of Legend. *IsraEl Al* 31: 54-53. (in Hebrew)

____ The Tale of Wenamun. *IsraEl Al* 34: 20-23.

____ Passover in a Plate. *Israel Hilton Magazine* (Spring): 4-10.

____ The Museum of the Great Escape. *The Dan Magazine* (Spring): 12-16.

____ The Voyage of the Rob Roy. *IsraEl Al* 30: 15-19.

____ To Soar Like a Bird. *IsraEl Al* 30: 8-12.

____ More than Aerospace. *IsraEl Al* 30: 27-28.

____ Soil-less Soil: A New Agriculture. *Israel Al* 33: 15-16.

1989 Das Boot vom See Genezareth. *Die Zukunft* (December): 28-30.

____ Raiders of the Past. *IsraEl Al* 29: 16-19.

____ Seafaring in Biblical Times. *IsraEl Al* 28: 12-18.

1988 The Boat in the Lake. *London Illustrated News* 276 (February): 53.

1987-1988 A Not-So-Innocent Abroad. *The Dan Magazine* (Winter): 4-6.

____ The Music of Ancient Israel. *IsraEl Al* 21: 19-24.

____ Caesarea. *Israel Hiltons Magazine* (Winter): 32-34.

____ The Once and Future Acco. *IsraEl Al* 21: 39-42.

____ Yaffo. *Isrotel Magazine* (Winter): 14-16.

1987 Luxor. *IsraEl Al* 18: 61-60. (in Hebrew)

____ The Old Sea and the Man. *IsraEl Al* 18: cover, 17-26.

____ The Woeful Tale of Wenamon. *The Israel Hiltons Magazine*: 26-28.

____ 19th Century Visitors to Jerusalem. *IsraEl Al* 19: 12-14.

____ Venice. *IsraEl Al* 18: 59-58. (in Hebrew)

1986-1987 Diplomats Dig In. *Keeping Posted* 6 (Winter): 62.

1986 An Encounter with Napoleon at Tantura. *IsraEl Al* 16: cover, 7-17. Primary author, with K. Raveh.

____ Raiders of the Lost Boat. *IsraEl Al* 15: cover, 6-11. Primary author, with K. Raveh.

1983-1984 The Guns of Tantura: Napoleonic Weaponry From Beneath the Sea. *Israel - Land and Nature* 9: 56-60. Primary author, with K. Raveh.

1983 Stone Anchors. *El Ha-Yam* 17 (September-October): 33-34; 18 (November-December): 28-29. Primary author, with K. Raveh. (in Hebrew)

____ The Discovery of Antiquities in the Sea. *El Ha-Yam* 16 (July- August): 34-36. (in Hebrew)

____ To the Mystery Wreck at the Habonim Coast. *El Ha-Yam* 18 (November-December): 20-23. Primary author, with K. Raveh and N. Lisovski. (in Hebrew)

ARTICLES FOR CHILDREN

In press How Deep Can They Go? *DIG Magazine* (4 pages and 5 figures) Submitted September 9th, 2013)

2011 Tracking Waterways. *DIG Magazine* 13(8 May/June): 22-25.

1993 A Special Sunken Treasure: Excavating a 2,000-Year-Old Boat. *Faces* (October): cover, 1, 4-8.

REPORTS ON GRANTS/PROJECTS

1999 The 1999 INA/ROBO Remote Sensing Survey opposite Tantura Lagoon, Israel. (Final Report)

1998 The 1997 Leon Levy Shipwreck Survey, Ashkelon, Israel. (Final Report) With the assistance of P. Sibella, D. Carlson and D. Davis.

1997 National Geographic Society Grant #5766-96. Exploration of Tantura Lagoon: Four Millennia of Seafaring. (Final Report).

1996 National Geographic Society Grant #5571-95. Excavation of a Byzantine-Period Shipwreck, Tantura Lagoon, Israel. (Final Report).

____ To the Sea of the Philistines: The Ashkelon Sidescan Sonar Shipwreck Survey (May 1996). (Final Report).

1995 National Geographic Society Grant #5322-94. The INA/CMS Joint Expedition to Tantura Lagoon, Israel. (Final Report).

COLLOQUIA & SESSIONS CHAIRED

2014 IKUWA 5 (International Conference on Underwater Archaeology), October 15-19, 2014 at Cartegena, Spain. Title: Methodology: Conservation & Analyses

2011 In Poseidons Reich XVI. Organized by the Deutsche Gesellschaft zur Förderung der Unterwasserachäologie e. V. (DEGUWA) in Heidelberg Germany, February 18-20. Session title: Akkulteration und Besiedlung.

____ American Institute of Archaeology Annual Meeting, San Antonio, January. Session title: A Half Century of Nautical Archaeology: Revisiting Excavations. Chair.

2009 American Institute of Archaeology Annual Meeting, Philadelphia, PA, January.

Session title: Ancient Mediterranean Ship Construction: A Colloquium in Honor of J. Richard “Dick” Steffy. Chair.

____ American Institute of Archaeology Annual Meeting, Philadelphia, PA, January. Session title: Crete and Thera. Chair.

2008 Xth International Symposium on Ship Construction in Antiquity, Hydra, Greece, August-September. Session title: Ports. Chair.

2007 In Poseidons Reich XII. Organized by the Deutsche Gesellschaft zur Förderung der Unterwasserachäologie e. V. (DEGUWA) in Cologne, Germany, February. Session title: Atlantic, North Sea & Baltic Sea. Chair.

____ American Institute of Archaeology Annual Meeting, San Diego, CA, January. Session title: Ships and Shipwrecks. Chair.

2006 American Institute of Archaeology Annual Meeting, Montreal, Canada, January. Session title: Deep-Submergence Archaeology: The Aegean and the Eastern Mediterranean Seas. Chair.

2005 American Institute of Archaeology Annual Meeting, Boston, MA, January. Session title: Deep-Submergence Archaeology: The Final Frontier. Chair.

____ IXth Symposium on Ship Construction in Antiquity, Agia Napa, Cyprus, August. Session title: Sails/Rigging & Ship Graffiti. Co-Chair.

PAPERS PRESENTED AT PROFESSIONAL MEETINGS

2014 IKUWA 5 (International Conference on Underwater Archaeology), October 15-19, 2014 at Cartegena, Spain. Title: On Digital Nautical Archaeology.

2013 Italy, Mediterranean and Europe in the Bronze Age: Trade, Travels and Migrations in the Mid to Late 2nd Millennium BC. International Conference at the University of Göthenborg, Sweden, April 26th, 2013. Title: Sea Peoples in Egypt.

____ American Institute of Archaeology Annual Meeting, Seattle, WA, January 3-6, 2013. Title: Dionysian Ship Carts: Iconography and Context.

2012 ASOR 2009 Annual Meeting. Chicago, IL, November 14-17, 2012. Title: Innovation in Ship Construction at Tantura Lagoon, Israel: results of the INA/CMS Joint Expedition.

2012 Smithson Resident Associates Program: Easter Island’s Secrets Revealed (All day Seminar). Smithsonian National Museum, September 22, 2012. Title: Rapa Nui Culture: The View from the Ocean (with J. Morris).

2011 Offshore Technology Conference (OTC) 2011, May 2nd-5th, Houston, Texas. Title: Deep Submergence Archaeology: The Final Frontier. (Breakfast Topical Lecture)

____ The Underwater Archaeology Society of BC 25th Annual Conference in Fort Langley National Historic Site, British Columbia, Canada. April 30th, 2011.Title: The Sea of Galilee Boat. (Conference keynote lecture)

____ The Underwater Archaeology Society of BC 25th Annual Conference in Fort Langley National Historic Site, British Columbia, Canada. April 30th, 2011.Title: Deep Submergence Archaeology: Fleets of Antiquity.

____ In Poseidons Reich XVI. Organized by the Deutsche Gesellschaft zur Förderung der Unterwasserachäologie e. V. (DEGUWA) in Heidelberg Germany, February 18-20. Title: Minoan/Cycladic Ships: An Overview.

2010 ASOR 2010 Annual Meeting. Atlanta, GA, November 17-20 2010. Title: Ahhotep's Silver Model Reconsidered.

____ In Poseidons Reich XV. Organized by the Deutsche Gesellschaft zur Förderung der Unterwasserachäologie e. V. (DEGUWA) in Vienna, Austria, February 19-21. Title: Innovation in Ship construction at Tantura Lagoon, Israel: Results of the INA/CMS Joint Expedition.

____ American Institute of Archaeology Annual Meeting, Anaheim, CA, January 6-9, 2010. Title: The Panathenaic Ship.

2009 ASOR 2009 Annual Meeting. New Orleans, LA, November 18-21 2009. Title: A Helladic-Style Wooden Ship Model from Gurob, Egypt.

____ International Symposium on Underwater Vehicles Technologies (Anavissos, Greece 26-27 March 2009). Organized by the Hellenic Centre for Marine Research. Title: The Forensics of Deep-Water Shipwrecks.

____ American Institute of Archaeology Annual Meeting, Philadelphia, PA, January. Workshop title: Deep Submergence Archaeology Revisiting the Final Frontier. Panelist.

2008 Xth International Symposium on Ship Construction in Antiquity, Hydra, Greece, August 27-September 2. Title: The Danaos Project (2007-2008).

____ Xth International Congress of Egyptologists. Rhodes, Greece, May 22nd-29th, 2008). Title: The Gurob Ship Model

____ 1200 BC: War, Climate Change & Cultural Catastrophe. Organized by the Schools of Archaeology and Classics at University College Dublin, Ireland, (7-9 March 2008). Title: On Helladic Galleys and Sea Peoples.

2007 In Poseidons Reich XII. Organized by the Deutsche Gesellschaft zur Förderung der Unterwasserachäologie e. V. (DEGUWA) in Cologne, Germany, February. Title: Deep Submergence Archaeology: The Final Frontier.

____ American Institute of Archaeology Annual Meeting, San Diego, CA, January. Title: The Gurob Model.

2005 IXth International Symposium on Ship Construction in Antiquity, Agia Napa, Cyprus, August. Title: In Search of Lost Fleets: A Preliminary Report on the Persian War Shipwreck Survey, 2003-2005 Expeditions. (Presenter, with J. Hale & R.L. Hohlfelder)

____ Keynote lecturer, student conference under the auspices of the Canadian Archaeological Institute at Athens and Concordia University at Concordia University, September. Title: Deep-Submergence Archaeology: The Persian War Shipwreck Survey.

2004 American Institute of Archaeology Annual Meeting, San Francisco, CA, January. Title: Visualizing Shipwrecks at Tantura Lagoon, Israel. (Co-presenter with D. Sanders). Also co-author with J. Hale (presenter) and R.L. Hohlfelder for presentation entitled The Persian War Shipwreck Project 2003: Deep-Water Survey Off Mt. Athos.

____ Cyprus American Archaeological Research Institute (CAARI) Workshop: Cyprus and Underwater Archaeology, Nicosia, Cyprus, January. Title: Deep-Submergence Archaeology. (Co-presenter with J. Morris)

____ First Conference on Deep-Water Archaeological Exploration: Technology and Perspectives, Athens, Greece, September. Title: The Persian War Shipwreck Survey 2003-2004: Preliminary Report.

____ American Schools of Oriental Research Annual Meeting, San Antonio, TX, November. Title: The 2004 Persian War Shipwreck Survey. (Presenter with J. Hale and R.L Hohlfelder)

2003 American Schools of Oriental Research Annual Meeting, Atlanta, GA, November. Title: The 2003 Persian War Shipwreck Survey. (Presenter with J. Hale and R.L Hohlfelder)

2002 American Institute of Archaeology Annual Meeting, Philadelphia, PA, January. Title: The Galilee Boat: A Porthole into the Past.

____ VIIIth Symposium on Ship Construction in Antiquity, Hydra, Greece, August. Title: Phoenicians in Portugal.

____ Communications in the Mediterranean from Paleolithic to Early Roman Times, Melos, Greece, September. Title: Ancient Mediterranean Navigation & the

Promise of Deep-Submergence Archaeology.

2001 Seminar on Sediment Moving and Imaging (discussions on the design of an excavating tool for deep-submergence archaeology); participant.

____ American Institute of Archaeology Annual Meeting, San Diego, CA, January. Title: Near and Far: The Case for Deep-Water Shipwrecks off Israel's Mediterranean Coast.

2000 Travel and Trade in the Ancient World, Wheaton College 45th Annual Archaeology Conference, November. Title: Ancient Seafaring in the Eastern Mediterranean.

1999 Technology and Archaeology in the Deep Sea: Towards a New Synthesis, Massachusetts Institute of Technology, Cambridge, MA. Panelist.

____ VIIth Symposium on Ship Construction in Antiquity, Pylos, Greece, August. Title: The *Moulid* of Abu Haggag and Boat Festivals in Egypt.

1998 Thirty-Sixth Annual Briefing: New Horizons in Science (Council for the Advancement of Science Writing), Cambridge, MA, November. Topic: Bronze Age Seafaring.

1997 First International Symposium "The Wall Paintings of Thera," Thera, Greece, August-September. Title: Some Notes on Mediterranean Seafaring During the Second Millennium B.C.

1996 VIth Symposium on Ship Construction in Antiquity, Lamia, Greece, August. Title: The INA/CMS Joint Expedition to Tantura Lagoon, Israel: Report on the 1994-1995 Seasons of Excavation.

____ Symposium on Underwater Archaeology, (Marine Branch of the Israel Antiquities Authority), Athlit, Israel, October. Title: Underwater Excavations and Surveys at Tel Dor.

1995 Invited lecturer for a seminar concerning "Cultural Interconnections in the Ancient Near East: The Sea Peoples," by the Near Eastern Section at The University Museum, University of Pennsylvania. Title: The Naval Battle at Medinet Habu: Concerning the Ships of the Sea Peoples and their Relation to Contemporaneous Mycenaean Ships.

1994 Res Maritimae: Cyprus and the Eastern Mediterranean. Prehistory Through the Roman Period, Nicosia, Cyprus, October. Title: Were the Sea Peoples Fleeing Mycenaeans? The Evidence from Ship Iconography.

1993 Vth Symposium on Ship Construction in Antiquity, Nauplion, Greece, August. Title: The Pylos Rower Tablets Reconsidered.

____ XIth Naval History Symposium Held with the Classical Association of the Atlantic States, United States Naval Academy, Annapolis, MD, October. Respondent to the session on Underwater Archaeology.

____ American Schools of Oriental Research Annual Meeting, Washington, DC, November. Title: Ethnicity and Late Bronze Age Shipwrecks.

1992 Conference of the Society for Historical Archaeology and the Council for Underwater Archaeology, Kingston, Jamaica, January. Title: The Battle of Migdal Reconsidered.

1991 Southwest Regional American Schools of Oriental Research Convention, Dallas, TX, March. Title: The Galilee Boat: Conclusions.

____ Thalassa II, Department of Classics, University of Texas, Austin, TX, October. Title: Aegeans in the Theban Tombs.

____ IVth Symposium on Ship Construction in Antiquity, Athens, Greece, August. Title: Bird-Head Devices on Mediterranean Ships.

1989 First Joint Archaeological Congress, Baltimore, MD, January. Title: The Kinneret Boat: Excavation and Conclusions.

____ IIIrd Symposium on Ship Construction in Antiquity, Athens, Greece, August. Title: The Kinneret Boat: The Excavation Report.

____ IV rassegni di archeologia subacquea, IV premio Franco Papò, Giardini-Naxos, Sicily, October. Title: The Discovery and Excavation of the Kinneret Boat.

1987 Seaborne Trade in Metals and Ingots, Oxford, England, January. Title: The Seaborne Late Bronze Age Metals Trade in Retrospect.

____ IInd Symposium on Ship Construction in Antiquity, Athens, Greece, August. Title: The Kinneret Boat: The Discovery and Excavation.

1985 Society and Economy in the Eastern Mediterranean, c. 1500-1000 B.C., Haifa, Israel, April-May. Title: Observations on Two Nautical Aspects of Canaanite Late Bronze Age Trade.

____ IIIrd International Symposium Thracia Pontica, Sozopol, Bulgaria, October. Title: *Shfifons*—Early Bronze Age Anchor-Shaped Cult Stones form the Sea of Galilee Region.

1982 VIth International Congress of Underwater Archaeology, Cartegena, Spain, March-April. Title: A Bronze Age Cargo off Hahotrim, Israel.

____ IXth Archaeological Conference in Israel, Jerusalem, Israel, April. Title: Cultic

Anchor-Like Stones from Bikat Kinarot Dating to the Early Bronze Age.

ENDOWMENTS, FELLOWSHIPS, RESEARCH GRANTS & MAJOR PRIVATE FUNDING

ENDOWMENTS

1999-present	Meadows Associate Professorship of Biblical Archaeology, (Texas A&M University)
1993-1999	Meadows Assistant Professorship of Biblical Archaeology (Texas A&M University)
1990-1993	Meadows Visiting Assistant Professorship of Biblical Archaeology (Texas A&M University)

FELLOWSHIPS

SP 2015	Glascock Internal Faculty Residential Fellow	$1,000 & course reduction
2009-2010	Glascock/Anthropology Stipendiary Faculty Fellow	$1,500
2003-2004	Glascock/Anthropology Stipendiary Faculty Fellow	$1,500
2002-2007	University Faculty Fellow (Texas A&M University) ($100,000)	$100,000

RESEARCH GRANTS & MAJOR PRIVATE FUNDING

2014	The Ioppa Maritima Project	The MacDonald Center for the Arts & Humanities	$200,000
2012	Digitization of photographic materials for *Studies in Tantura Lagoon (Dor), Israel (1994-1996)* (Texas A&M University Press)	Ed Rachal Foundation	$7,000
2011	Publication subvention grant for *The Gurob Ship-Cart Model and Its Mediterranean Context* (Texas A&M University Press)	Archaeological Institute of America	$7,500
2010	The Eratosthenes Seamount Deepwater Survey	Office of the Vice President for Research, Texas A&M University	$10,000

2010	The Eratosthenes Seamount Deepwater Survey	College of Liberal Arts	$500
2009	The Danaos Project	The MacDonald Center for the Arts & Humanities	$401,815
2009	Publication	Anonymous Donor	$10,000
2008	The Danaos Project	The MacDonald Center for the Arts & Humanities	$546,246
2007	The Danaos Project	The MacDonald Center for the Arts & Humanities	$216,227
2006	The Persian War Shipwreck Survey	Anonymous Donor	$200,000
2005	The Persian War Shipwreck Survey	Anonymous Donor	$200,000
____	The Persian War Shipwreck Survey	The L.J Skaggs and Mary C. Skaggs Foundation	$7,500
2004	The Danaos Project	The MacDonald Center for Ancient History	$200,000
____	The Persian War Shipwreck Survey	Anonymous Donor	$150,000
____	The Persian War Shipwreck Survey	The L.J Skaggs and Mary C. Skaggs Foundation	$10,000
2003	The Persian War Shipwreck Survey	Anonymous Donor	$90,000
____	The Persian War Shipwreck Survey	Melbern G. Glasscock Center for Humanities Research at Texas A&M University	$2,000
____	The INA/CNANS Joint Expedition: Radiocarbon Dating	Archaeological Institute of America: Archaeology of Portugal Fund	$10,450
2002	The INA/CNANS Joint Expedition	Anonymous Donor	$50,000
2000	Deep-Water Research	The L.J Skaggs and Mary C. Skaggs Foundation	$15,000
1999	ROBO Remote Sensing Shipwreck Survey, Tantura	Mr. George Robb (Robb, Peck, McCooey Financial Services, Inc.)	$98,000

____	Deep-Water Shipwrecks, Ashkelon	Office of the Vice President for Research, Texas A&M University	$6,098
1998	Tantura Lagoon Research	The L.J Skaggs and Mary C. Skaggs Foundation	$10,000
1997	Leon Levy Shipwreck Survey, Ashkelon	The Leon Levy Expedition to Ashkelon	$75,000
1996	Ashkelon Side-Scan Sonar Shipwreck Survey	The Leon Levy Expedition to Ashkelon	$11,066
____	Tantura Lagoon Expedition	National Geographic Society	$20,000
____	Tantura Lagoon Expedition	The L.J Skaggs and Mary C. Skaggs Foundation	$7,500
1995	Tantura Lagoon Expedition	National Geographic Society	$20,000
1994	Tantura Lagoon Expedition	National Geographic Society	$18,700
1992	Bible Arts Center, Dallas exhibition of the Galilee Boat Model	Meadows Foundation of Texas	$10,000

EDITORIAL SERVICES TO SCHOLARLY PUBLICATIONS

2013 Book reviewer of *The Oxford Handbook of the Bronze Age Aegean*. Ed. Eric Cline. Reviewed for the *International Journal of Nautical Archaeology*.

2011 Reviewer for the Israel Antiquities Authority of a manuscript for their peer-reviewed journal, *Atiqot.* Title: Artifact Assemblage Recovered for a Roman Shipwreck off the Carmel Coast, Israel by E. Galili, B. Rosen and J. Shavit.

2006 Endorsed Ed. R. Hohlfelder, 2008. *The Maritime World of Ancient Rome.* University of Michigan Press, Ann Arbor.

____ Invited editorial in *Biblical Archaeology Review*.

2005 Book reviewer for *The Northern Mariner*.

____ Manuscript reviewer of *The Maritime World of Ancient Rome*. Ed. R. Hohlfelder. Reviewed for University of Michigan Press.

____ Endorsed *The Sacred Bridge: Carta's Atlas of the Biblical World.* By A. F. Rainey, A. F. and R. S. Notley (Jerusalem: Carta [2006]).

2004 Consultant for National Geographic Society publications volume, *Mystery of the Ancient Seafarers: Early Maritime Civilizations* by R.D. Ballard and T. Eugene.

____ Requested by the Biblical Archaeology Society to respond to reader's query, in *Archaeology Odyssey* 7/4: 9 & 7/6: 8

____ Reviewer for the Israel Antiquities Authority of a manuscript for their peer-reviewed journal, *Atiqot.* Title: Artifact Assemblage Recovered for a Roman Shipwreck off the Carmel Coast, Israel by E. Galili, B. Rosen and J. Shavit.

2003 Requested by the Biblical Archaeology Society to respond to reader's query, in *Archaeology Odyssey* 6/3: 10-11.

2002-2003 *Studies in Nautical Archaeology* monograph series, Texas A&M University Press; General Editor.

2002 Book reviewer for *The International Journal of Maritime History*.

2000 Book reviewer for *The International Journal of Maritime History*.

1998-2001 Editorial Advisory Board, *The Explorers Journal;* member.

1998 Manuscript reviewer of J.T. Baruffi, *Naval Warfare Operations in the Bronze Age Eastern Mediterranean.* Reviewed for E.J. Brill

____ Manuscript reviewer of R. Higham, *Maritime Minoa: the Phaistos Case.* Reviewed for Texas A&M University Press.

____ Aided the Biblical Archaeology Society in responding to a reader's query, in *Bible Review* 14/2(1998): 22.

1997 Manuscript reviewer of *The International Encyclopedia of Maritime and Underwater Archaeology*. Ed. J. Delgado. Reviewed for Texas A&M University Press.

1992 Book reviewer for *The American Neptune*.

____ Reported on the IVth International Symposium on Ship Construction in Antiquity, Athens in *International Journal of Nautical Archaeology*

21(1992) 159-161. For the Nautical Archaeology Society.

1991-2002 *Studies in Nautical Archaeology* monograph series, Texas A&M University Press, Editorial Board; member.

1985 Book reviewer for *The Mariner's Mirror*.

n.d. Sivan, R. and D. Harel, *The Saga of the 2000-Year-Old Boat.* Fundraising prospectus in support of a museum for the Galilee Boat. (Archaeological advisor).

GRANT PROPOSAL REVIEWED FOR ORGANIZATIONS

• Israel Science Foundation
• National Geographic Society

ADJUNCT/AFFILIATE POSITIONS

2013-present The Jaffa Cultural Heritage Project; Associate Director; PI Ioppa Maritima Project.

2011-present Religious Studies, Texas A&M University; Affiliated Faculty.

2009-present Journalism Studies Program, Texas A&M University; Affiliated Faculty.

ACADEMIC TRUSTEESHIPS

2011-2013 Academic Trustee, Archaeological Institute of America

COMMITTEE MEMBERSHIP IN SCHOLARLY SOCIETIES

2011-present Chair, Institute of Nautical Archaeology (INA) Archaeological Committee

2011-present Member, Professional Responsibilities Committee, Archaeological Institute of America

2011-present Member Travel Committee, Archaeological Institute of America

2011 Co-Chair, Underwater Archaeology Sub-Committee; Archaeological Institute of America

1997-2010 Member, Underwater Archaeology Sub-Committee; Archaeological Institute of America

MEMBERSHIP IN SCHOLARLY SOCIETIES (PRESENT & PAST)

American Schools of Oriental Research

Archaeological Institute of America (Life Member)

Biblical Archaeology Society

Explorers Club (Fellow National)

Hellenic Institute of Marine Archaeology (Corresponding Member)

Institute of Nautical Archaeology (Faculty)

Israel Exploration Society

Nautical Archaeology Society

Sigma Xi

Society of Archer-Antiquaries

Society for Nautical Research

HONORS & SPECIAL RECOGNITION RECEIVED

2010	Biography included in Marquise *Who's Who in America 2011*. 65th Edition. Vol. 2. Marquis Who's Who, New Providence: 4726.
2009-2010	Anthropology/Glascock Faculty Fellow (2009-2010). This award includes a fund of $1,500.
2009-2010	The AIA Martha Sharp Joukowsky Lecturship (2009-2010). This lectureship comes with a $12,500 stipend out of which the lecturer defrays travel expenses for 12 national lectures.
2003	Anthropology/Glascock Faculty Fellow. This award includes a fund of $1,500.
2002	Texas A&M University Faculty Fellow, Class of 2002. This award includes a fund of $100,000 administered over five years.
2000	Irene Levi-Sala Award for best popular book for *Seagoing Ships and Seamanship in the Bronze Age Levant* (Texas A&M University Press: College Station). The award includes a fund of $3,000.
1999	Awarded membership, in Sigma Xi, the Scientific Research Society.
1998	Selected as a featured grantee on National Geographic Interactive

(http://www.nationalgeographic.com/research/grantee/98/wachs.html).

1997 One of 15 National Geographic Society grantees profiled in "In the Field." (*National Geographic Magazine* 191: 104-105.)

1997 Biblical Archaeology Society's Biennial Award for Best Popular Book on Archaeology in 1995-1996 for *The Sea of Galilee Boat: An Extraordinary 2000 Year Old Discovery* (Plenum: New York).

____ Biographee in *Who's Who in the South and Southwest 1997-1998.* Silver 25th Edition. Marquis Who's Who, New Providence: 951.

1996 Biographee in *Contemporary Authors: A Bio-Bibliographical Guide to Current Writers in Fiction, General Nonfiction, Poetry, Journalism, Drama, Motion Pictures, Television and Other Fields.* Volume 150. Ed. K.J. Edgar. Gale, Detroit: 451.

1995 Biographee in *Who's Who in the South and Southwest.* 24th Edition. Marquis Who's Who, New Providence: 919.

1993 Biographee in *Who's Who in Biblical Studies and Archaeology:* 2nd Edition. Biblical Archaeology Society, Washington: 312.

____ Awarded membership, the Explorers Club (Fellow National).

1984 MA in Near Eastern Archaeology, *cum laude.*

1974 BA in Near Eastern and Classical Archaeology, *cum laude.*

LECTURES

INTERNATIONAL

2013 University of Göthenborg, Sweden.

2010 University of Toronto, Toronto, Ontario, Canada AIA Joukowsky Lecture.

____ Memorial University of Newfoundland, Newfoundland, Canada. AIA Joukousky Lecture.

____ University of New Brunswick, Fredricton, New Brunswick, Canada. AIA Joukousky Lecture.

____ Maritime Museum of the Atlantic, Halifax, Nova Scotia, Canada AIA Joukousky Lecture.

2007 University of Calgary, Calgary, Canada. Calgary Society for Mediterranean Studies.

2006 Brock University, St. Catharines, ON, Canada. AIA Traveling Lecturer Series

____ Saint Paul University, Ottawa, Canada

____ Library and Archives Canada, Ottawa, Canada. AIA Traveling Lecturer Series

____ Pan-Macedonian Center, Toronto, Canada. Canadian Institute in Greece (CIG)

2004 Vancouver Institute, Vancouver, BC, Canada

____ Vancouver Maritime Museum, Vancouver, BC, Canada

____ University of Sydney, Sydney, Australia. For the Near Eastern Archaeology Foundation

____ Western Australia Maritime Museum, Perth, Australia

____ University of Aukland, Aukland, New Zealand

2003 Canadian Archaeological Institute at Athens (CAIA), Athens, Greece.

____ Archaeological Research Unit, Department of History and Archaeology, University of Cyprus, Nicosia, Cyprus

2002 Vancouver Maritime Museum, Vancouver, BC, Canada. First James Russell Lecture, AIA Traveling Lecturer Series

____ Vancouver Institute, Vancouver, BC, Canada

2000 Yigal Allon Center, Kibbutz Ginosar, Israel. The Galilee Boat: A 2000th Anniversary. (Keynote speaker)

1999 Winnipeg, Manitoba, Canada. AIA Traveling Lecture Series

1995 Bible Lands Museum, Jerusalem, Israel

1992 Bible Lands Museum, Jerusalem, Israel

NATIONAL

2013 Missouri History Museum. AIA St. Louis Branch.

____ University of Oklahoma, Norman, OK

____ University of Arkansas, Fayetteville, AR

____ Rice University, Houston, TX

____ University of Dallas, Dallas, TX

____ Prairie Museum, Sweetwater, TX.

2012 Johns Hopkins University Homewood Campus. AIA Traveling Lecturer Series.

____ Aggie Muster, Yoakum, TX.

____ AIA Houston Texas Branch. AIA Traveling Lecturer Series.

2011 Honolulu Academy of Arts. AIA Traveling Lecturer Series.

____ University of Richmond, Richmond VA. AIA Traveling Lecturer Series.

2010 University of Michigan, Ann Arbor, MI. AIA Joukousky Lecture.

2009 Mt. Holyoke College, South Hadley, MA. AIA Joukousky Lecture.

____ Worcester Art Museum, Worcester, MA. AIA Joukousky Lecture.

____ Boston University, Boston, MA. AIA Joukousky Lecture.

____ Oriental Institute, University of Chicago, Chicago, IL. AIA Joukousky Lecture.

____ Valparaiso University, Valparaiso, IN. AIA Joukousky Lecture.

____ University of South Florida, Tampa, FL. AIA Joukousky Lecture.

____ Florida Atlantic University, Boca Raton FL. AIA Joukousky Lecture.

____ Florida State University, Tallahassee, FL. AIA Joukousky Lecture.

____ University of Florida, Gainesville, FL. AIA Joukousky Lecture.

____ Arizona Center for Judaic Studies, University of Arizona. The Raphael Patai Memorial Lecture.

2008 Missouri History Museum. AIA St. Louis Branch.

____ Lone Star College – Montgomery, Conroe, TX. Lyceum.

____ University of Omaha, Norman, OK. Meet the Scholars. Marine Archaeology Symposium. Oklahoma University Center for Classical Archaeology and Civilization.

2006 University of Albany, Albany, NY. AIA Traveling Lecturer Series

____ Trinity University, San Antonio, TX. AIA Branch

2005 Denver, CO. AIA Traveling Lecturer Series

____ Ocean Institute, Dana Point, CA

____ University of Hawaii at Manoa, Honolulu, HI. AIA Branch

____ University of St. Thomas, Houston, TX. Friends of Archaeology, 15th Annual Lecture on Greek Archaeology

2004 University of Hawaii at Manoa, Honolulu, HI. AIA Branch

____ Honolulu Academy of Arts, Honolulu, HI

____ Biblical Archaeology Society's Biblical & Archaeology Fest VII, San Antonio, TX. Plenary Session.

____ Utah Museum of Natural History, UT

2003 University of St. Thomas, Houston, TX. 15th Annual Distinguished Lecture: The Shiffick Lecture in Archaeology

____ Benton Walters Explorers Society. Support group for the Houston Natural History Museum, Houston, TX

____ Department of Near Eastern Studies, John Hopkins University

____ University of Texas at Austin Continuing & Extended Education Noncredit Short-Term Academic Courses. University of Texas, Austin, TX

____ Skirball Cultural Center, Los Angeles, CA. AIA Traveling Lecturer Series

____ Santa Barbara Museum of Art, Santa Barbara, CA. AIA Traveling Lecturer Series

____ Honolulu Academy of Arts, Honolulu, HI. AIA Traveling Lecturer Series

2002 University of Michigan, East Lansing, MI. Anna Margaritte McCann-Taggart Lecturer, AIA Traveling Lecturer Series

____ Detroit Institute of Art, Detroit, MI. Anna Margaritte McCann-Taggart Lecturer, AIA Traveling Lecturer Series

____ Cleveland Museum of Art, Cleveland, OH. Anna Margaritte McCann-Taggart Lecturer, AIA Traveling Lecturer Series

____ Dickinson College, Carlisle, PA. Anna Margaritte McCann-Taggart Lecturer, AIA Traveling Lecturer Series

____ University of Washington, Seattle, WA. William A. McDonald Lectureship, AIA Traveling Lecturer Series

____ University of Oklahoma, Norman, OK. Marine Archaeology Symposium, The OU Center for Classical Archaeology and Civilizations

____ University of Oregon, Eugene, OR. AIA Traveling Lecturer Series

____ University of Oregon, Eugene, OR. AIA Traveling Lecturer Series

____ Stanford University, Stanford, CA. AIA Traveling Lecturer Series

____ University of Colorado, Boulder, OR. AIA Branch

____ Lubbock Christian University, Lubbock, TX

____ University of Judaism, Los Angeles, CA

2001 Department of Middle Eastern Studies, The Program in Mediterranean Archaeology and the Michael C. Carlos Museum of Emory University

____ Biblical Archaeology Society Seminar, Fort Worth, TX

____ Miami, FL. For the Israel Government Tourism Organization

____ Winston-Salem, NC. For the Israel Government Tourism Organization

____ Charlotte, NC. For the Israel Government Tourism Organization

____ Raleigh, NC. For the Israel Government Tourism Organization

____ Greensborogh, NC. For the Israel Government Tourism Organization

2000 Arizona State University, Phoenix, AZ. AIA Traveling Lecturer Series

____ Nevada University, Las Vegas, NV. AIA Traveling Lecturer Series

____ University of Missouri at Columbia, Columbia, MO. AIA Traveling Lecturer Series

____ St. Louis Arts Museum, St. Louis, MO. AIA Traveling Lecturer Series

____ Toledo, OH. AIA Traveling Lecturer Series

____ Miami University Art Museum, Oxford, OH. AIA Traveling Lecturer Series

____ Ohio State University, Columbus, OH. AIA Traveling Lecturer Series

____ Marshall University, Huntington, WV. AIA Traveling Lecturer Series

____ Bible Archaeology Fest III, Nashville, TN. Biblical Archaeology Society

____ Southern Baptist Convention, Orlando, FL. Israel Government Tourism Office

1999 Smithsonian Museum, Washington, D.C. Archaeology Magazine at 50

____ Orange County Jewish Community Center, Orange County, CA. Underwater Israel

____ Madison, WI. AIA Traveling Lecturer Series

____ Valparaiso, IN. AIA Traveling Lecturer Series

____ University of St. Thomas, Houston, TX

1998 Explorers Club, NY Headquarters. In conjunction with the Explorers Club Annual Dinner.

____ University of Arizona, Tucson. AIA Traveling Lecturer Series

____ Santa Fe, NM. AIA Traveling Lecturer Series

____ University of Colorado, Boulder. AIA Traveling Lecturer Series

1997 Washington, D.C. AIA Traveling Lecturer Series

____ Baltimore, MD. AIA Traveling Lecturer Series

____ Scarsdale (Westchester), NY Public Library. AIA Traveling Lecturer Series

____ Scarsdale (Westchester), NY Synagogue

____ Houston, Rice University. AIA Branch

____ San Diego Maritime Museum. AIA Branch

____ University of California, San Diego.

1996 Wilemette University, Salem, OR. AIA Traveling Lecturer Series (Kershaw Lecturer)

____ Stanford University, CA. AIA Traveling Lecturer Series (Kershaw Lecturer)

____ Newport Harbor Art Museum, Newport Beach, CA. AIA Traveling Lecturer Series (Kershaw Lecturer)

____ Temple Beth El, Orange County, CA

____ Explorers Club, NY Headquarters. In conjunction with the Explorers Club Annual Dinner.

____ Explorers Club, Texas Chapter. San Antonio, TX

____ Friends of the Institute of Nautical Archaeology, Portland, OR

____ Portland Art Museum, Portland, OR. In association with the Friends of the Institute of Nautical Archaeology

1995 University of Kentucky, Springfield, IL. AIA Traveling Lecturer Series

____ University of Cincinnati, Cincinnati, OH. AIA Traveling Lecturer Series

____ Biblical Archaeology Society, Pittsburgh Branch, Pittsburgh, PA

1994 Grayson College, Dennison TX

____ University of North Carolina, Greensboro NC. AIA Traveling Lecturer Series

____ University of Georgia, Athens, GA. AIA Traveling Lecturer Series

____ University of South Florida at Tampa, Tampa FL. AIA Traveling Lecturer Series

1993 Biblical Archaeology Society Bible & Archaeology Seminar in Dallas, TX. (three lectures)

____ Drew University, NJ. AIA Traveling Lecture Series

____ Princeton University, NJ. AIA Traveling Lecture Series

____ SUNY at Albany, NY. AIA Traveling Lecture Series

____ Harvard Semitic Museum, Harvard University, Cambridge, MA. Sponsored by the Department of Near Eastern Languages and Civilizations. (Two lectures)

1992 Archaeological Institute of America (AIA), Houston Society, in conjunction with the Consulate General of Israel in Houston, TX

____ Biblical Archaeology Society, Milwaukee Branch, Milwakee, WI

____ Biblical Arts Center, Dallas, TX. In association with the traveling Galilee Boat Model Exhibit, sponsored by the Meadows Foundation of Texas.

____ Texas Seaport Museum, Galveston Island, TX. In association with the traveling

Galilee Boat Model Exhibit, sponsored by KUHT-PBS television of Houston.

1991 Cobb Institute of Archaeology, Mississippi State University, MS

____ Institute of Archaeology, University of California, Los Angeles, CA. (Second Bruce Hector Underwater Archaeology Lecturer)

____ Department of Classical Studies, Trinity University, San Antonio, TX

____ Twenty-Ninth Annual Briefing New Horizons in Science, Council for the Advancement of Science Writing, Inc., Chicago, IL

Brenner Steve

Full Professor at Bar Ilan University

Research Fields:
Oceanography
Meteorology and Climatology

Acadmeic Training

B.S. Meteorology and physical oceanography; City College of New York, 1975
Ph.D. Meteorology; Massachusetts Institute of Technology, 1982

Professional Employment

1980-1985 US Air Force Geophysics Laboratory, Research scientist
1985-2003 Israel Oceanographic and Limnological Research, Senior scientist and head of Department of Physical Oceanography
1994-2000 Bar Ilan University, Department of Geography, adjunct senior lecturer
2000-2005 Bar Ilan University, Department of Geography and Environment, Associate professor
2003-2009 Bar Ilan University, Department of Geography and Environment, department chairperson
2005- Bar Ilan University, Department of Geography and Environment, Full professor

Specialization fields

1. Numerical modeling of oceans and atmospheres
2. Circulation in the Mediterranean Sea
3. Circulation in the Gulf of Elat
4. Operational ocean forecasting
>>>> MFSTEP - Mediterranean Forecasting System
>>>> MOON- Mediterranean Operational Oceanography Network
>>>> ECOOP - European Coastal Sea Operational Observing and Forecasting System
>>>> Powerpoint presentation on operational forecasting in the Mediterranean
5. Large scale air-sea interaction
6. Short and long range climate prediction

Publications

Roads, J. and S. Brenner, 2002. Global model seasonal forecasts for the Mediterranean region. Isr. J. Earth-Sci., 51, 1-16.

Vjushin, D., Govindan, R.B., S. Brenner, A. Bunde, S. Havlin, and H.J. Schellnhuber, 2002. Lack of scaling in global climate models. J. Phys.: Condens. Matter, 14, 2275-2282.

Govindan, R.B., D. Vjushin, S. Brenner, A. Bunde, S. Havlin, and H.J. Schellnhuber, 2002. Global climate models violate scaling of the observed atmospheric variability. Phys. Rev. Lett., 89, 028501.

Berman, T., N. Paldor, and S. Brenner, 2003. The seasonality of the tidally driven circulation in the Gulf of Elat. Isr. J. Earth Sci., 52, 11-19.

Berman, T., N. Paldor, and S. Brenner, 2003. Annual cycle of SST in the Eastern Mediterranean, Red Sea, and Gulf of Elat. Geophys. Res. Lett., 30(5), 1261, doi: 10.1029/2002GL015860

Brenner, S., 2003. Simulations with a relocatable, nested, high resolution model: the eastern Levantine experience. In: Oceanography of the Eastern Mediterranean and Black Sea, A. Yilmaz (Editor), Tubitak Publishers, Ankara, Turkey, pp. 1022-1028.

Zodiatis, G., Drakopoulos, P., S. Brenner, and S. Groom, 2003. CYCLOPS Project: the hydrodynamics of the warm core eddy south of Cyprus. In: Oceanography of the Eastern, A. Yilmaz (Editor), Tubitak Publishers, Ankara, Turkey, pp. 18-23.

Brenner, S., 2003. High-resolution nested model simulations of the climatological circulation in the southeastern corner of the Mediterranean Sea. Annal. Geophys., 21, 267-280.

Vyushin, D., I. Zhidkov, S. Havlin, A. Bunde, and S. Brenner, 2004. Volcanic forcing improves atmosphere-ocean coupled general circulation model scaling performance. Geophys. Res. Lett., 31(10), doi: 10.1029/2004GL019499

Groom, S., B. Herut, S. Brenner, G. Zodiatis S. Psarra, N. Kress, M. Krom, C. Law, and.P.Drakopoulos, 2005. Satellite derived spatial and temporal biological variability in the Cyprus eddy. Deep Sea Res. II, 52, 2990-3010.

Zodiatis, G., P. Drakopoulos, S. Brenner, and S. Groom, 2005. Variability of the Cyprus warm core eddy during the CYCLOPS Project. Deep Sea Res. II, 52, 2897-2910.

Krom, M.D., T.F. Thingstad, S. Brenner, P.Carbo, P. Drakopoulos, T.W. Fileman, G.A.F. Flaten, S. Groom, B. Herut, V. Kitidis, N. Kress, C.S. Law, M.I. Liddicoat, R.F.C. Mantoura, A. Pasternak, P. Pitta, T. Polychronaki, S. Psarra, F. Rassoulzadegan, E.F. Skjoldal, G. Spyres, T. Tanaka, A. Tselepides, P. Wassman, C. Wexels-Riser, E.M.S. Woodward, G. Zodiatis, and T. Zohary, 2005. Summary and overview of the CYCLOPS P additiona Lagrangian experiments in the Eastern Mediterranean. Deep Sea Res. II, 52, 3090-3108.

Zodiatis, G., S. Brenner, D. Hayes, I. Gertman, and. P. Drakopoulos, 2006. The Atlantic water in the eastern Mediterranean Levantine basin. Geophys. Res. Abstr., 8, 07862 (Sred-ID: 1607-7962/gra/EGU06-A-07862.

Brenner, S., I. Gertman, and A. Murashkovsky, 2007. Pre-operational ocean forecasting in the southeastern Mediterranean: Model implementation, evaluation, and the selection of atmospheric forcing. J. Mar. Systems, 65, 268-287.

Rosentraub, Z. and S. Brenner, 2007. Circulation over the southeastern continental shelf and slope of the Mediterranean Sea: Direct current measurements, winds, and numerical model simulations. J. Geophys. Res. – Oceans, 112 (C11001), 21 pp. doi:10.1029/2006JC003775.

Brenner, S., A. Murashkovsky, and I. Gertman, 2007. Assessment of one year of high-resolution operational forecasts for the southeastern Mediterranean shelf region in the MFSTEP project. Ocean Sci. Discuss., 3, 2059-2085.

Ben Sasson, M., S. Brenner, and N. Paldor, 2008. Estimating air-sea heat fluxes in semi-enclosed basins: The case of the Gulf of Elat (Aqaba). J. Phy. Oceanogr., revised

Project Scientist III, Benthic Ecologist

Education

Master of Science in Marine Science, University of South Alabama, 2003

Bachelor of Arts in Biology, Wittenberg University, 2000

Ms. Fawcett is a marine biologist with over 12 years experience in marine and freshwater biology. She has served as Project Manager, Project Scientist, and/or Field Scientist on several coral relocation programs; environmental baseline surveys; habitat assessments; and restoration and monitoring programs in coral reefs, seagrass beds, hard bottom, and estuarine habitats. She has served as Project Manager, Project Scientist, and/or Lead Author on numerous environmental impact assessments (EIAs), monitoring and implementation plans, field survey reports, and decommissioning projects; supervised field staff in data collection; and provided assistance in the collection and analysis of samples and data for numerous environmental field studies, including both multidisciplinary baseline studies and environmental monitoring programs in the coastal areas of Florida, New Jersey, Puerto Rico, Qatar, and the United Arab Emirates and deep water habitats in the Gulf of Mexico and the Mediterranean Ocean.

Prior to environmental consulting, Ms. Fawcett was a Senior Scientific Associate with the South Florida Water Management District–Everglades Division. She was responsible for logistical and field support, field sampling, and project management of a mandated bimonthly monitoring program. Other responsibilities included Hydrolab and YSI maintenance, data collection, quality assurance/quality control (QA/QC), data analysis, permit renewal, and preparing and editing grant proposals and annual reports. Ms. Fawcett contributed to the preparation of Everglades National Park Comprehensive Annual Reports.

Ms. Fawcett is a certified National Association of Underwater Instructors Advanced Open Water SCUBA diver and is trained in Red Cross cardiopulmonary resuscitation (CPR) and first aid. She has been active in the Palm Beach County, Florida Artificial Reef Program by conducting biological monitoring and co-authoring grant proposals for successful procurement of funding from the Florida Fish and Wildlife Conservation Commission. She is skilled in small boat operations and has completed the U.S. Coast Guard Auxiliary Boating Skills and Seamanship Course.

EXPERIENCE

2006 to Present: CSA Ocean Sciences Inc. – Project Scientist II, Benthic Ecologist

- Project Manager for the preparation of multiple Environmental Impact Analyses for ConocoPhillips prospects in the Gulf of Mexico. Responsibilities included preparing the EIA and coordinating the completion the EIA among the client, technical review, editing, and document production staff as well as budget management.
- Co-Project Manager and contributing author on an analysis of decommissioning options associated with a deepwater platform in the Gulf of Mexico, with an emphasis on the current regulatory environment and platform disposal options.
- Field Scientist and author on multiple deepwater monitoring surveys for oil and gas development in the Levantine Basin and continental slope, offshore Israel. Responsibilities included assisting in sample collection, preservation, and shipping; in-situ video data analysis; and report preparation.
- Project Manager and Lead Author on an Environmental and Social Impact Assessment for an oil and gas development offshore of Cameroon. Responsibilities included preparing the ESIA and coordinating the completion the ESIA among the client, subcontractors, in-country representative, technical review, editing, and document production staff as well as budget management.
- Project Manager for the preparation of Environmental Impact Assessment (EIA) for a Hess prospect in the Gulf of Mexico. Responsibilities included coordinating the completion the EIA among the client, EIA author, technical review, editing, and document production staff as well as budget management.

- Project Manager for the preparation of 25 Environmental Impact Analyses for Shell Exploration & Production Company prospects in the Gulf of Mexico. The EIAs were prepared in accordance with the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) requirements in effect as of 14 December 2010. Responsibilities included coordinating the completion the EIAs, with up to four written concurrently, among the client, EIA authors, technical editing, and document production staff as well as budget management.
- Field Manager and Lead Field Scientist for the RasGas Coral Relocation and Monitoring Project.
- Lead Field Scientist for Bahia Icacos Environmental Survey and Habitat Mapping Project.
- Field Scientist for environmental surveys off Indian River County, Florida, to assess nearshore hard bottom habitat prior to and after construction of three beach nourishment projects. Establish permanent transects and collect close-up video and repetitive *in situ* quadrat data to characterize and monitor hard bottom communities.
- Field Scientist for Hillsboro/Deerfield Beach Renourishment Monitoring Project. Pre-, during, and post-construction nearshore hard bottom and reef characterization and monitoring surveys were conducted in association with the beach renourishment project. Assisted in establishing permanent transects, measuring sediment accumulation, assessing permanent quadrats, and collecting data on sand-hard bottom intercept positions and coral stress observations.
- Lead Field Scientist for Puerto Rico Aqueduct and Sewer Authority (PRASA) wet season coral community monitoring surveys near the Arecibo and Aquadilla Regional Waste Water Treatment Plant outfalls offshore Puerto Rico. Surveys were conducted in compliance with 301(h) waiver demonstration. Responsibilities included video and digital photographic data collection of pre-established transects, data analysis, and report preparation.
- Project Manager/Lead Field Scientist for Biscayne National Park (BISC) Seagrass Restoration Project at No Name Shoal. Restoration activities conducted at two orphan seagrass injuries on No Name Shoal included: a) the placement of approximately 350 yd^3 of loose fill and b) the installation 80 bird roosting stakes. Approximately 272 m^2 of seagrass habitat was returned to grade to improve the likelihood of natural seagrass colonization. Responsibilities included participation in a planning meeting and site assessment survey, seagrass injury mapping, preparation and implementation of a seagrass restoration plan, field oversight of restoration activities, on-sight coordination with BISC staff and sub-contractors, turbidity monitoring, and report preparation.
- Project Manager/Lead Field Scientist for BISC 2010 Derelict Trap and Debris Removal Project. Over a 16-day period, approximately 697 trap equivalents were removed from 1.9 km^2 of shallow patch reef areas east of Elliot Key. Responsibilities included the preparation and implementation of a debris removal plan, field survey oversight, on-sight coordination with BISC staff oversight, and report preparation.
- Supporting Scientist and Field Scientist during emergency coral reef restoration efforts associated with the grounding of the naval destroyer *USS PORT ROYAL* approximately 0.5 mi offshore of Honolulu International Airport's Reef Runway. Member of field team responsible for damage assessment and reattachment of over 5,300 coral colonies.
- Lead Field Scientist for the Village of Key Biscayne Seagrass Restoration and Mitigation Project. Responsibilities included preparation of a restoration and mitigation plan, field implementation of baseline and biannual monitoring surveys, data collection and analysis, and report preparation.
- Lead Field Scientist for a confidential client for a deep water port and preferred route survey offshore northeastern USA. Survey tasks included collection of towed video and digital photographic data, habitat characterization within the survey area, and QA/QC of data.
- Project Scientist for the Shell Pearl GTL Proposed Pipelines Coral Relocation Project. Responsible for scientific oversight and support for the removal, transportation, reattachment, installation and preparation of monitoring sites, and baseline monitoring of approximately 600 corals as mitigation for pipeline installation activities offshore the State of Qatar.

- Project Manager/Field Scientist for the Qatargas Coral Relocation Project. Responsibilities included supervising and conducting the removal, transportation, and reattachment of 4,500 hard corals as mitigation for pipeline installation activities offshore the State of Qatar and the selection, installation, and monitoring of six reattachment sites at 6 and 12 months post-reattachment. Compiled and prepared a coral management plan, project report, monitoring survey reports, documentary video, and several presentations.
- Field Scientist for the Dolphin Energy Limited Mitigation and Coral Recruitment Study. Responsibilities included installation of monitoring stations at the EcoReef, concrete-coated pipeline, rock pile, and control habitats and conduction of baseline monitoring.
- Field Scientist for the Biscayne National Park Seagrass Restoration Project. Responsibilities included oversight and photographic documentation of turbidity screen installation and removal, sediment bag placement, and installation of bird stakes in selected orphan grounding sites on Middle Featherbeds in Biscayne National Park.
- Lead Scientist for Leif Hoegh Re-route Survey in Tampa Bay. Survey tasks included collection of towed video data and habitat characterization within the survey area and delineation of seagrass habitat. Responsible for towed video data collection, QA/QC of data, and seagrass assessment.
- Field Scientist for the Texas Reef Year 4 Monitoring Survey to document temporal and spatial changes of the epibenthic and ichthyofaunal assemblages associated with the artificial reef offshore Hutchinson Island, Martin County, Florida. Responsibilities included conducting qualitative and quantitative diver video transects.
- Field Scientist/Diver for monitoring coral and seagrass health and levels of sedimentation in association with the maintenance dredging of Truman Harbor, the turning basin, and the Key West Ship Channel (U.S. Department of the Navy, 2002 to 2007).
- Project Manager/Field Scientist for Shell Pearl GTL Proposed Pipelines Coral and Seagrass Survey. Survey tasks included collection of towed video data providing complete coverage of the survey area, habitat delineation from review of the towed video data, and quantitative characterization of coral and seagrass habitats encountered within the survey area. Responsibilities included project oversight, scheduling of field survey, data collection, and preparation of Dive Plan, Health, Safety, and Environment (HSE) Plan, Survey Methodologies Plan, survey report, Power Point presentation, and Coral Mitigation Plan,
- Field Scientist for M/V *MARGARA* Restoration Project. Assisted in *in-situ* baseline data collection of hard and soft corals in emergency restoration and control areas for identification, reattachment status, coral size, and coral health.
- Chief Field Scientist/Diver for a field sample and data collection effort for a 301(h) waiver demonstration and Mixing Zone Validation Study at the Aguadilla, Arecibo, and Ponce Regional Wastewater Treatment Plant outfalls off the coast of Puerto Rico. Tasks included collection of sediment and fish samples, oversight of water sample collection, and collection of permanent coral transect diver video data. Survey reports and the results of video and still photograph analyses are being submitted to CH2M Hill (Puerto Rico Aqueduct and Sewer Authority, 2005 to present).
- Project Manager for the New Doha International Airport Mitigation project. Project oversight of harvest and transplant of hard corals and pearl oysters conducted as mitigation for the New Doha International Airport, State of Qatar.
- Project Manager for the North Field Bravo Environmental Baseline Survey offshore the State of Qatar. Responsibilities included project oversight, data analysis, and report preparation.
- Project Manager/Author of the Environmental Assessment of Exploration Drilling, West Cape Three Points Block, offshore Ghana.
- Project Manager/Co-author of environmental impact assessments (EIAs) for the Gumusut-Kakap Field Development Project and Export Pipeline Project offshore Sabah, Malaysia. Responsibilities included project oversight, preparation of two EIAs and preparation and presentation of impact analysis to the client.

- Field Scientist for the M/V *EASTWIND* Restoration Project offshore Broward County, Florida. Assisted in impact assessment, restoration, report preparation, and data assembly.
- Project Manager for the M/V *DEBBET* Restoration and Monitoring Project in Biscayne National Park, Florida. Supervised and conducted restoration and monitoring activities, data analysis, and report preparation.
- Field Scientist for the Texas Reef Year 2 Monitoring Survey to document temporal and spatial changes of the epibenthic and ichthyofaunal assemblages associated with the artificial reef offshore Hutchinson Island, Martin County, Florida. Responsibilities included conducting qualitative and quantitative diver video transects, roving diver fish counts, data analysis, and report preparation.
- Field Scientist for the Florida Power & Light Broward County Subbottom Survey and Sediment Grain Size Analysis projects. Responsibilities included preparation of report and Sediment Sampling Plan.

2005 to 2006: Marine Resources, Inc. – Staff Scientist

- Project Manager of the *HEIDI BABY* Seagrass Restoration Project. Project consisted of filling a 98.3 m^3 blowhole and inbound trench created by a 44-ft Sportfisher that ran aground on a *Thalassia testudinum* shoal outside of Whale Harbor Channel in Islamorada, Florida. Responsibilities included oversight of material placement within the injury area, photo and video documentation of restoration activities, and document preparation.
- Field Scientist during the benthic survey to generally characterize the substrate and associated macro-benthic community for the Fort Pierce Marina project.
- Staff Scientist/National Environmental Policy Act (NEPA) Specialist for the *ALLIE B* Grounding Site Restoration Plan and Environmental Assessment and the *IGLOO MOON* Grounding Site Restoration Plan and Environmental Assessment. Responsibilities included documentation and quantification of current site conditions of the injuries, compilation of a visual time-series presentation of temporal changes in the condition of the injury site, and document preparation.
- Staff Scientist/NEPA Specialist for the Habitat Suitability Analysis: Compensation for Injured Reef in Support of Restoration Planning for the Berman Oil Spill (San Juan, Puerto Rico) conducted to identify marine habitats that could be utilized as compensation for lost ecological services provided by the hard bottom reef injured by the vessel grounding. Responsible for conducting a literature search, data compilation, and document preparation.
- Field Scientist for the Texas Reef Year 1 Monitoring Survey to document temporal and spatial changes of the epibenthic and ichthyofaunal assemblages associated with the artificial reef offshore Hutchinson Island, Martin County, Florida. Responsibilities included conducting qualitative and quantitative dive transects, video transects, and report preparation.

2003 to 2004: South Florida Water Management District – Senior Scientific Associate

- Project Manager of bimonthly transect monitoring of dissolved oxygen (DO), temperature, specific conductivity, and pH in the Everglades. Responsibilities included deployment and retrieval of Hydrolabs and YSIs by helicopter, Hydrolab and YSI maintenance, data acquisition, QA/QC, data analysis, permit renewal, and end-of-year report preparation.
- Senior Scientific Associate involved in the Periphyton Project to better understand the primary production of various systems within the Everglades ecosystem. Responsibilities included determining the primary production of periphyton mats using a DO micro-profiling system, completing trend analyses of multiple long term databases, and logistical and field support for a short term stable isotope pulse-chase experiment within the Everglades.

2000 to 2003: University of South Alabama – Graduate Research Assistant

- Project Manager of the Harmful Algal Bloom Monitoring Program in Mobile Bay, Alabama. Responsibilities included scheduling monthly sampling cruises; collecting water samples from 10 offshore sites; chlorophyll *a* analysis; creating a database and inputting nutrient, chlorophyll *a*, and harmful algal bloom counts from sampling cruises; and coordinating efforts with the Alabama Department of Public Health.

- Research Assistant for benthic field studies sampling in natural and artificial seagrass beds of various sizes, processing of samples, and species identification.
- Research Assistant for Alabama Center for Estuarine Studies: Top Down Trophic Cascade Project. Responsibilities included collection of benthic macrofauna and seagrass samples, sample processing, and species identification.

PRESENTATIONS

Kilbane-Fawcett, D.A., B.D. Graham, R.D. Mulcahy, A. Onder, and M. Pratt. 2008. Coral Relocation for Impact Mitigation in Northern Qatar. The 11th International Coral Reef Symposium (Abstract). Mini-Symposium 24: Reef Restoration, Fort Lauderdale, FL.

Gottlieb, A., S. Hagerthey, R. Shuford, D. Kilbane-Fawcett, and S. Newman. 2004. The effects of varying conductivity on Everglades periphyton community structure. Society of Wetland Scientists. Seattle, WA. July 19 to 23. Poster presentation.

Kilbane-Fawcett, D. 2004. Monitoring artificial reefs in Palm Beach County: October 1, 2000 to September 30, 2002. Florida Artificial Reef Summit. Sarasota, FL. April 27 to 28. Poster presentation.

Kilbane-Fawcett, D. 2004. The status of artificial reefs in Palm Beach County: October 1, 2000 to September 30, 2002. Benthic Ecology Meeting. Mobile, AL. March 25 to 28. Oral presentation.

PROFESSIONAL CERTIFICATIONS

NAUI Advanced SCUBA Diver
PADI open water SCUBA Diver
AAUS Certification
First Aid/CPR/DAN Oxygen Administration
Nitrox Certified
Certified USCG Safe Boating and Seamanship Skills

Senior Scientist, Marine Ecologist

Education

Doctor of Philosophy, Ecology, University of Maryland, 2011

Bachelor of Science, Biology (Marine Biology and Ecology Options), Florida Institute of Technology, 2001

Dr. Kelly is a marine ecologist with over 10 years of experience in marine environmental science. He has a strong background in linking the ecological processes of benthic and pelagic systems, investigating the importance of habitat complexity on predator-prey interactions, and examining how anthropogenic pressures affect benthic invertebrate and fish predator communities.

As a Senior Scientist at CSA Ocean Sciences Inc. (CSA), he has served as a Chief Scientist on several research cruises evaluating the impact of anthropogenic disturbance on deep-sea benthic systems. He has been responsible for field collection, management, and analysis of seawater, sediment, and infaunal samples. He has experience in designing and implementing statistically rigorous observational and manipulative research studies. He regularly coordinates field work, supervises field staff in data collection, and prepares field survey reports.

Prior to consulting, Dr. Kelly was a principal investigator as a Ph.D. graduate student in a study researching the suitability of introducing the non-native suminoe (*Crassostrea ariakensis*) oyster into Chesapeake Bay to help alleviate the problems associated with the loss of native eastern (*Crassostrea virginica*) oyster biomass. This project was a collaboration among several universities and local, State, and Federal government agencies. His dissertation also included research on determining how complex aquatic habitats alter predator-prey relationships within a tri-trophic food web.

EXPERIENCE

2011 to Present: CSA Ocean Sciences Inc. – Senior Scientist, Marine Ecologist

- Chief Scientist for three environmental surveys within the Eastern Mediterranean Sea to assess deep-sea benthic habitat prior to and after anthropogenic disturbances. Established permanent transects for observation, sediment, and seawater collection using a remotely operated vehicle (ROV). Statistically analyzed environmental data and collaborated on the writing of technical reports.

2004 to 2011: University of Maryland – Graduate Research Assistant

- Investigated the importance of essential fish habitat (i.e. oyster reefs, corals, mangroves), and how these structurally complex habitats affect both invertebrate prey and fish predator species through attraction, enhanced secondary production, and the interactions between them.
- Researched the suitability of the exotic suminoe oyster (*Crassostrea ariakensis*) for introduction into Chesapeake Bay to help alleviate the loss of native eastern (*Crassostrea virginica*) oyster biomass.
- Examined seasonal physiological differences of the suminoe and eastern oyster under temperate mesohaline and sub-tropical polyhaline regions.

2001 to 2003: U.S. Peace Corps, Zambia – Rural Aquaculture/Fisheries Extension Agent

- Developed a sustainable fishery in Northwestern Province, Zambia. Trained rural farmers how to construct and maintain Tilapia (*Oreochromis niloticus*) ponds using only locally available materials.
- Collaborated with fish farmer associations within Northwestern Province, Zambia to develop market strategies to optimize selling price for fishery products.

1999 to 2001: Dynamac Corporation/NASA Life Sciences – Agricultural Technician

- Conducted research pertaining to the growth of sustainable crops (i.e. spinach, radish, wheat) for long-duration space flight missions.

Summer 2000: Institute for Bird Populations – Monitoring Avian Productivity Internship

- Field Scientist for environmental studies pertaining to the breeding condition of songbird populations in the backcountry of Denali National Park, Alaska.

Summer 1999: Hawaii Volcanoes National Park – Hawksbill Turtle Monitoring Program Internship

- Monitored backcountry beaches for Hawksbill turtle nesting activity on the Big Island of Hawaii.
- Gathered data for adult nesting females and hatchling success rate.

Spring 1999: Mote Marine Laboratory – Fisheries Stock Enhancement Internship

- Conducted research dealing with stock enhancement of recreational Snook populations in Sarasota Bay and surrounding tributaries.

1994 to 1997: New Jersey State Aquarium – Husbandry Technician/Science Education Guide

- Interpreted exhibits, performed educational programs on many ecological topics. Assisted with the creation and writing of many new educational programs.

PUBLICATIONS (Peer-Reviewed)

Kelly, C.J., S.E. Laramore, J. Scarpa, and R.I.E. Newell. 2011. Seasonal comparison of physiological adaptation and growth of Suminoe (*Crassostrea ariakensis*) and eastern (*Crassostrea virginica*) oysters. Journal of Shellfish Research. 30:737-749.

Kelly, C.J. and R.L. Turner. 2011. Distribution of the Hermit Crab *Clibanarius vittatus* and *Pagurus maclaughlinae* in the northern Indian River Lagoon, Florida: A reassessment after 30 years. Journal of Crustacean Biology. 31:296-303.

PUBLICATIONS (Peer-Reviewed Technical Paper)

Stryjewski. E., G.G. Goins, and C.J. Kelly. 2001. Quantitative morphological analysis od spinach leaves grown under light-emitting diodes or sulfur-microwave lamps. SAE Technical Paper 2001-01-2272.

Monje, O., H.T. Wang, C.J. Kelly, and G.W. Stutte. 2001. Nutrient Delivery System water pressures affect growth rate by changes in leaf area, not single leaf photosynthesis. SAE Technical Paper 2001-01-2277.

Ph.D. DISSERTATION

Kelly, C.J. 2011. Growth and physiology of eastern and suminoe oysters and the implications of increased habitat complexity for associated oyster reef fauna. Ph.D. Dissertation. University of Maryland, College Park, MD. 230 pp.

ORAL PRESENTATIONS

Kelly, C.J., and R.I.E. Newell. 2011. The behavior of fish predators and their interaction with prey species are influenced by the level of structural complexity within their habitat. Benthic Ecology Meeting, Mobile AL, 16 to 21 March.

Kelly, C.J. and R.I.E. Newell. 2010. The importance of habitat complexity, refuge, and prey availability on the attraction of grass shrimp, white perch, and striped bass to structure. American Fisheries Society, Pittsburgh PA, 14 September.

Kelly, C.J. and R.I.E. Newell. 2009. Seasonal scope for growth of diploid *Crassostrea ariakensis* and *Crassostrea virginica* under ambient conditions simulating the mesohaline and polyhaline regions of Chesapeake Bay. Coastal and Estuarine research Federation, Portland OR, 3 November.

Kelly, C.J., R.I.E. Newell, J. Scarpa, S.E. Laramore, and R.B. Carnegie. 2008. Diploid *Crassostrea virginica* and *Crassostrea ariakensis* studies in mesocosms simulating Chesapeake Bay and Florida estuaries. National Shellfisheries Association, Providence RI, 8 April.

Kelly, C.J., E. Stryjewski, and G. Goins. 2001. Quantative morphological analysis of spinach leaves grown under light-emitting diodes or sulfur-microwave lamps. International Conference of Environmental Systems, Orlando FL, 12 July.

Kelly, C.J. and R.L. Turner. 2001. The influence of altered hydrology on the population distribution of two species of hermit crab (*Clibanarius vittatus* and *Pagurus maclaughlinae*) in the Indian River Lagoon System. Florida Academy of Sciences, Saint Leo University, Saint Leo FL 9 March. [Outstanding Student Paper Award for an undergraduate; Florida Institute of Technology Sigma Xi Chapter award for best undergraduate paper.

CERTIFICATIONS

CPR/First Aid, Emergency First Response, 2012
Oxygen Administration, Emergency First Response, 2012
Scientific Diver, AAUS, 2012 to present
Open Water SCUBA Diver, PADI, 1996

KATHLEEN T. GIFFORD

Project Scientist I

Education

Master of Science in Chemical Oceanography, The Florida Institute of Technology, 2009

Bachelor of Science in Marine Sciences, The Richard Stockton College of New Jersey, 2007

Ms. Gifford is a chemical oceanographer with over 5 years experience in field studies, including water quality identification and collection. She has served as a Vessel Manager, Lead Field Scientist, Field Scientist, and Safety Officer on numerous oceanographic studies. As a participating scientist on various projects, she has taken part in the collection and analysis of samples and data as well as reporting the results.

Prior to consulting, Ms. Gifford served as a Seasonal Naturalist for the Seacoast Center in Rye, New Hampshire. Her background involves an array of aquatic and terrestrial work with emphasis on nearshore water quality fieldwork. Her academic emphasis on Chemical Oceanography is supported by expertise in analysis of water quality parameters, and by proficiency in data management and analysis. She has experience obtaining and analyzing water and sediment samples from different aquatic environments, including creeks, rivers, estuaries, and beaches. Ms. Gifford has served as a Teaching Assistant to the Florida Institute of Technology for seven semesters, emphasizing a holistic approach connecting multiple disciplines of science. She ran three laboratory classes unsupervised; these classes focused on the analysis of the physical and chemical properties of local waterways, survey of air quality, and guiding students to build research ideas in biological, meteorological, chemical, and physical oceanography. Ms. Gifford is a certified National Association of Underwater Instructors (NAUI) Open Water SCUBA, Professional Association of Diving Instructors (PADI) Underwater Naturalist, Underwater Photographer, and Enriched Air Diver and has certifications in Divers Alert Network (DAN) O_2 Provider. She also is trained in Red Cross cardiopulmonary resuscitation (CPR) and first aid.

EXPERIENCE

2010 to Present: CSA Ocean Sciences Inc. – Project Scientist I

- Lead Field Scientist for Puerto Rico Aqueduct and Sewer Authority (PRASA) 301(h) outfall inspection and data collection for the Arecibo, Aguadilla, Ponce, Bayamon, and Carolina Regional Waste Water Treatment Plant outfalls offshore Puerto Rico. Responsibilities included oversight of video data quality, daily safety meetings, deck operations, data analysis, and report preparation.
- Quality Control Manager for CSA. Responsibilities include creating and updating standard operating procedures, creating project specific quality control plans, and reviewing and managing field collected data in Excel.
- Field and safety diver for numerous projects located locally in Florida. Responsibilities included dive safety practices and assisting lead scientist in monitoring coral, and mapping hard bottom edges.
- Lead Field Scientist for Puerto Rico Aqueduct and Sewer Authority (PRASA) 301(h) Dye study: Mixing Zone validation data collection for the Bayamon and Carolina Regional Waste Water Treatment Plant outfalls offshore Puerto Rico. Responsibilities included oversight of data quality, daily safety meetings, and deck operations.
- Lead Field Scientist/Diver for Puerto Rico Aqueduct and Sewer Authority (PRASA) field sample and data collection, wet and dry season coral community monitoring surveys near the Bayamon and Carolina Regional Waste Water Treatment Plant outfalls offshore Puerto Rico. Surveys were conducted in compliance with 301(h) waiver demonstration. Responsibilities included collection of sediment and fish samples, oversight of water sample collection, and collection of video and digital photographic data collection of pre-established coral transects, deck operations, data analysis, and report preparation.
- Field Scientist for the RasGas Coral Relocation and Monitoring Project. Participated in the removal and transportation of corals as well as establishment of monitoring locations.

- Field Scientist/Diver for Puerto Rico Aqueduct and Sewer Authority (PRASA) field sample and data collection, wet and dry season coral community monitoring surveys near the Aguadilla, Arecibo, and Ponce Regional Waste Water Treatment Plant outfalls offshore Puerto Rico. Surveys were conducted in compliance with 301(h) waiver demonstration. Responsibilities included collection of sediment and fish samples, oversight of water sample collection, and collection of video and digital photographic data collection of pre-established coral transects, deck operations, data analysis, and report preparation.
- Lead Field Scientist/Vessel manager/Safety Officer for numerous oceanographic cruises in the Gulf of Mexico. Helped QA/QC scientific procedures and oversaw operations on some cruises by managing crew, care of instrumentation and net collection, navigation, and troubleshooting. Responsibilities included water quality collection using a Seabird CTD with the SeaSave Program and simple Hypack for navigation, water and plankton sample collection, rosette water collection, 1-m MOCNESS, Bongo, Neuston and Manta net collection, high-volume filtering methods, and safety procedures, including daily safety meetings with JSAs.

2010: Seacoast Science Center, Rye – Naturalist Teacher

- Educated school groups and the public on the importance of the Rocky Shore environment. Adaptations of the organisms that live and grow within the environment was heavily discussed as well as environmental protection.

2008 to 2009: Dr. John Trefry, Florida Institute of Technology – Grain Size Analyst

- Analyzed wet sediment samples from Lake Worth Lagoon, Florida and the Cheshki Sea, Alaska for grain sizes of gravel, sand, silt + clay and clay.

2007 to 2009: Florida Institute of Technology – Teaching Assistant "Marine and Environmental Chemistry

- Instructed undergraduates in use of field and laboratory equipment. Experiments focused on analyzing physical and chemical properties of local waterways to evaluate and compare trends of river and lagoon systems. "Atmospheric Pollution Laboratory." Instructed undergraduates in use of PM 10 and Total Suspended Particulate collection instruments to survey local air quality. Maintained instrumentation. "Marine and Environmental Field Projects." Instructed undergraduates in use of field and laboratory equipment for research purposes. Experiments focused on gaining the knowledge of developing and conducting personal research ideas in regards to biological, meteorological, chemical, and physical oceanography. Manufactured and maintained sampling apparatuses.

2007: The Richard Stockton College of New Jersey – Teaching Assistant "Tropical Marine Biology"

- Guided undergraduates in nature and scuba diving tours to determine the local physical and marine environment of the Florida Keys. The main emphasis was on the ecology, life histories, systematic, and physiology of the plants and animals. "Methods in Oceanography." Instructed undergraduates in use of laboratory equipment. Experiments focused on examining physical, chemical, and geological oceanographic principles. Main emphasis was on data collection, analysis and interpretation of the principles.

2006 to June 2007:Jenkinson's Aquarium, Point Pleasant, New Jersey – Tour Guide and Chemical Analyst

- Conducted tours of the aquarium to the public and school groups to introduce them to the marine environment and organisms that live there. Also, rotated shifts of chemical analysis including nutrient analysis, salinity and dissolved oxygen readings on the tanks and feeding the smaller animals such as reptiles and the small aquariums.

RELEVANT COURSE WORK

Participated in an independent study starting September 2005 to May 2007 at the Richard Stockton College of New Jersey. Water samples from local waterways and from the New Jersey Adventure Aquarium were analyzed to determine trends of source influence. Samples were tested for various nutrient levels including phosphates and silica.

ORAL CERTIFICATIONS (Individual)

The Influence of Stormwater on the Dissolved Fluorescent material in Crane Creek, Turkey Creek, and the Adjacent Indian River Lagoon. The Annual Conference of Florida Academy of Sciences, Fort Pierce March 2010.

CERTIFICATIONS

CPR/First Aid, Emergency First Response
Open Water Diver, NAUI
Oxygen Administration, Emergency First Response
Nitrox certified, PADI
Underwater Naturalist certified, PADI
Underwater Photography certified, PADI

CV- YOSSI AZOV

1

Managing Director – MVI Israel

Education

Doctor of Science in Environmental & Water Resources Engineering, Technion - Israel Institute of Technology, Haifa, Israel, 1979

Master of Human Environmental Sciences, Hebrew University of Jerusalem, Israel, 1975

Bachelor in Biology, Hebrew University of Jerusalem, Israel, 1973

An expert on the environmental impacts of marine pollution associated with eutrophication and effects on marine food chain, Dr. Azov has over 30 years of experience with environmental, ecological, biological, and engineering issues concerning oceanic, coastal, and land problems. He has published over 30 papers in scientific journals in his field. Relevant experience includes Dr. Azov's participation in the environmental impact assessment of proposed marine outfall for the wastes of Industrial plants in Haifa Bay and his role as scientific coordinator for a project concerning the monitoring of sea water during marine works conducted by Noble Energy. In addition, he has evaluated the biological effects of the marine sludge outfall of Greater Tel-Aviv wastewater treatment plant and evaluated the effects of brine from effluent desalination on marine life. He has also evaluated the causes for phytoplankton bloom in artificial marine lagoon in Eilat as well as the effects of heated water on the fauna and flora of the Hertzelia Marina. In addition, he participated in a specialist forum at the Grand Water Research Institute – Technion concerning water desalination plants.

Dr. Azov has served as a scientific advisor for a number of projects throughout the proposed project area. He served as the scientific advisor to the Israel Rivers Remediation Authority concerning remediation of Hadera River; for bi-national research conducted at the Technion concerning CO_2 mitigation by algae; and for numerous plants, including the Greater Haifa wastewater treatment plant, the Arad wastewater treatment plant, the construction of a demonstration plant in Thessaloniki, Greece for wastewater treatment in South Europe sponsored by E.E.C., the construction of a demonstration plant in Sau-Paulo, Brazil for wastewater treatment in small municipalities, the Greater Tel-Aviv wastewater treatment plant concerning the effects of lagoon drying on the surrounding area, and the Bet Jan wastewater treatment plant in case of photosynthetic bacteria bloom.

In addition, Dr. Azov has served as the Coordinator of many monitoring projects, including the Caesarea Industrial Park monitoring program concerning effects on groundwater quality, the Greater Tel-Aviv wastewater reclamation program, and the Haifa Complex wastewater reclamation program

EXPERIENCE

2013 to Present: CSA Ocean Sciences Inc. – Managing Director – Marine Ventures Intl. – Israel

- Responsible for the general management of the Israel CSA operations and office.

1997 to Present: Private Consultant

- Numerous consulting contracts in areas of marine pollutions, water quality, water treatment, groundwater quality, wastewater treatment, algal growth and production, etc.

1996 to 1997: Environmental and Water Resources Engineering Department, Technion, Haifa – Senior Research Fellow

- Research involved wastewater treatment and effluent quality. Monitoring of groundwater quality.

1987 to 1996: Environmental and Water Resources Engineering Department, Technion, Haifa – Senior Research Associate

- Research involved wastewater treatment and effluent quality.

1984 to 1987: Environmental and Water Resources Engineering Department, Technion, Haifa, Israel – Research Associate and Project Engineer

- Research field: "Effluent supply for irrigation in northern Israel."

1981 to 1984: Israel Oceanographic & Limnological Research Institution, Haifa – Scientist

- Main research fields: Marine phytoplankton, Marine food chain, Primary production in Eastern Mediterranean. Research conducted both on board ship and in the laboratory.

1980 to 1981: Woods Hole Oceanographic Institution, U.S.A. – Post-Doctoral Researcher

- Research field: "Effect of ammonia on marine and fresh water algae."

1976 to 1980: Environmental and Water Resources Engineering Department, Technion, Haifa – Head of Biological Research Group

- Research field: "Algal growth and production for animal feed."

1973 to 1975: Human Environmental Sciences Department, Hebrew University of Jerusalem, Israel – Research Assistant

- Research field: "Ammonia toxicity to algae."

1997 to Present: Technion – Israel Institute of Technology, Haifa, Israel – Adjunct Senior Teaching Fellow

- Graduate course in "Hydrobiology."

2005 to Present: Haifa University, Haifa, Israel – Adjunct Senior Teaching Fellow

- Graduate course in "Water and Wastewater Treatment."

PUBLICATIONS (Corporate)

Abeliovich, A. and Y. Azov. 1976. Toxicity of ammonia to algae in sewage oxidation ponds. Appl. Environ. Microbiol. 31:801-806.

Oron, G., G. Shelef, A. Levi, A. Meydan, and Y. Azov, Y. 1979. Algae bacteria ratio in high-rate ponds used for waste treatment. Appl. Environ. Microbiol. 38:\570-576.

Shelef, G., Y. Azov, R. Moraine, and G. Oron. 1980. Algal mass production as an integral part of a wastewater treatment and reclamation system. In:Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 163-189.

Azov, Y., G. Shelef, R. Moraine, and A. Levi. 1980. Controlling algal genera in high-rate oxidation ponds. In: Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 245-253.

Azov, Y., G. Shelef, R. Moraine, and A. Levi. 1980. Controlling algal genera in high-rate oxidation ponds. In: Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 245-253.

Azov, Y., G. Shelef, R. Moraine, and G. Oron. 1980. Alternative operating strategies of high-rate sewage oxidation ponds. In: Algae Biomass, Production and Use (G. Shelef and C.J. Soeder, eds.), Elsevier Biomedical Press, pp. 523-529.

Goldman, J.C., Y. Azov, C.B. Riley, and M.R. Dennett. 1982. The effect of pH in intensive algal cultures. J. Exp. Mar. Biol. Ecol. 57:1-13.

Azov, Y., G. Shelef, and N. Narkis. 1982. Effect of hard detergents on algae in a high-rate oxidation pond. Appl. Environ. Microbiol. 43:491-492.

Azov, Y., G. Shelef, and R. Moraine. 1982. Carbon limitation of biomass production in high-rate oxidation ponds. Biotechnol. Bioengr. 24:579-594.

Azov, Y. and G. Shelef. 1982. Operation of high-rate oxidation ponds: theory and experiments. Water Res. 16:1,153-1,160.

Azov, Y. 1982. Effect of pH on inorganic carbon uptake in algal cultures. Appl. Environ. Microbiol. 43:1,300-1,306.

Azov, Y. and J.C. Goldman. 1982. Free ammonia inhibition of algal photosynthesis in intensive algal cultures. Appl. Environ. Microbiol. 43:735-739.

Shelef, G., Y. Azov, and R. Moraine. 1982. Nutrients removal and recovery in a two-stage high-rate algal wastewater treatment system. Wat. Sci. Tech. 14:8700.

Berman, T., D.W. Townsand, S.Z. El-Sayed, C.C. Trees, and Y. Azov. 1984. Optical transparency, chlorophyll and primary productivity in the Eastern Mediterranean near the Israeli coast. Oceanol. Acta 7:367-372.

Berman, T., Y. Azov, and D.W. Townsand. 1984. Understanding oligotrophic oceans: Can Eastern Mediterranean be a useful model? In: Lecture Notes on Coastal and Estuarine Studies, 8: Marine Phytoplankton and Productivity (O. Holm-Hansen et al., eds.) Springer Verlang Publs., pp. 101-112.

Azov, Y. 1986. Seasonal patterns of phytoplankton productivity and abundance in near shore oligotrophic waters of the Levant Basin (Mediterranean). J. Plankton. Res. 8:41-53.

Berman, T., Y. Azov, A. Schneller, P. Walline, and D.W. Townsand. 1986. Extent, transparency and phytoplankton distribution of the neritic waters overlying the Israel coast. Oceanol. Acta 9:439-447.

Shelef, G. and Y. Azov. 1987. High-rate oxidation ponds: The Israeli experience. Wat. Sci. Tech. 19:249-255.

Azov, Y. and G. Shelef. 1987. Effect of pH on the performance of high-rate oxidation ponds. Wat. Sci.Tech. 19:381-383.

Azov, Y. 1990. Eastern Mediterranean - a marine desert? Marine Poll. Bull. 23:225-232.

Azov, Y. and G. Shelef. 1991. Effluents quality along a multiple-stage wastewater reclamation system for agricultural reuse. Wat. Sci. Tech. 23:2119-2126.

Azov, Y., M. Juanico, G. Shelef, A. Kanarek, and M. Priel. 1991. Monitoring the quality of secondary effluents reused for unrestricted irrigation after underground storage. Wat. Sci. Tech. 24:267-275.

Teltsch, B., M. Juanico, Y. Azov, I. Ben Harim, and G. Shelef. 1991. The clogging capacity of reclaimed wastewater: a new quality criterion for drip irrigation. Wat. Sci. Tech. 24:123-131.

Teltsch, B., Y. Azov, M. Juanico, and G. Shelef. 1992. Plankton community changes due to effluents addition to a freshwater reservoir used for drip irrigation. Water Res. 26:657-666.

Azov, Y., M. Juanico, and G. Shelef. 1992. Monitoring large scale wastewater reclamation systems - policy and experience. Wat. Sci. Tech. 26:1,545-1,553.

Shelef, G., Y. Azov, A., Kanarek, G. Zac, and A. Shaw. 1994. The Dan Region sewerage wastewater treatment and reclamation scheme. Wat. Sci. Tech. 30:229-238

Armon, R., K. Dozoretz, Y. Azov, and G. Shelef. 1995. Residual contamination of crops irrigated with different effluent quality: A field study. Wat. Sci. Tech. 31:239-248.

Juanico, M., R. Ravid, Y. Azov, and B. Teltsch. 1995. Removal of trace metals from wastewater during long-term storage in seasonal reservoirs. Water, Air & Soil Pollution. 82:617-633.

Azov, Y. and T. Tregubova. 1995. Nitrification processes in stabilization reservoirs. Wat. Sci. Tech. 31:313-319.

Juanico, M., Y. Azov, B. Teltsch, and G. Shelef. 1995. Effect of effluents addition to a freshwater reservoir on the filter clogging capacity of irrigation water. Water Res. 29:1,695-1,702.

Shelef, G. and Y. Azov. 1995. The coming era of wastewater reclamation and reuse in the Mediterranean Basin. Invited paper to the 2nd International Symposium on Wastewater Reclamation and Reuse, Iraklio, Crete. Wat. Sci. Tech. 31:313-319.

Azov, Y., M. Khinich, S. Rabkin, A. Ben Yosef, and G. Shelef. 1996. Control of algae in the reservoirs of the 'Third Line'. In: Preservation of Our World in the Wake of Change (Y. Steinberger, ed.), Vol VI A/B, ISEEQS Pub. Israel, pp. 707-710.

Juanico, M., R. Ravid, Y. Azov, and B. Teltsch. 1999. Trace metals. In: Reservoirs for Wastewater Storage and Reuse (I. Dor and M. Juanico, eds.). Springer Publs. pp. 219-232.

Shelef, G. and Y. Azov. 2000. Meeting stringent environmental and reuse requirements by an integrated pond system at the 21st century. Wat. Sci. Tech. 42 (10-11) pp. 299-305.

Pearson, H.W., D.D. Mara, and Y. Azov. 2000. Waste Stabilization Ponds: Technology and the Environment. Wat. Sci. Tech. 42 (10-11).

Project Scientist – MVI Israel

Education

Master of Science in Environmental Studies, Tel-Aviv University, 2012

Bachelor of Science in Marine Sciences & Biotechnology, Ruppin Academic Center, 2009

Mr. Mills has been working in the oil and gas industry for over 3 years during which time he gained valuable experience and knowledge in exploration and production (upstream) of crude oil and natural gas, including drilling of exploratory wells, well completion operations, well testing, production, and export of petroleum. Since joining CSA Ocean Sciences Inc. (CSA) in 2013, he has been focused on multiple monitoring surveys in the eastern Mediterranean Sea.

Mr. Mills had the unique opportunity to get hands-on experience in field engineering work, practicing the principles of fluids dynamics, hydraulics, and three-phase separation. Through his training as a marine biologist and his studies in environmental sciences, he successfully implemented this knowledge and expertise into his work. When working as an environmental superintendent, Mr. Mills coordinated the onshore production operations with environmental regulations and promoted environmental awareness among his colleagues. Upon turning to offshore operations, he acquired expertise in the fields of Health, Safety, and Environment (HSE) and permitting while working actively under the Halliburton Project team for the Gabriella drilling project. There, Mr. Mills played an important role in promoting the environmental monitoring, discharge permit, and the oil spill contingency plan.

During his years at university, he gained experience in environmental, ecological, biological, physical, and chemical issues concerning coastal and oceanic problems. He participated in numerous projects testing water properties in the eastern Levant and characterizing seasonality in the planktonic community.

In his thesis dissertation, Mr. Mills investigated the role of microorganisms in bleaching of the Mediterranean coral *Oculina patagonica*. The purpose of this project was to elucidate the reason for seasonal bleaching in the coral and provide evidence for temperature-regulated infection by a *Vibrio* species. The research supported the bacterial bleaching hypothesis and included the utilization of advanced molecular techniques, classic microbiological tools, and frequent SCUBA diving under rough sea conditions.

EXPERIENCE

2013 to Present: CSA Ocean Sciences Inc. – Project Scientist, Marine Ventures International, Inc., Israel

- Project Scientist in multiple monitoring surveys for oil and gas operators within the eastern Mediterranean Sea to assess deep-sea benthic habitat prior to and after anthropogenic disturbances. Surveys include the collection of seawater and sediment samples from a vessel using common methodology and a remotely operated vehicle (ROV).
- Contributing author of Environmental Analysis Statement, including editing and in-depth preparation of the section related to air pollution regulation, process-derived air emissions impact, and waste management and resource exhaustion in Israel.
- Contributing author of Oil Contingency Spill Program, assisting in the preparation of coastal and nearshore habitat characterization.

2012 to 2013: Gabriella Offshore Drilling Project, Adira Energy Israel Ltd, Ramat-Gan – HSEQ Representative

- Assisted in the development, monitoring, and management of Health, Safety, Environment and Quality (HSEQ) Management Systems.
- Ensured compliance with the statutory requirements and promoting permits approval.
- Liaised with all contractors and sub-contractors to ensure that company requirements were followed.
- Assisted in HSEQ internal and external audits.

2010 to 2012: Meged-5 Crude Oil Production Site, Givot Olam Oil Ltd, Shoham – Environmental Superintendent

- Promoted an environmental agenda to reduce externalities.
- Implemented environmental regulatory requirements at the production site.
- Liaised with foreign well services companies and personnel to bridge environmental standards.
- Responsible for the proper maintenance of chemicals on site and assuring safe handling.
- Edited and reviewed standard operating procedures.

2012 to Present: The School of Marine Sciences & Oceanic Environment, Ruppin Academic Center, Michmoret – Student Instructor

- Assisted in the coordination of planning and logistics of short courses dealing with the marine and coastal environment, including lecturing and frontal presentation of relevant topics in the fields of oceanography, zoology, botany, and geomorphology.

2010 to 2011: Marine Ecosystems Laboratory, Israel Oceanographic & Limnological Research Institution, Haifa, Israel – Ecological Research Assistant and Lab Technician

- Research Field: Abrasion Platforms habitat and benthic-pelagic coupling.
- Established experimental designs and setups specializing in coastal benthos ecology.
- Initiated and promoted advanced research ideas (i.e., ocean acidification effect on abrasion platforms and the imposed implications on coastal abrasion).

2008 to 2009: Ramat Hanadiv Forest Park, Binyamina, Israel – Ecological Research Assistant

- Devised and prepared ecological surveys of terrestrial vegetation in research on innovative environmental management programs and provided scientific data for educational activities. The research focused on the dispersion of pine trees in the southern end of Mount Carmel and their interactions with the Mediterranean shrubland.

PUBLICATIONS (Peer Reviewed)

Mills, E., K. Shechtman, Y. Loya, and E. Rosenberg. 2013. Bacteria appear to play important roles in both causing and preventing the bleaching of the coral *Oculina patagonica*. Marine Ecology Progress Series. Prepress – doi: 10.3354/meps10391.

PROFESSIONAL CERTIFICATIONS

Dive Master – World Underwater Federation (CMAS) and the Israeli Diving Federation
Licensed Skipper for coastal and international waters (level 60) – State of Israel, Ministry of Transport (MOT)
First Aid and CPR certified

PROFESSIONAL AFFILIATIONS

Israeli Society of Microbiology, 2012
Israeli Diving Federation, 2013
Israeli Association for Aquatic Sciences, 2010

GIS Coordinator

Education

Master of Science in Geographic Information Science, Florida State University 2012

Bachelor of Science in Geography and Economics, Florida State University

Mr. Noack is an experienced geographer, Geographic Information Systems (GIS) Analyst, cartographer, database designer and effective manager. Since joining CSA Ocean Sciences Inc. (CSA) in 2012, he has been responsible for geographic analysis, interpretation, and synthesis on numerous multidisciplinary projects for government and industry clients. These projects include environmental impact assessments, interpretation of benthic and terrestrial environments, baseline studies of the marine environment, natural resource damage assessments, and restoration projects. Mr. Noack is involved in the development of new technologies with in the GIS group at CSA, including full motion video (FMV) processing and analysis. Mr. Noack serves as quality analysis and quality control (QA/QC) officer for all geospatial data.

EXPERIENCE

2012 to Present: CSA Ocean Sciences Inc. – GIS Coordinator

- Operations coordinator for CSA's GIS department. Responsible for task management and execution of all GIS projects within CSA. Developed data standards and nomenclature for geo-database and filing structure. Produce and manage maps, metadata, images, reports, and plans for assessment, submittals, and reports. Perform quality assurance/quality control (QA/QC) of all outgoing GIS projects.
- Generated Environmental Sensitivity Index (ESI) geo-database documenting baseline conditions of shoreline types and associated environmental resources. These data support planning and prioritization of response (both scenario and actual response efforts) for oil and gas operators. These data also allow for measurements of impacts during a spill, natural disaster or other environmental events (flooding, tsunami, sea level rise, etc).
- Performed analysis of data for multiple cable installations in US and international waters. Developed method for identifying potential hazards for cable crossings as well as identified auxiliary datasets for use in exclusionary and possible landing analysis.
- Preformed analysis and compilation of data for multiple Environmental Assessments and Environmental Impact Assessments from field collected data. Involved in design and implementation of database standards for use in building a comprehensive database both spatial and non-spatial for use by decision makers to assess disparate datasets.
- Collected, gathered, and analyzed data for production of figures to support EIA report and Environmental Baseline Survey (EBS) for proposed drilling operations offshore Trinidad.

2012 to 2012: Florida State University-Graduate Teaching Assistant, Department of Geography

- Assisted instructor with dissemination of course material.
- Responsible for grading of weekly assignments.
- Provided feedback to students on improving the quality of submissions.

2011 to 2012: Florida State University-Academic Support Specialist, Student Athlete Academic Services

- Provided assistance for student athletes with course comprehension and study skills.
- Instructed individuals, small group, and large group sessions.
- Participated in monthly training sessions to improve knowledge in student services.

2010 to 2011: Florida State University-Undergraduate Research Assistant, Department of Geography

- Utilized ArcGIS mapping and MSAccess to assemble and query a large climate database.
- Participated in NSF-funded research on urban weather and climate.

COMPUTER SKILLS

Proficient in ArcGIS 10.2.1 Desktop Product Suite and Extensions, ArcGIS Server 10.2.1, Fledermaus 7, GPS Software, ERDAS Imagine, Adobe CS6 Product Suite, Microsoft Office 2012 Product Suite, Microsoft Visio, Microsoft Visual Studio 2012, Microsoft SQL Server 2012, Python, C#, ASP.NET 4.5, R statistical computing.

PROFESSIONAL CERTIFICATIONS

ESRI Certificates 2012
Advanced Techniques for Cartographic Representations
Advanced Format Translations with ArcGIS Data Interoperability Spatial ETL Tools
Building Models for GIS Analysis Using ArcGIS
Creating and Integrating Data for Natural Resource Applications
Deriving Rasters for Terrain Analysis Using ArcGIS
Getting Started with Cartographic Representations for ArcGIS
Getting Started with Geodatabase Topology
Getting Started with Hazus-MH 2.0
Getting Started with the Geodatabase
Integrating User-Supplied Data into the Hazus-MH 2.0 Flood Model
Introduction to the Hazus-MH 2.0 Comprehensive Data Management System
Introduction to the Hazus-MH 2.0 Earthquake Model
Introduction to the Hazus-MH 2.0 Flood Model
Introduction to the Hazus-MH 2.0 Hurricane Model
Introduction to the Hazus-MH 2.0 Inventory
Introduction to the Hazus-MH 2.0 Storm Surge Model
Loss Estimation Using the Hazus-MH 2.0 Earthquake Model
Loss Estimation Using the Hazus-MH 2.0 Flood Model
Loss Estimation Using the Hazus-MH 2.0 Hurricane Model
Processing Raster Data Using ArcGIS 10
Python Scripting for Geoprocessing Workflows (for ArcGIS 10)
Python Scripting for Map Automation in ArcGIS 10
Understanding Hazus-MH 2.0 Earthquake Model Results
Understanding Hazus-MH 2.0 Flood Model Results
Understanding Hazus-MH 2.0 Hurricane Model Results
Using Raster Data for Site Selection
Working with Geodatabase Domains and Subtypes in ArcGIS
ESRI Certificates 2011
3D Visualization Techniques using ArcGIS 10
Basics of Python (for ArcGIS 10)
Learning ArcGIS desktop (for ArcGIS 10)
Learning ArcGIS 3D analyst
Cartographic Design Using ArcGIS 9

PROFESSIONAL AFFILIATIONS

International Honor Society in Social Sciences

American Society of Photogrammetry and Remote Sensing

Association of American Geographers

Florida Society of Geographers

GIS Analyst/Cartographer

Education

Master of Arts in Geography, East Carolina University, 2013

Bachelor of Arts in Geography, University of North Carolina Wilmington, 2009

Mr. Gore is a professional geographer whose main areas of expertise include Geographic Information Systems (GIS), cartography, and remote sensing. Since joining CSA Ocean Sciences Inc. (CSA) in 2012, he has supported various GIS-related projects with geospatial and remote sensing analysis, cartographic products, and database management. These projects include Environmental Impact Assessments (EIAs), environmental monitoring surveys; digital image classification and interpretation of benthic and terrestrial environments; environmental baseline surveys (EBSs) of marine environments; and natural resource damage assessments, restoration, and relocation projects. Mr. Gore utilizes his extensive cartographic and geospatial background to support GIS-related projects with professional quality maps, data analysis, production, and management while utilizing various remote sensing data products.

EXPERIENCE

2012 to Present: CSA Ocean Sciences Inc. – GIS Analyst/Cartographer

- In-house cartographer and GIS analyst for CSA GeoSpatial Services (GSS) business line. Responsible for producing and managing maps, geospatial data, metadata, images, and documents for various GIS-related projects. Conduct quality assurance/quality control (QA/QC) on maps, geospatial data, and documents for GIS-related projects.
- Analyzed, managed, and produced data and figures to support EIA, EBS, and environmental monitoring survey reports for proposed drilling operations offshore Cyprus, Israel, Suriname, Trinidad and Tobago, Morocco, Ghana, New Zealand, and Brazil.
- Produced geospatial data and created survey designs and figures for proposed drilling operations offshore Cyprus, Israel, Suriname, Trinidad and Tobago, Morocco, Ghana, New Zealand and Brazil.
- Classified shoreline for a portion of the Cyprus coast utilizing both satellite imagery and geo-coded ground-truth photos. Assisted in creating an Environmental Sensitivity Index (ESI) map for the Cyprus coast.
- Analyzed, managed, and produced data and figures to support annual nearshore hardbottom monitoring and artificial reef surveys for Martin, St. Lucie, and Indian River Counties, Florida. Performed image classification to determine the spatial extent of nearshore hardbottom benthic habitats.
- Analyzed, managed, and produced data and figures to support a sand trap and reef survey in the Ft. Pierce Inlet, Florida. Used ground-truthed field data and aerial imagery to characterize the spatial location of various benthic habitats within Ft. Pierce Inlet.
- Gathered, analyzed, managed, and produced data and figures to support Outer Continental Shelf (OCS) environmental impact survey reports for geological & geophysical activities in the Atlantic Ocean and Gulf of Mexico.
- Analyzed, managed, and produced data and produced figures to support seagrass and coral mitigation, relocation, and restoration projects in Miami Harbor, Florida and offshore Qatar.
- Analyzed, managed, and produced data and figures to support cable repair projects in Miami, Florida.
- Analyzed, managed, and produced data and figures to support a benthic habitat characterization study offshore Key West, Florida.
- Analyzed, managed, and produced data and figures to support an offshore heated water plant study for the St. Lucie Nuclear Power Plant, Florida. Created temperature surface rasters by interpolating field points containing temperature data collected around offshore discharge pipes.

2010 to 2012: Renaissance Computing Institute (RENCI) at East Carolina University – GIS Analyst/Graduate Research Assistant

- Assisted Dr. Thomas Allen with remote sensing research for the U.S. Fish and Wildlife Service to determine the effectiveness of Synthetic Aperture Radar (SAR) to delineate the locations of coastal wetlands in the Alligator River and Cedar Island National Wildlife Refuges, North Carolina.
- Developed an award-winning mapping project dealing with future sea-level rise in the Albemarle-Pamlico Estuarine System, North Carolina; data will be utilized by the Albemarle-Pamlico National Estuarine Program for further research, outreach, and publication.
- Produced maps and posters for various professional conferences, presentations, and publications.

2010: University of North Carolina – Volunteer Teaching/Research Assistant

- Used Google Earth to digitize polygons and assign values to damaged or collapsed structures outside Port-au-Prince, Haiti for a Haiti Damage Assessment project.
- Assisted Dr. Joanne Halls with Introduction to GIS course labs.
- Assisted Dr. Joanne Halls with a Masonboro Island, North Carolina research project gathering, organizing, and analyzing GPS and LIDAR data.

2008: U.S. Army Corps of Engineers – GIS Technician (Undergraduate Internship)

- Prepared digital North Carolina county maps using ESRI's ArcMap.
- Acquired, updated, and managed geospatial data using ESRI's ArcCatalog.
- Reviewed and organized CAMA (Coastal Area Management Act) permits.
- Obtained low-level government security clearance.
- Determined areas of possible wetland disruption by matching the positions on satellite images to those on site plans for various development projects.

PUBLICATIONS

Sea-Level Rise Vulnerability in the Albemarle-Pamlico Estuarine System, 2012 ESRI Map Book, Volume 27.

Allen, T.R., Y. Wang, B. Gore, J. Swords, and D. Newcomb. 2011. *Coastal wetland mapping and monitoring using time series SAR imagery and LiDAR: Alligator River National Wildlife Refuge, North Carolina*. 18th William T. Pecora Remote Sensing Symposium, American Society for Photogrammetry and Remote Sensing, Herndon, Virginia, November 14-17.

Gore, Brent R. 2013. *Modeling Wetland Response to Future Sea-Level Rise in the Pamlico and Croatan Sounds, North Carolina* (Master's thesis). East Carolina University, Greenville, North Carolina.

HONORS AND AWARDS

2011 North Carolina Space Grant Graduate Research Fellowship; *Satellite Remote Sensing of Wetlands in the Albemarle-Pamlico Estuarine System using Synthetic Aperture Radar for Sea-Level Rise Modeling*

3rd Place, Best Map Product in a Digital Display Format, ESRI Map Gallery Contest 2011; *Sea-Level Rise Vulnerability in the Albemarle-Pamlico Estuarine System*

2nd Place, Battle of the GeoMaps, North Carolina Arc Users Conference 2011; Potential *Sea-Level Rise Inundation In the Albemarle-Pamlico Estuarine System*

1st Place, Outstanding Use of Cartographic Practices in a GIS Environment, Central Florida GIS Workshop Map Gallery Contest 2013; *Sea-Level Rise Vulnerability in the Albemarle-Pamlico Estuarine System*

COMPUTER SKILLS

Proficient in ESRI ArcGIS 10.2, ArcView, ArcMap, ArcInfo, Arc Catalog, ERDAS Imagine 2011, Adobe Photoshop CS5, Sea-Level Affecting Marshes Model v6 (SLAMM).

PROFESSIONAL AFFILIATIONS

Undergraduate Certificate in Geographic Information Science (GIS) – University of North Carolina Wilmington

Graduate Certificate in Geographic Information Science and Technology (GIST) – East Carolina University

NATALIE C. KRAFT

Technical Editor

Education

Master of Environmental Management in Coastal Environmental Management, Duke University, 2013

Bachelor of Science in Marine Science and Biology, University of Miami, 2011

Ms. Kraft is a technical editor and writer with a background in marine biology and coastal management. She joined CSA Ocean Sciences Inc. (CSA) in 2013 and is responsible for technical editing, reviewing, proofreading, copy editing, organizing, and standardizing scientific reports associated with baseline and mitigation studies, monitoring surveys, and environmental impact assessments, primarily for oil and gas companies as well as State and Federal government agencies. Ms. Kraft has contributed to the technical editing and review of regional Environmental Impact Statements for geological and geophysical activities in the Atlantic Ocean under the Bureau of Ocean Energy Management and will be responsible for similar upcoming documents in the Gulf of Mexico. Other baseline study and monitoring survey reports Ms. Kraft has edited include coral relocation studies, beach nourishment projects, and ship grounding events. As part of her role with CSA, Ms. Kraft helped develop a document numbering system as part of the greater corporate effort towards a document control regime.

Prior to joining CSA, Ms. Kraft served as a coastal scientist in a variety of capacities and locations in the Gulf of Mexico, Atlantic Ocean, and Caribbean Sea. She has experience with scientific writing and editing, marine ecology and conservation, coral reef science, overfishing, habitat degradation and restoration, water and air quality monitoring, marine policy, and environmental education. Ms. Kraft also co-created, contributed articles to, and served as the Editor-in-Chief of *Wave*, an online magazine developed in the Marine and Atmospheric Science Department at the University of Miami to represent the undergraduate program as a whole; to be a uniting link among all of the marine science-related organizations; and to share student and faculty accomplishments and interests with prospective and current students and faculty as well as the greater community.

EXPERIENCE

2013 to Present: CSA Ocean Sciences Inc. – Technical Editor

- Technical editing, proofreading, standardization, and quality control of scientific reports pertaining to multidisciplinary baseline and mitigation studies, monitoring surveys, and environmental impact assessments.
- Reviewing more than 100 environmental reports addressing environmental, socioeconomic, and technical aspects of development activities for major oil and gas companies, such as Chevron U.S.A. Inc. and Anadarko Production Company, for submission to Federal and State regulatory agencies, including the Bureau of Ocean Energy Management and the Bureau of Safety and Environmental Enforcement.
- Ensuring clarity and accuracy of corporate health and safety documents and standard operating procedures for CSA and its clients in the oil and gas industry.

2012: Duke Carbon Offsets Initiative – Seasonal Wetland Carbon Offset Researcher

- Drafted a grant proposal for a wetland restoration and carbon offset project in southern Louisiana as part of a larger project studying the feasibility of affordable carbon offsets through wetland restoration and preservation.
- Developed a strategic plan for addressing future wetland carbon projects in Louisiana and North Carolina.
- Collaborated with key organizations and companies on wetland carbon offset policy development domestically and internationally.

2011: Trinity Consultants – Air Quality Regulations Student Consultant

- Wrote a comprehensive strategic plan that enabled Trinity Consultants to remain informed on future greenhouse gas emission regulation changes pertinent to their client base.

2009 to 2010: Institute for Tropical Marine Ecology – Coastal Ecology Field Researcher

- Executed coral reef assessments and analyzed marine invertebrate, macroalgal, and fish population data in Dominica, West Indies.

- Reported on the effects of unregulated subsistence fishing in the shallow waters surrounding Dominica to alert the government of the need for better coastal management.
- Extended the project to the island of Bonaire, Netherlands Antilles, where marine protection efforts have been enforced for more than 30 years to provide a preliminary comparison of coral reef community health.

REPRESENTATIVE CORPORATE PUBLICATIONS TECHNICALLY EDITED

Bureau of Ocean Energy Management. 2014. Atlantic OCS Proposed Geological and Geophysical Activities in the Mid-Atlantic and South Atlantic Planning Areas: Final Programmatic Environmental Impact Statement. Prepared for the U.S. Department of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. GSA Task Order No. M11PD00013. 3 vols.

CSA Ocean Sciences Inc. 2014. Immediate Post-Construction Nearshore Hardbottom Characterization Survey for the St. Lucie County South Beach Project. Prepared for St. Lucie County, under contract to Coastal Technology Corporation, Vero Beach, FL. 63 pp. + apps.

CSA Ocean Sciences Inc. 2014. Environmental Impact Assessment for Block 12 Multi-Well Drilling Program Offshore Cyprus. Prepared for Noble Energy International Ltd, Nicosia, Cyprus. 308 pp. + apps.

CSA Ocean Sciences Inc. 2014. 2013 Post-Construction Hardbottom Monitoring Survey for the Martin County Shore Protection Project: FDEP Permit Number 0295380-001-JC. Prepared for Taylor Engineering, Jacksonville, FL. 47 pp. + apps.

CSA Ocean Sciences Inc. 2014. Supplemental Exploration Plan Environmental Impact Analysis for Buckskin South Prospect, Keathley Canyon Block 871, Lease OCS-G-32650, offshore Louisiana. A final report for Chevron U.S.A. Inc.

CSA Ocean Sciences Inc. and LGL Ecological Research Associates, Inc. 2014. Gulf of Mexico Cooling Water Intake Structure Entrainment Monitoring Study. Final Report for ExxonMobil Upstream Research Company, Houston, TX. 54 pp. + apps.

PUBLICATIONS (INDIVIDUAL)

Kraft, N., L. Moss, X. Dong, and Y. Wang. 2013. Economic Viability of Blue Carbon Offsets in Coastal North Carolina and Louisiana. Master of Environmental Management thesis, Duke University. 67 pp.

Kraft, N. 2011. A comparison of reef fish populations in Dominica, West Indies and Bonaire, Netherlands Antilles – Are marine parks effective? Bachelor of Science thesis, University of Miami.

Appendix D

Leviathan Field Development Background Monitoring Survey

(To be Submitted Separately)

Appendix E

Bathymetry and Seafloor Morphology Charts

Confidential

Appendix F

Archaeology Information

Confidential

Appendix G

Mineral Oil-Based Mud Information (INNOVERT Mud System)

Confidential

Appendix H

Safety Data Sheets

Confidential

Appendix I

Thermomechanical Cuttings Cleaner

Halliburton – Thermomechanical Cuttings Cleaner (TCC)

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Disclaimer

Because of the uncertainty of variable well conditions the necessity of relying on facts and supporting services furnished by others, Halliburton IS UNABLE TO GUARANTEE THE EFFECTIVENESS OF THE PRODUCTS, SUPPLIES OR MATERIALS, NOR THE RESULTS OF ANY TREATMENT OR SERVICE, NOR THE ACCURACY OF ANY CHART INTERPRETATION, RESEARCH ANALYSIS, JOB RECOMMENDATION OR OTHER DATA FURNISHED BY Halliburton. Halliburton personnel will use their best efforts in gathering such information and their best judgment in interpreting it, but Customer agrees that Halliburton shall not be liable for and Customer SHALL RELEASE, DEFEND AND INDEMNIFY Halliburton against any damages or liability arising from the use of such information even if such damages are contributed to or caused by the negligence, fault or strict liability of Halliburton.

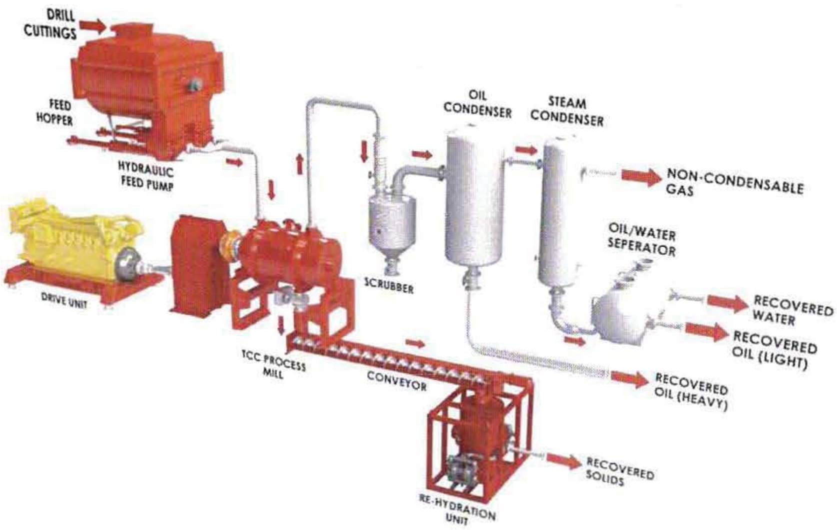
Halliburton TCC Diesel Driven

Halliburton Thermomechanical Cuttings Cleaner

The Halliburton Thermomechanical Cuttings Cleaner (TCC) process unit is designed for processing of oil contaminated drilling waste like typical drill cuttings, slop-mud and spent drilling mud. The composition of this feed is expected to be inside the range:

- Dry solids content 40-80%
- Base oil content 10-30%
- Water content 10-30%

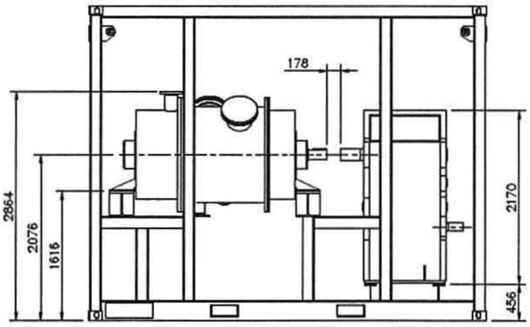
The unit is designed to be an onshore and offshore processing plant that uses mechanical action which is applied directly to the drill cuttings to create temperatures that rise above the boiling points of water and oil. Reaching these temperatures will release the hydrocarbons from the solids to an acceptable overboard disposal limit (< 1% OOC). The remaining water and oil vapor with be then condensed into the relevant streams and revered separately. Recovered oil will be pumped back into the offshore installation's mud system and water will be disposed overboard if it meets the offshore disposal guidelines. Typical recovered OIW (oil on water) content of the recovered water is < 30PPM.



HALLIBURTON | Baroid

Process System

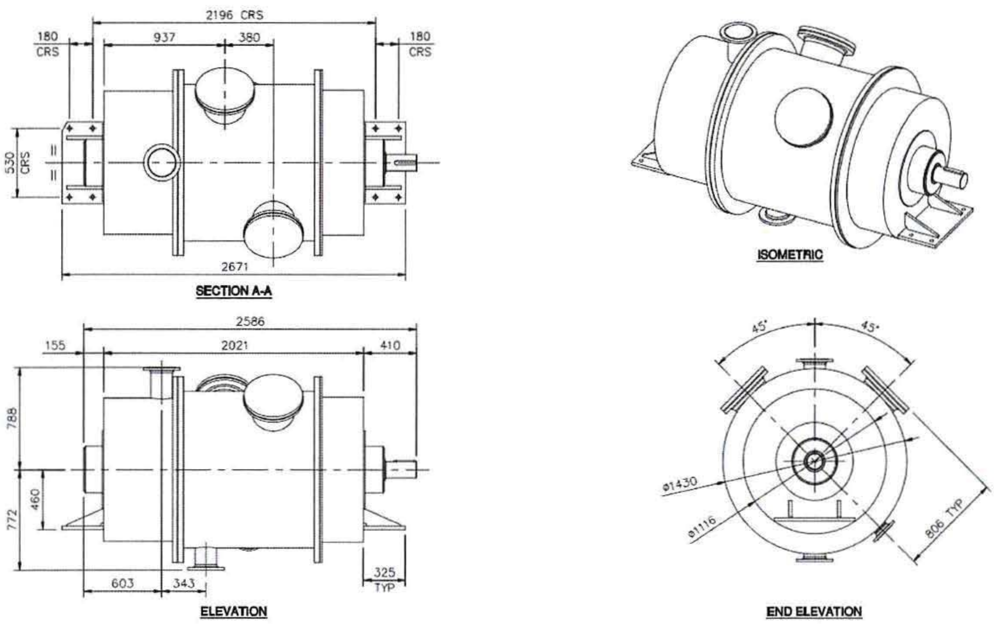
The purpose of the process unit is to evaporate oil and water in the process mill and then to condense the vaporized water and hydrocarbons, recovering the oil phase for reuse in new drill mud or as a fuel source for the diesel drive.



The process mill is the heart of the TCC process. Its main function is to generate friction heat to force the evaporation of water and oils present in the feed material. The rotor operates with the rotational speed of 600 – 700 rpm, which creates a ring shaped bed of material along the stator wall. Due to the intense agitation of the rotor, motor energy is transferred as heat to the material bed, allowing water and oil in the material to be efficiently flash evaporated.

The load on the drive end is strongly determined by the thickness of the material bed, and this is automatically controlled by means of the process mill discharge valve allowing the discharge of bed material. Exhaust gas is taken out near the center of the process mill and directed to the gas outlet vapor line; this coupled with the labyrinth ring inside the process mill prevents a large portion of the solids being carried over in the gas phase.

The process mill discharge valve is primarily used to discharge solids from the process mill. Most of the solids (approx. 90%) are discharged directly from the process mill discharge valve. This valve is automatically controlled to maintain the power set point of the drive unit.



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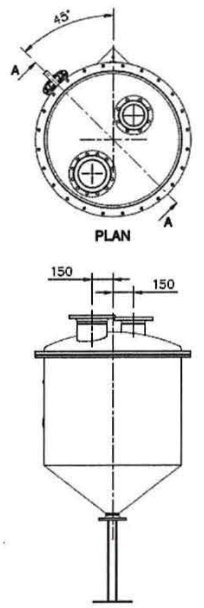
Condenser System

The condenser module is broken into 4 stages; the oil scrubber is the primary vessel that's acts as the final solids removal from the recovered vapor. From there the vapor travels through an oil condenser, water condenser and oil/water separator.

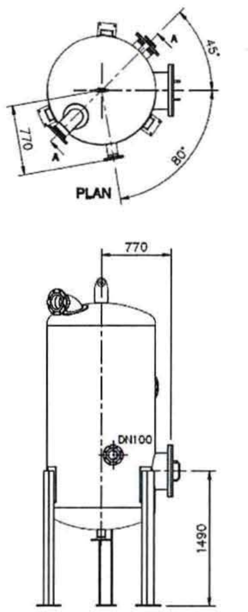
The oil scrubber brings the temperature in the vapor down, which induces condensation of some oil. The oil is then used to wash out residual particles present in the gas. About 0.5 – 1% of the solid material treated in the process mill is still present in the gas when it enters the condenser system. In the oil scrubber just enough oil is condensed to provide washing of the remaining solids and to create an oil sludge that can be pumped in circulation in the scrubber. Oil sludge will be produced at a rate of between 25 – 50 kg/hr with a solids content of 25%. Water condensation and cooling is controlled by a temperature set point which in turn is controlled by the TCC control system. The oil condenser reduces the vapor temperature down further too about 105 - 110°C which induces condensation of most of the oil remaining in the vapor stream.

The steam condenser brings the temperature down to below 100°C which induces condensation of all steam and residual light oils.

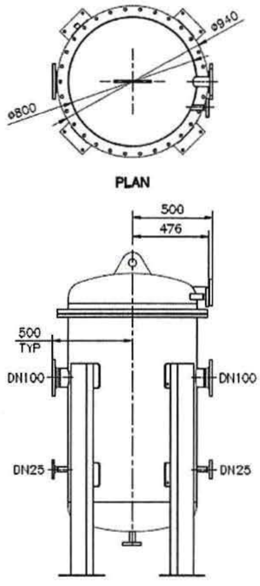
The light oils are removed from the water phase in the oil/water separator before the water is cooled and re-circulated in the condenser.



Oil Scrubber



Oil Condenser



Water Condenser

TCC Feed System

The TCC feed module and shaker protects the mill by removing items that will potentially damage the mill or cause premature wear. The units are designed to receive cuttings from excavators, augers and pneumatic systems. They ensure cuttings are blended to the correct consistency and ensure that there is a solid slug of cuttings into the mill which is essential following the initial nitrogen purge.

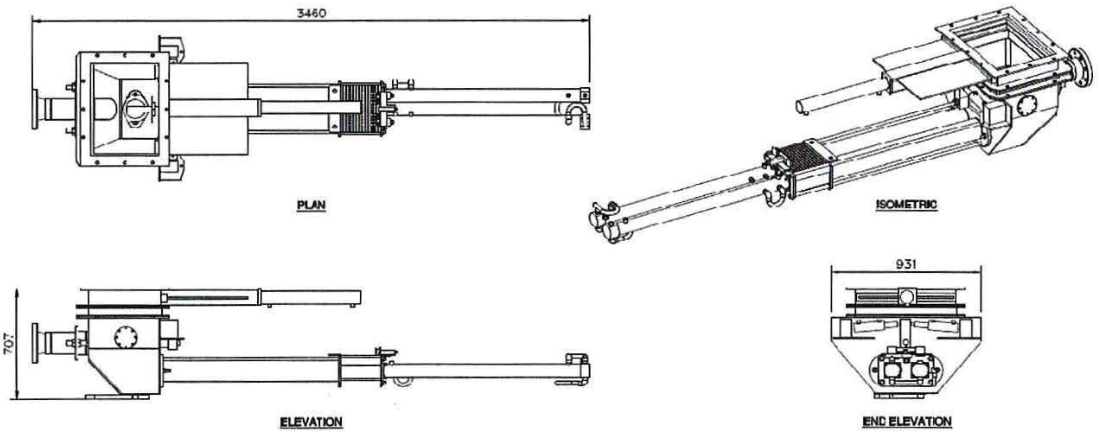
Our original offshore design of feed unit is running successfully in Algeria and is based on the design supplied to Kazakhstan and Colombia. However we have made further improvements to facilitate higher processing rates and provide redundancy in an offshore environment.

We have modified the agitator blades, added and second agitator shaft and added a further feed pump. All of the additions were taken in a view to create greater consistencies while pumping feedstock to the TCC process mill. The addition of a twin shaft feed hopper is to improve blending of cuttings with the recovered sludge.

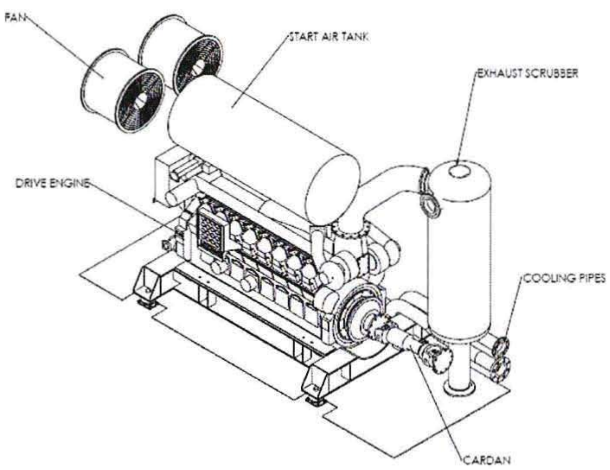
As standard we have multiple flushing points on the hopper and on each feed pump. Scrubber sludge (a by-product of the condensing process) is fed back and used when cuttings require lubrication or dilution to aid transfer. During initial start-up new oil or diesel may be required.

We monitor the volume of raw cuttings pumped to the process mill by means of a stroke counter mounted onto each feed pump. This counts and records the total amount of strokes by the Putzmeister pumps. By measuring the density (S.G) of the material on a regular basis we can within reasonable limits determine the amount of raw cuttings processed on a shift basis.

In addition to this we verify the sum by means of the load cells which the main hopper is mounted on.



Drive System



The TCC unit shown is the largest we have built to date and is based on a CAT 3516 engine. The continuous power rating of the CAT 3516 engine is 1710hp (1275 kW) at 1800 rpm (rating level A). This allows for an average processing rate just under 6T/Hr.

To allow the unit to operate in Zone II conditions exhaust gasses are required to be cooled to below 200.C. The Halliburton TCC unit will have installed a unique cooling system where an exhaust scrubber is used to capture and cool gasses down to below 100.C, these exhaust gasses are flushed with water and discharge overboard. Flushing gasses overboard through the overboard discharge line eliminates emissions on the deck and thus eliminating the requirement to redirect exhaust gasses to a safe area of the installation.

3GP is a totally new concept for providing PROACTIVE Zone 2 explosion protection for Category 3G diesel engines.

By continuously checking critical temperatures, detecting over-speed and monitoring the air supply to the induction system and the surrounding area, 3GP can shut down the engine before a potentially hazardous event occurs.

A unique forced gas calibration test ensures system integrity prior to operation every time.

Reliability, Improved uptime and reduced maintenance dependency is achieved by the 3GP 'Safe Engine' concept in two key ways:

- The elimination of exhaust flame traps
- The introduction of an engine monitoring system for diesel engines which are to be operated in Zone 2 areas

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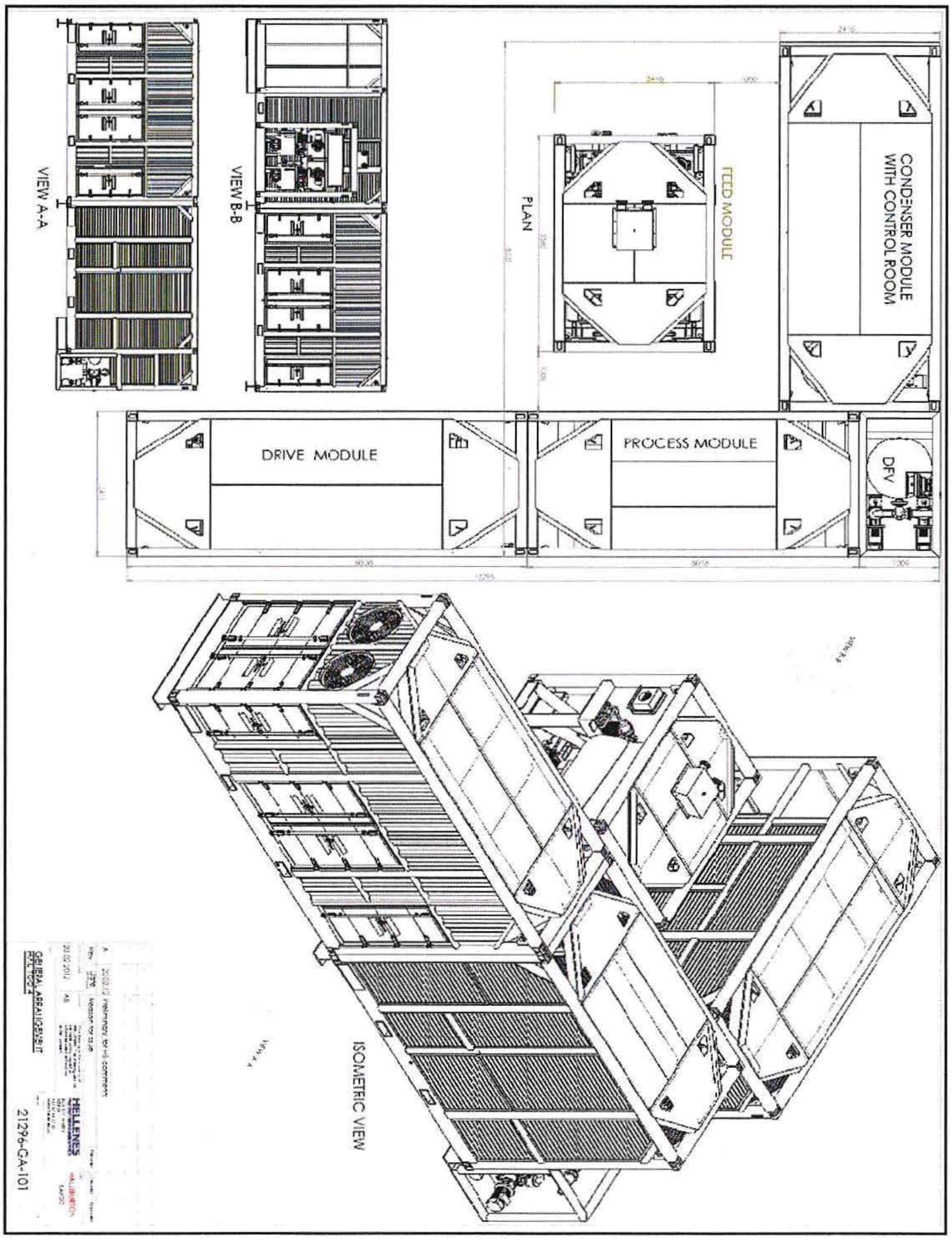
TCC – Data Sheet



HALLIBURTON | Baroid

TCC Energy Balance

The below calculations show how the 1.3MW Diesel drive TCC is capable of achieving 6MT/HR of processing across the whole well.

Energy balance for TCC

Data for operation:

Hourly throughput	***6,000***	kg/h
Solids	***70.0*** %	weight
Base oil	***15.0*** %	weight
Water	15.0 %	weight

Composition of drilling waste

Solid =	70.0 % wt	ρ_S	=	***2200*** kg/m³	=	49.7 % vol
Oil =	15.0 % wt	ρ_O	=	***870*** kg/m³	=	26.9 % vol
Water =	15.0 % wt	ρ_W	=	***1000*** kg/m³	=	23.4 % vol
	100.0 % wt	ρ_m	=	1561 kg/m³		100.0 % vol

Thermodynamical data:

C_S	=	0.88 kJ/kgK
C_O	=	2.10 kJ/kgK
C_W	=	4.19 kJ/kgK
$c_{p,W}$	=	1.95 kJ/kgK
$h_{fg,O}$	=	275 kJ/kg
$h_{fg,W}$	=	2260 kJ/kg

Operational data for TCC oil scrubber:

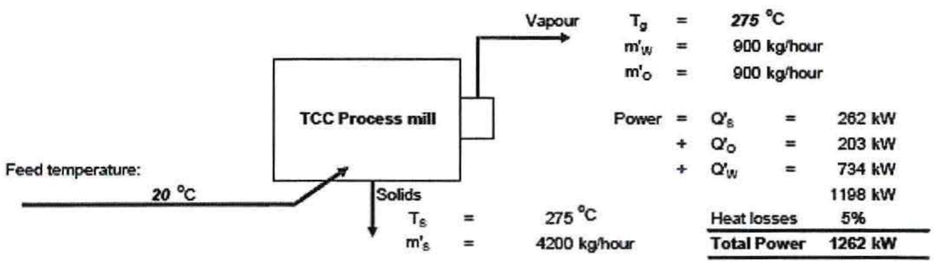
Required for scavenging:	***0*** kg per hour
Soilds removed in scrubber:	***0*** kg per hour

Composition of feed to TCC (mixture of oil sludge and drilling waste):

Solids	4,200 kg per hour
Base oil	900 kg per hour
Water	900 kg per hour
Total	6,000 kg per hour

1. Law ballance:

$$W = m'C_S(T_S - T_m) + m'_O(C_O(T_g - T_m) + h_{fg,O}) + m'_W(C_W(100 - T_m) + C_{p,W}(T_g - 100) + h_{fg,W})$$



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Any questions/comments or changes you would
like to make to the logs and/or summary,
Please do not hesitate to email.

E-mail: baroidsurfacesolutions@halliburton.com

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www.halliburton.com

HO7736

Appendix J

Survey Vessel and Helicopter Specifications

MMC887 PSV/ MW619-47/48

PLATFORM SUPPLY VESSEL
OUTLINE SPECIFICATION

04th October 2012,
Rev.0

CLASSIFICATION ABS +A1, (E) Offshore Support Vessel, +AMS, +DPS-2, +FFV Class 1, +ACCU

OTHER COMPLIANCES

International Load Line Convention 1966
International Tonnage Convention 1969
COLREG 1972
SOLAS 1974 with amendments (where applicable)
International Radio Communication Regulations
MARPOL 73/78 (Annex I, II, IV, V, VI)
UWILD Certificate

FLAG Malaysia

PRINCIPLE DIMENSION

Length O.A	:	87.075 m
LPP	:	83.00 m
Breadth MLD.	:	18.80 m
Design Draft	:	5.90 m
Max Draft	:	6.05 m
Deadweight	:	Abt. 5000 Tonnes
Gross Tonnage	:	Abt. 3601 Tonnes
Net Tonnage	:	Abt. 1430 Tonnes
Deck Cargo	:	Abt. 2250 Tonnes
Deck Strength	:	5 Tonnes/m^2
Speed	:	Abt. 14.30 knots at 100% MCR, 5m draft
Deck Area	:	1000 m^2
Complement	:	47 + 1 men
Fuel Type	:	Gas Oil

TANK CAPACITY (APPROXIMATION)

Fresh Water inc. Potable Water	:	620	m^3
F.O. (Total)	:	945	m^3
Liquid Mud / Brine	:	2491	m^3
Dry Bulk Cargo Tank (Cement/Baryte)	:	400	m^3
Drill Water / Water Ballast	:	1800	m^3
Methanol (SG 0.9)	:	429	m^3

MMC887 PSV/ MW619-47/48

PLATFORM SUPPLY VESSEL
OUTLINE SPECIFICATION

04th October 2012,
Rev.0

BULK HANDLING SYSTEM	Suitable for Carriage of Cement/Baryte Class : ABS Total Capacity : 14,125ft^3 approx.400m^2 (in 5 tanks) Working pressure: 80 psi
MAIN PROPULSION	Main Propulsion – 2 x 2000 kW Fixed Pitch Azimuth Thruster c/w VFD Bow Thruster - 1 x 910 kW Tunnel Thrusters CPP c/w electric motor speed at 1800 rpm driven Retractable Thruster - 1 x 800 kW Retractable Thrusters CPP c/w electric motor speed at 1200 rpm driven
POWER PLANT	1) Prime Mover(Diesel Engine) - 4 x 1825 kW Cummins Engine c/w generator, 480/3/60 2) Emergency / Harbour Generator - 1 x 350 kW approx, 480/3/60
DECK MACHINERY	1) Anchor Windlass - Electric driven, 2 Declutchable Drum, 2 Declutchable cable lifter, 2 Fixed Warping End Nominal Pull : 10 mT, 0 – 20m/min 2) Deck Crane - 2.0 mT SWL at outreach 10m 3) Others - 2 x Capstan (7.5mT pull) and 2 x Electric Mooring Winch(10mT pull)

MMC887 PSV/ MW619-47/48

PLATFORM SUPPLY VESSEL
OUTLINE SPECIFICATION

04th October 2012,
Rev.0

FIRE FIGHTING EQUIPMENT

1) External Fire Fighting System – Class FiFi 1 having 2 in nos main fire pump (1600m^3/h) driven by generator engine front PTO c/w 2 x Fire Monitors (1200m^3/h) and with fixed water spraying system as per classification rules.

2) Fixed Fire Protection System - Engine Room, Paint Store & Emergency Generator Room installed with fixed CO2 Fire protection system

NAVIGATION EQUIPMENT

1) Echo Sounder
2) Radars
3) Voyage Data Recorder
4) Magnetic Compass
5) Auto Pilot
6) AIS
7) Weather Facsimile Receiver
8) Doppler Speed Log
9) Ship Security Alert System

COMMUNICATION EQUIPMENT

1) GMDSS for Area A3
2) PA/Talk back
3) Auto Telephone System

DYNAMIC POSITION SYSTEM

Dynamic positioning system according to ABS DPS-2 c/w with 2 off DP operator stations, 1 off cJoy Operating Terminal, 1 off cJoy Wing Terminal(Portable), 2 off Gyrocompass, 2 off Wind sensors, 2 off Motion reference units, 1 off Spotbeam, 1 off RADius Position reference system, 2 off DGPS, 2 off UPS, 2 off Alarm and Event Printer

The following basic operational modes are included:

• Joystick Mode
• Auto Pilot Mode
• Auto Heading Mode

MMC887 PSV/ MW619-47/48

PLATFORM SUPPLY VESSEL
OUTLINE SPECIFICATION

04th October 2012,
Rev.0

ACCOMMODATION

Fully Air-Conditioned c/w hot water heating and air distribution system.
One off electrical heater to be installed in cabins.

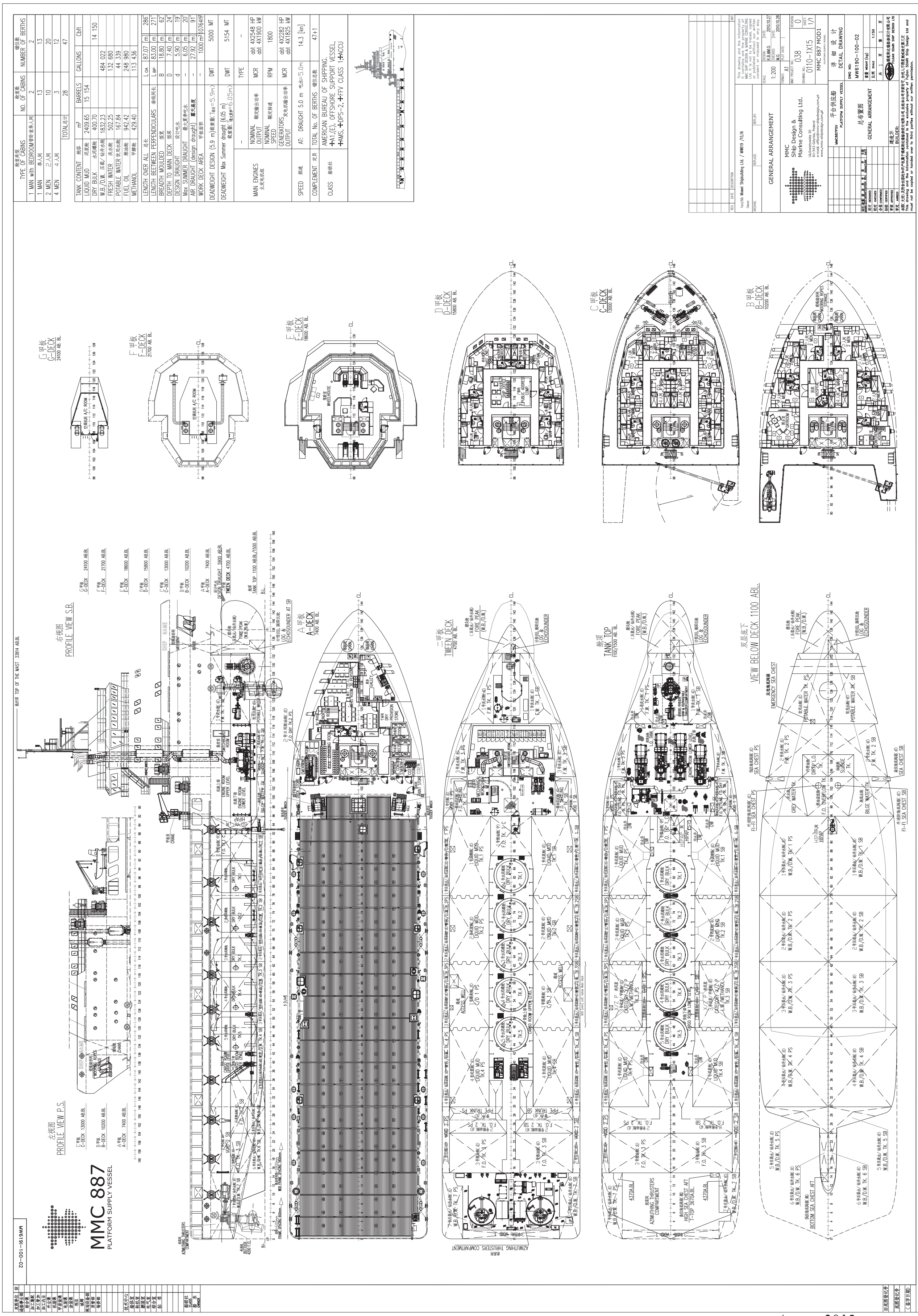
2 x 1 - 2 men
13 x 1 man cabin – 13 men
10 x 2 men cabin – 20 men
3 x 4 men cabin – 12 men
Total – 47 men
Dispensary – 1 man

SPARE PARTS

Class Standard requirements applied.

NOTE: ANY EXEMPTIONS REQUIRED FROM THE FLAG STATE WILL BE THE RESPONSIBILITY OF THE BUYER.

- END -


MMC 887
PLATFORM SUPPLY VESSEL

TECHNICAL SPECIFICATION

111/0050-1 MOD3 rev."0"

MMC 887 MOD.3 PSV

PLATFORM SUPPLY VESSEL

FOR
Client

MMC SHIP DESIGN AND MARINE CONSULTING Ltd.

29.12.2010

INDEX

SECTION 000 – GENERAL AND MAIN PARTICULARS

001 – 1 INTENT

This specification describes a Platform Supply Vessel (PSV), as per General Arrangement MMC 887 MOD 3, Platform Supply Vessel, 111 /0110-1.Rev.0.
The vessel will be fitted with a large open aft deck and accommodation forward.

Machinery will be located forward. Aft of the engine room tanks for liquids and dry bulk will be located. Aft of the supply tanks, a Azimuthing Thruster Compartment will be arranged. Thrusters' compartment for retractable and bow thruster will be arranged forward.

The hull will be subdivided by longitudinal bulkheads and a number of transverse bulkheads. All interior spaces including the Engine Room will be protected by a double hull. Wing-tanks will be utilized for Cargo Fresh Water and Water Ballast / Drill Water. Double bottom tanks will be used for Water ballast and Drill Water. Methanol tanks will be arranged in two Liquid Mud tanks as per General Arrangement.

The vessel will be fitted with a duplex Dynamic Positioning system according to IMO DP Class 2.

The vessel will comply with ABS Fire Fighting notation – FFV Class 1 and Oil recovery Class 2.

002 – 1 GROUPING SYSTEM AND UNITS

The following grouping key was used through the Specification:

Class 0
General information including specifications, hydrostatics, hydrodynamics, stability, strength, bill of materials, tests and trials.

Class 1
Hull construction strictly considered including erections and elements permanently welded to it as foundations, signs, marks and penetrations.

Class 2
Deck arrangement including anchoring, mooring, steering, life saving, deck planking, deck access, vessel's access facilities.

Class 3
Interior equipment including painting, insulation, sheathing, floor covering, doors and widows, as well as accommodation, deck stores and provisions stores outfit.

Class 4
Engine Room including shafts lines, main propulsion, boilers, exhaust lines, generating sets, related mechanisms and devices, workshops, floors, lifting facilities.

Class 5
All piping including liquid and dry cargo, ship's own and off-ship Fire Fighting, as well as HVAC and oil recovery installations.

Class 6
All Electric, Electronic, Automation and cabling installations.

Class 9

Inventory and Spare parts

SI units are to be used throughout the Specification and in all Classification Documents, unless otherwise stated.

003 – 1 DEFINITIONS

The following terms used through the Specification have the following meaning:

Approved: Means any kind of Class, Authority and/or Buyer acceptance.

"As built": Final drawings and documentation including all eventual revisions implemented during vessel's construction

Authority: National (Flag) or International Institutions to regulations of which the vessel is built

Builder: Shipyard contracted by the Buyer to build the vessel

Buyer: Ship-owner ordering the vessel from the Builder

Class: Classification Society to which rules the vessel is built

Length (L): As defined by the International Load Line Convention

Length (L_{OA}): Maximum length of the vessel

Load Line: The International Load Line Convention (ILLC) signed in London on 5th April 1966

Maker: Equipment manufacturer's name, whose products are going to be installed in the vessel

Makers' List: List of alternative producers, commonly agreed by Buyer and Builder, amongst which final supplier of specific equipment can be chosen by Builder

Producer: Equipment, machinery, whole system or material maker, who is going to provide professional advice, regarding his products installation or utilization.

Basic SI and/or metric units

Measure	Unit	Symbol
Area	Square metre	m^2
Capacity	Litre Cubic metre 1 m^3 = 1,000 litres	l (or litres) m^3 (or cum)
Electric current intensity	Ampere	A
Electric potential	Volt	V
Energy	Joule kilocalorie	J = Nm 1kcal= 4.18kJ
Force	Newton	N = kg·m/s^2
Frequency	Hertz	Hz = s^{-1}
Length	Meter Centimeter Millimeter 1metre=100centimetres=1,000millimetres	m cm mm
Mass	Kilogram Tone 1 tone = 1,000 kilograms	kg t (or tones)
Power	Watt Kilowatt 1kilowatt=1,000watts	W = J/s kW
Pressure	Pascal Bar	Pa = N/m^2 1bar= 10^5Pa
Revolutions	RPM	min^{-1}
Temperature	Centigrade (Celsius) Kelvin	℃ K
Time	Hour Minute Second 1hour=60minutes=3,600seconds	h min s
Viscosity	Centistokes	1cSt = 10^{-6} m^2/s

Another units referred be commonly used in Offshore and Shipbuilding domains:

Measure	Unit	Symbol
Capacity (liquids)	Barrel	1 bbls = 0.159 m^3 1 bbls = 159 litres 1 cum = 6.2893 bbls
Capacity (liquids)	Gallon	1 gal = 0.003785 m^3 1 gal = 3.785 litres 1 cum = 264.2 gal
Capacity (dry bulk)	Cubic foot	1cuft = 0.0283 m^3 1 cuft = 28.3 litres 1 cum = 35.3357 cuft
Diameter (pipes and wires)	inch (symbol 1")	1inch = 1" = 2.54cm
Power	horsepower	1 hp = 0.74569 kW 1 kW = 1.341 HP
Specific gravity	sg	t / m^3
Speed	knot	1kn = 1Nm/h 1Nm =1852 m = 1.852 km 1kn = 1.852 km/h

004 – PROCEDURES DURING OUTFITING THE VESSEL

Builder is to be obligated to keep the following procedures when constructing and outfitting the vessel:

1. Special respect is to be paid due to care and diligence in the protection and the cleanliness of all items of equipment being installed in the vessel according to the best Builder's practice.
2. All materials intended for, or allocated for the construction of the vessel, are to be properly stored or protected from the weather immediately upon arrival at the Builder's yard. Electrical, electronic and interior communication equipment shall be protected against damp and condensation. Sensitive electronics shall be protected from extreme temperatures as required by vendor.
3. Heater elements of electric motors higher than 50 [kW] should be energized after installation on board.

005-1 – QUALITY OF MATERIAL AND ARTICLES

1. Materials used for building and construction of the vessel, are to be as described below:

- Quality of materials complying with the requirements of the Classification Society and/or the relevant International Standard, and/or specification. All workmanship is to be executed using best shipbuilding practice.
- All items of equipment and outfit are to be manufactured, installed, tested and completed in accordance with the Classification and Statutory Requirements.
- Special attention is to be given to the finishing of steel structure.
- Lugs temporarily welded to permanent steel parts for positioning or mounting, are to be carefully removed by flame cutting and finally ground.
- All materials and items of equipment used in the construction of the vessel are to be new, recent manufacturer, undamaged and of marine quality for the specified purpose. All

materials and equipment identified in these specifications, as Client's standards, by trade name, manufacturer, model or type, are to be supplied. Substitution of such materials or items with other products is only acceptable after obtaining Client's written approval.

006 – TESTING

During the construction stage of the vessel the Builder shall carry out the following tests and presentation to the Owner's representative:

1. Seams are to be tested according to the "Welding plan" or "Welding table",
2. After steel and hot work completion tightness test is to be carried for all tanks, cofferdams and voids (method shall be agreed with Classification Surveyor).
3. After completion, all piping systems are to be pressure tested, cleaned and flushed.
4. After surface preparation and before painting or coating application all surfaces in tanks, voids, cofferdams and other spaces are to be presented.
5. After completion, all systems, subsystems, machinery foundation or machinery fastening are to be presented.
6. All data recorded during tests are to be tabulated and issued to the Client as a "Tests report".
7. All testing shall be done according to regulatory body approval.

007A – DOCK TRIALS

Dock trials are to be held by the Builder prior the sea trials, according to the detailed "Dock Trials Program". The program is to be agreed with the Client two (2) weeks prior to test start. Tests are to be carried out with respect to the following:

1. Trials are to be carried out in accordance with the requirements of the Classification Society, equipment manufacturers and/are to be witnessed by Owner's Representatives.
2. All systems and machinery are to be tested after system completion to demonstrate satisfactory working and compliance with specification requirements.
3. All systems essential to the seaworthiness of the vessel are to be tested as far as practicable, during dock trials.
4. All data recorded during tests are to be tabulated and issued to the Client as a "Dock Trials Report".

007B – SEA TRIALS

Sea trials are to be held by the Builder when vessel is substantially complete, except for the minor items of work which may by left unfinished (after Owner's acceptance) and after dock trials are completed. Sea trials are to be carried out according to "Sea Trials Program" and according to Class requirements. "Sea Trials Program" is to be presented to the Client three (3) weeks prior to trials start. An arrangement to obtain all necessary records is to be provided by the Builder.

The following tests are to be carried out:

1. Speed Trial as in table below (MCR for main electric propulsion motors):

Engine output		Number of runs		Records	Loading condition
100%	MCR	Four	(4)	Speed, course and records as in Endurance Trial	Corresponding to the draft 5,0 [m], even keel, wind speed not exceeding 2 in Beaufort scale
90%	MCR	Two	(2)		
75%	MCR	Two	(2)		
60%	MCR	Two	(2)		

2. Endurance trial – to be carried out after propulsion system adjustment as in table below (MCR for main electric propulsion motors):

Engine output		Time	Remarks	Loading condition
100%	MCR	min 4 hours consecutively	Full records of the diesel engines, prime movers, exhaust gases temperature and beck pressure, temperature in engine room.	Corresponding to the draft of 5,0 [m], even keel

Note:
- No others trials are to be conducted during endurance trial except noise and vibration measurements.
- Endurance trial can be carried out in conjunction with speed trial.

3. Maneuvering trial – circulation trial, stop and emergency stop trial,
4. Anchor equipment trial,
5. Partial examination of the main machinery is to be carried out after Sea Trials completion. The parts are to be opened up for Owner's inspection. When the inspection is to be finalized satisfactory Sea Trials are recognized as completed.
6. If serious defect is noted during the inspection, Owner reserve the right to demand further sea trials to demonstrate that rectification of defects has been carried out to the Owner's satisfaction.

007C – INCLINING EXPERIMENT AND DEADWEIGHT

1. After ship completion Builder will carry out inclining experiment. The experiment program is to be presented to the Owner two (2) weeks prior to the test. Test is to be carried out according to the Rule's guideline regarding inclining experiment. The experiment is to be witnessed by

Owner's Representative. Results are to be presented to the Owner and Classification Society and are to be considered in Final Stability Calculations.
2. On the sister vessel Builder can carry out only "Deadweight Test" instead of full inclining experiment.
3. Deadweight components are as presented below:
   - Cargo,
   - Stores,
   - Ships provisions,
   - Loose cargo securing equipment,
   - Loose towing equipment,
   - Crew and effects,
   - Spare parts and tools not required by the Rules.
4. Lightship weight shall include the following:
   - Spare equipment according to the Class requirements stowed on board,
   - Media in the mechanisms.

007D – DP TRIALS

1. During Sea Trials Builder together with DP system vendor will carry out DP adjustment and commissioning. In addition to the class requirements FMEA is to be provided.

008 – NOISE AND VIBRATION

1. Noise measurements are to be carried out during Endurance Trail in the following spaces:
   - Engine Room,
   - Wheelhouse,
   - Living rooms.
2. Vessels arrangement, insulation and machinery fastening is to be sufficient to obtain noise levels complying with recommendation given in IMO Resolution no A 468/XII. During special operation conditions (i.e. towing, off loading, maneuvering) vessel shall be free of excessive noises.
3. Vibration measurements are to be carried out during Endurance Trial in the following leaving spaces:
   - Wheelhouse,
   - Living spaces,
   - Spaces normally attended by the crew,
   - Generator Sets.
4. Vessel's arrangement, insulation and machinery fastening is to be sufficient to obtain vibration levels complying with ISO 6954 for leaving and crew attended spaces and ISO 2372 for machinery foundations. In special operation modes (i.e. towing, off loading, maneuvering) vessel shall be free of excessive vibrations. For normal working stations where personnel may be exposed to an area of vibration for more than eight (8) hours an excessive vibration are defined as follows:
   - Vibration velocity 9 [mm/sec] fore frequency of 5 [Hz] and above or
   - Constant acceleration of 0,029g for frequency below 5 [Hz].
5. Noise and Vibrations measurements are to be recorded and issued to the Owner together with "Sea Trial Report".

009 – REMAINING FUEL AND OIL

1. The Builder will furnish all media (fuel oil, water, hydraulic oil, etc.) necessary to conduct all tests, dock and sea trials. Media remaining on board after trials completion are to be left on board and invoiced to the Owner based on the current port published rates.

010 – CLEAN VESSEL PRIOR TO DELIVERY

1. Prior to delivery, the interior and exterior of the vessel shall be swept, washed down or otherwise cleaned by removing trash, sand, etc, to place vessel in habitable condition for arrival of the crew.

011 – VESSEL'S DELIVERY

1. Vessel is to be delivered at the Builder's pier.

012 – CLASSIFICATION DOCUMENTS

1. Builder shall prepare and submit for approval to the Classification Society a set of Classification Documents. Builder is obligated to incorporate all comments and remarks made by Classification Society.

013 – OWNER'S COMMENTS AND MODIFICATIONS

1. Builder is obligated to submit, via e-mail in PDF or AutoCAD format, to the Owner a set of Classification Documents. Builder shall incorporate all Owner's comments and remarks if they do not cause variation to the Order and the Specification. Owner is obligated to approve documents or make comments within 14 calendar days since submittal date.
2. The Owner's representative shall have the right, in co-operation with the Builder, to discuss arrangements and details with the Builder's subcontractors. The discussion shall take place before ordering of equipment from subcontractors. Equipment suppliers shall be issued drawings that have impact on their equipment for their comment.
3. All modifications exceeding the Specification require distinct agreement or annex,
4. No additions, involving extra costs and delivery time, are to be supplied and fitted without previous confirmation in writing from the Owner or Owner's Representative.

014 – "AS BUILT" DOCUMENTATION

1. Three (3) sets of "As built" documentation, in paper, on CD as a PDF or AutoCAD format and three (3) sets of main machinery instruction, manuals are to be delivered to the Owner.

015 – COOPERATION WITH CLASIFICATION SURVEYOR

1. Builder is obligated to the close cooperation with Classification Surveyor. Tests, trials and presentations are to be witnessed by Surveyor where necessary according to the Class requirements. Builder is obligated to incorporate all Surveyors comments and remarks with regard to the Class requirements and Class approved documents.

016 - 1 – CLASS SIGN

1. The hull, all systems and equipment shall be designed and constructed to comply with Rules and Regulations for the Classification of Ships issued by American Bureau of Shipping to obtain the following Class sign:

✠A1, (E) Offshore Support Vessel, ✠AMS, ✠DPS-2, ✠FFV Class 1; +ACCU;
✠Oil Recovery Class 2

016 - 2 – FLAG

1. The vessel will fly flag of Vanuatu.

016 - 3 – REGULATIONS

1. The vessel shall be designed and built in accordance with and comply with all Statutory Regulations for this type of ship but not limited to:
   - Rules and Regulations for the Classification of Ships issued by American Bureau of Shipping,
   - International Load Line Convention 1966,
   - International Tonnage Convention 1969,
   - COLREG 1972,
   - SOLAS 1974 with amendments (where applicable),
   - International Radio Communication Regulations,
   - MARPOL 73/78 (Annex I, II, IV, V, VI).

017 – CERTIFICATES

1. Builder shall deliver one (1) original, plus one (1) copy of the following certificates or/and statements of compliance with the following:
   - Classification Certificate,
   - UWILD Certificate,
   - Survival Craft Certificate,
   - Life rafts and hydrostatic releaser,
   - SART Certificate,
   - Builder's Certificate
   - Master Carpenter's Certificate,
   - Lien Free Certificate,
   - Radio Station License - (OWNER to apply for),
   - Harmonized Statutory System Certificate (HSSC),
   - COLREGS 1972,
   - SOLAS Certificates,
   - International Load Line Certificate,
   - International Tonnage Certificate,
   - Tonnage Certificate,
   - Suez Canal Tonnage Certificate,
   - Panama Canal Tonnage Certificate,

- MARPOL Annex I (Oil) Certificate,
- MARPOL Annex II Noxious Liquid Substances Certificate (This shall denote for: "Drilling Fluids Containing Zinc Salts and Potassium Chloride",
- MARPOL Annex IV (Sewage) Statement of Compliance,
- MARPOL Annex VI (Air Pollution) Statement of Compliance,
- MARPOL Annex V Garbage Management Plan Certificate,
- IMO ISPS CODE,
- SOLAS Cargo Ship Safety Construction Certificate,
- SOLAS Cargo Ship Safety Equipment Certificate,
- SOLAS Cargo Ship Safety Radio Certificate (GMDSS amendments),
- SOLAS Cargo Securing Manual,
- International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk (NLS Certificate).

017-1 – MANUALS

1. The following manual are to be provided:

- MARPOL Annex II **S**hipboard **M**arine **P**ollution **E**mergency **P**lan for Noxious Liquids Substances (SMPEP),
- MARPOL Annex II **P**rocedures and **A**rrangements Manual (P&A Manual),
- MARPOL Annex V Garbage Management Manual,
- Methanol Procedures and Arrangement Manual,
- Cargo Securing Manual,
- FiFi System Operating Manual,
- Manuals are to be issued four (4) weeks before vessel handover.

018 – MAIN CHARACTERISTIC

1. The vessel shall have the following main dimensions, machinery and capacity:

Length overall	88.93 [m]	291	[ft]
Length between perpendiculars	83.00 [m]	271	[ft]
Breadth molded	18.80 [m]	62	[ft]
Depth molded to Main (A) Deck	7.40 [m]	24	[ft]
Design Draught	5.90 [m]	19	[ft]
Max Summer Draught, max. Draught	6.05 [m]	20	[ft]
Gross tonnage [GT]	TBC [-]		
Net tonnage [NT]	TBC [-]		
DWT at Max Summer Draught	5 100 [MT]		
Max speed at 100% MCR (propulsion electric motors) and 5.0 [m] draught	14.30 [knt.] (Based on the model tests)		
Fuel Oil	939 [m^3]	248 057	[gal]
Water Ballast / Drill Water	1 832 [m^3]	483 963	[gal]
Dry Bulk	~400 [m^3]	~14 125	[cbft]
Cargo Fresh Water	502 [m^3]	132 614	[bbl]
Liquid Mud	2 409 [m^3]	15 150	[bbl]
Brine	429 [m^3]	2 698	[bbl]
Methanol	429 [m^3]	113 329	[gal]
Potable Water	167 [m^3]	44 116	[gal]
Recovered Oil	1682 [m^3]	444 337	[gal]
Work Deck Area	1 000 [m^2]		
Deck Strength	5 [MT/m^2]		
Main Engines	4 x ~2 095 [kW]	4 x ~2 809 [HP]	
Main Generators Output	4 x ~2 000 [kW]	4 x ~2 500 [kVA]	
Complement	52 Persons		
Azimuthing Thruster	2 x 2 000 [kW]		
Retractable Thruster	1 x 800 [kW]		
Tunnel Thruster	1 x 910 [kW]		
Ships operation modes	Free running		
	Firefighting		
	DP		
	Oil Recovery		

019 – AMBIENT CONDITIONS

1. The following ambient conditions are to be taken under consideration for engineering purpose:

Summer:

Outside temperature	40ºC	80% RH
Inside temperature	22ºC	35% RH
Seawater	32ºC	

Winter:

Day outside temperature	-20ºC	Max. 20% RH
Inside temperature	22ºC	35% RH
Seawater	1ºC	

0120 – BODY LINES

1. Vessels hull form, with bulbous bow, was developed to provide required deadweight at relatively low resistance, proper accommodation of thrusters and to provide good sea keeping and maneuverability.

0160-1 – SUBDIVISION UNDER MAIN (A) DECK

The following is to be observed:

1. Under the Main Deck vessel is to be divided into the following main, watertight compartments (looking to aft):
   - Forepeak – collision zone,
   - Bow and Retractable Thruster Compartment,
   - Two levels of Engine Room,
   - Two levels of Cargo Room,
   - Azimuthing Thrusters Compartment.
2. Fire class divisions are to be provided according to the Rules.

0160-2 – ABOVE MAIN (A) DECK SUBDIVISION

1. Above the Main (A) Deck two (2) tiers of Forecastle and three (3) tiers of Deckhouse are to be constructed. The spaces are to be dedicated mainly for accommodation / domestic spaces and for deck stores including Emergency/Harbor Generator Room, CO_2 Room. Two (2) Funnels are to be arranged close to ship's center line and led about 3 [m] above the Wheelhouse Top. A/C compartment is to be arranged at the Wheelhouse Top, between the funnels. Fire class divisions are to be arranged according to the Rules.

SECTION 100 – HULL STRUCTURE

101 – CONSTRUCTION AND MATERIAL

The following principals are to be observed during hull and deckhouse construction:

1. Hull and deckhouse are to be of welded construction and made of Gr. A steel, certified by classification society. In order to reduce weight of the vessel HT steel might be applied.
2. Scantling arrangement and members' section modulus or thickness is to be determined by class requirements,
3. Structural reinforcements (insert plates, extra members) are to be provided in way of heavy machinery.
4. Draining holes are to be arranged and evenly distributed through structural members in tanks, cofferdams and voids. Hole radius and distance between holes should be adjusted according to actual conditions.
5. Vent holes are to be arranged and evenly distributed through tanks structural members. Distance between holes to be adjusted according to actual conditions.
6. Lightening and communication openings are to be provided in double bottom and wing tanks, voids are to be sized to a scantling member outline dimensions.
7. Details (type, size, etc.) of structures will finally follow the drawings approved by Class and those recommended in this specification will be considered into design before submitted relevant drawings to Class for final approval.
8. Methanol tanks are to be fabricated from stainless steel 316 L.

110 – BOTTOM

Inner bottom shall cover Bow and Retractable Thruster Room, Engine Room, Cargo Room and Azimuthing Thrusters Compartment. The following are to be observed:

1. Inner bottom height in Engine Room – 1100 [mm] with recess for Fi-Fi pumps,
2. Inner bottom sloping – under LM tanks 5 deg (1100 [mm] inboard),
3. Framing system in Engine Room – mixed according to the Rules,
4. Framing system in remaining areas – longitudinal,
5. Suction wells are to be arranged in Liquid Mud tanks,
6. Bilge wells are to be arranged as mentioned in paragraph 521-1,
7. Longitudinals spacing – 600 [mm],
8. Floors spacing in Engine Room area – 600 [mm],
9. Web spacing – 1,800 [mm],
10. Longitudinal twin girder, under each main generator, continued aft as a single girder is to be provided as well as continuous center girder. The girders are to be extended aft and fore as far as possible.

120 – BULKHEADS

Bulkheads are to be constructed as below:
1. Stiffening – vertical
2. LM tanks are to be arranged as a vertical box without any stiffening inside as far as practicable.
3. Stiffening of tanks/machinery spaces bulkheads directed into tanks (except LM tanks).

130 – SHELL

Shell is to be designed with regards to the following principals:

1. Framing system – longitudinal,
2. Longitudinals space – 600 [mm],
3. Web spacing – 1800 [mm],
4. Shell thickness is to be determined by the Class requirements.
5. Special attention is to be paid to plate thickness in way of azimuthing thrusters trunks,
6. 25 [mm] thick shell belt of about 750 [mm] wide is to be provided below the sheer line extending from stern towards bow and terminated in way of C-Deck aft end,
7. 20 [mm] thick belt of 1000 [mm] wide is to be provided below the forecastle sheer and shall extend full length of second tier of forecastle,
8. Shell insert of 20 [mm] is to be provided in way of anchor pocket.

130-5 – BULWARK

Solid bulwark at the Main (A) Deck and fore part of the C-Deck is to be provided. The following principals are to be observed:

1. Main (A) Deck bulwark height is to be 1200 [mm],
2. C - Deck bulwark height is to be 1200 [mm] – forward rake on bow as shown on GA,
3. Incorporate into bulwarks freeing ports are to be in according to the Rules,
4. Main (A) Deck Bulwark top is to be finished with steel pipe about 127x8 [mm], C-Deck bulwark is to be finished with HP profile,
5. Bulwarks are to be supported by stanchions (brackets) at every 3rd frame,
6. Pilot doors, 900 [mm] wide with sliding dogs are to be provided at PS and SB of Main (A) Deck bulwark.

130–6 – CARGO RAIL

Cargo rail is to be constructed as below:

1. Cargo rail is to be located PS and SB of the working deck. Clear breadth of the work deck is to be 16000 [mm]. Cargo rail height is to be 2800 [mm] throughout the length of the working deck.
2. Top of the cargo rail is to be finished with tabular pipe of abt. 254x12,5 [mm],
3. Stanchions are to be arranged at every 3rd frame in way of the Main (A) Deck webs,
4. One (1) horizontal girder is to be provided in the middle of the cargo rail height,
5. Cargo rail closure plates is to be 12 [mm] thick (all stanchions and girders placed outboard),
6. Five (5) working deck access openings per side of min. clearance 1200x2000 [mm] are to be arranged (see GA). The openings are to be arranged in way of the Liquid Mud manholes.
7. Water freeing openings are to be arranged to freeing the water accumulated under a wooden sheeting,
8. Number (according to paragraph 621) of the openings for flood lights are to be arranged above the horizontal girder. Those openings are to be also protected with vertical round bars,
9. Each opening edge is to be finished with round bars,
10. Number and size of openings is to be reduced to practicable minimum,

11. No equipment or valves to protrude onto the cargo deck. The cargo rails should be straight inside from front to back, with nothing sticking into the cargo deck. Only recess for the electric motor of methanol pump is acceptable.

130-7 – SHELL APPENDAGES

Bilge keels are to be arranged as below:

1. Construction made of HP 300x14 profile on the doubler plate,
2. The bilge keel should be as large as possible, the maximum length reasonable and orientated parallel to full speed water flow lines.

140-1 – MAIN (A) DECK

Main (A) Deck is to be arranged without any camber and sheer. The following is to be observed:

1. Deck strength in work deck area – 10 [MT/m^2].
2. Framing system – longitudinal.
3. Longitudinals spacing – 600 [mm].
4. Web spacing – 1800 [mm].
5. Plate thickness – determined by the Rules.

140-2 – B & C-DECK

B and C-Deck are to be constructed as below:

1. Framing system – longitudinal.
2. Longitudinals spacing 600 [mm].
3. Web spacing – 1800 [mm].
4. Deck without camber and sheer.
5. Plate thickness – not less than 5 [mm].

150-1 – AFT PEAK AND STERN STRUCTURE

Aft peak is to be constructed as below:

1. Shape providing good water flow into the propellers and proper fastening of azimuthing thrusters,
2. Framing system – transversal,
3. Frame spacing – 600 [mm],
4. Transom/Side corner radius – 1500 [mm].

150-2 – SKEG

1. Centerline aft single skeg is to be arranged for better course stability. The skeg is to be compound of transversal framing system with use of a slot welding (reduced as much as practicable).

160 – FORE PEAK AND BOW STRUCTURE

Fore end of the vessel is to be compound of transversal framing system and will contain of the following:

1. Two (2) anchor pockets for proper anchors stowage.
2. Two (2) hawse pipes to accommodate anchor shanks and to direct the chain into the windlass gipsy wheel. Hawses will be fitted with chain and anchor washing arrangement and will be finished at both end with 30 [mm] round bar to take bearing of the chain.
3. Two (2) chain lockers of sufficient capacity to accommodate anchor chain. Each locker is to be fitted with galvanized, portable steel false floor. The floor shall be located min 200 [mm] above the locker bottom and shall have 30 [mm] diameter draining holes. The floor thickness is to be sized for chain weight and floor support system. In addition one (1) access manhole for each locker is to be provided for service and cleaning.
4. Sufficient chain securing shall be fastening to strong point at the forward skin of the locker. Arrangement is to be done that the chain may be slipped from the fore peak (mooring ropes storage compartment).

170 – DECKHOUSE

Three (3) tiers deckhouse is to be constructed on the C-Deck. The following is to be observed:

1. Plate thickness – not less than 5 [mm].
2. Side and front elevation is to be vertically stiffened, frame spacing is to be 600 [mm].
3. Vertical bulkheads are to be vertically stiffened.
4. All windows and door cut out areas are to be properly stiffened and framed.
5. Special attention is to be paid to provide maximum visibility from the wheelhouse.
6. Proper draining and gathers made of flat bar along the elevation (inside) are to be provided.

181 – HULL MARKS

The following hull marking is to be provided:

1. Draft marks are to be provided at centerline transom, aft end, midship and fore end of the shell (PS&SB). Marks are to be made of 100 [mm] height (in projection) Arabic digits painted white. Digits are to be cut of plate and welded to the shell.
2. Freeboard mark, according to Class requirements, is to be provided PS&SB at the midship. Mark is to be white painted, cut from plate and welded to the shell.
3. Welded hull marking is to be provided at the shell in accordance with UWILD certificate. The following marks are to be provided:
   - Tanks boundaries and symbols,
   - Bulkheads boundaries,
   - Anodes description,
   - Bottom plugs marks,
   - Maximum draft waterline (chain welds),
   - Special marks in example: bow thruster, retractable thruster, bulbous bow, azimuthing thrusters, log and echo-sounder mark,

- Assigned IMO number digits are to be cut of plate and welded to the shell (close to sheer), then painted with contrast paint.

182 – OWNER'S EMBLEM, AND SHIP NAME

1. The vessel name of Owner's choice is to be provided at transom and at the forward end of the hull (PS&SB). Letters or digits are to be cut from plate, welded to the shell, and painted according to the Owner's choice.
2. Two (2) sideboards showing vessel name are to be provided. Boards are to be located at PS&SB on the middle of the Main (A) deck.
3. Two (2) Owner's emblem marks are to be placed at PS&SB of the deckhouse elevation. Emblem is to be cut from plate, welded to the elevation and painted according to provided pattern.
4. Two (2) MMC project symbols are to be placed at the deckhouse elevation (PS&SB). Wording MMC 887 of 300 [mm] height is to be cut from plate, welded to the elevation and painted black.

183 – ANODES

1. Welded type, zinc or aluminum anodes mounted on doubler plates are to be provided on the bilge turn, skeg and inside the sea chests. Number of anodes is to be calculated for five (5) years protection.

191 – SEA CHESTS

In this paragraphs number of sea chest are corresponding to the central cooling system. The central cooling system is acceptable as far as is fully covering the DP2 Class Requirements.

1. The following sea chests are to be arranged:

   - One (1) bottom and one (1) side sea chest and are to be provided in the Engine Room,
   - Two (2) dedicated sea chest are to be arranged for "FFV Class" 1 Fi-Fi pumps,
   - Two (2) sea chest in the Azimuthing Thrusters Compartment for azimuthing thrusters, frequency converters and Dry Bulk compressors,
   - One (1) sea chest for emergency Fi-Fi pump located in the Bow and Retractable Thruster compartment.

2. Capacity of each sea chest and clear suction area is to be calculated with respect to the pumps capacity:

   - Each chest is to be fitted with hinged cover, fabricated of deep galvanized round bars,
   - Each sea chest is to be fitted with proper sea water filter (with easy cleaning possibility),
   - Proper arrangement for chests venting is to be provided.

3. In the convenient place, approved by the vendor one (1) seachest and 18" valve for future hydroacustic transducer shall be provided.

SECTION 200 – DECK EQUIPMENT

209 – LABELS

1. Each hatch is to be fitted with screwed brass plate, with engraved name of the compartment into which the hatch is giving access.
2. Each deck machinery is to be fitted with screwed brass plates with engraved machinery name,
3. English language is to be used.

224-1 – DECK CRANES

1. One (1) electro hydraulic, knuckle or fixed boom crane is to be installed as presented on the General Arrangement. The crane capacity is to be 3 [MT] at 10[m].

231 – ANCHOR EQUIPMENT / BOW MOORING FITTINGS

1. Size and number of anchor/mooring equipment is to be calculated as per Class requirements. Initial calculation was carried out and the following was found:

Number of anchors	2
Mass per anchor (HHP)	2 x 2,475 [kg]
Total chain length	495 [m] (18 Shackles per 27.5 [m] each)
Chain size (Grade 2)	50 [mm]

The following anchor / mooring equipment are to be installed:

1. Two combined Mooring and Anchor winch with the following specification will be installed:

- Drive: Electric (or hydraulic) motor with heater
- Power: ~15 [kW],
- Number of chain pulleys: One off,
- Chain: Diameter 50 [mm],
- Pulling force chain hoist: ~65/32 [kN] at 10/20 [m/min],
- Coupling: Mechanical,
- Brake: Band brake, manually operated,
- Chain stopper: With securing device,
- Number of cat-heads: One off,
- Diameter: 300 [mm],
- Length: 300 [mm].

2. Anchor is to be self balancing, HHP type,
3. Anchor chain is to be made of "Grade 2" material, galvanized,
4. Adapter piece complete with swivel is to be fitted directly to the anchor.
5. An arrangement for anchors and chain washing is to be provided (See paragraph 551-1).
6. Two (2) chain stoppers are to be provided.
7. The following mooring fittings are to be provided at C-Deck:

- Five (5) panama chocks,
- Three (3) bollards,
- Two (2) prefabricated mooring rope baskets.

232 – AFT MOORING EQUIPMENT / FITTINGS

The following mooring equipment aft is to be installed:

1. Two (2) electrically (or hydraulically) driven, locally controlled mooring capstans of pull 7,5 [MT], located aft PS & SB with wire drum with a capacity of 100 [m] of 12 [mm] wires,

2. The following fittings are to be installed:

   - Two (2) deck penetrating bollards located aft of passage between bulwark and cargo rail,
   - Two (2) bollards located around amidships,
   - Eight (8) panama chocks – Four (4) located aft and four (4) located amidships.

3. Two (2) prefabricated drums for mooring ropes located in the immediate vicinity of the mooring capstansaft.

233-3 – TUGGER WINCHES

Two (2) 10 [MT] tugger winches are to be fitted at fore end of work deck as presented on General Arrangement. Tuggers are to be electrically (or hydraulically) driven and locally controlled. Drum capacity is to be enough to accommodate 100 [m] of steel wire of suitable breaking strength. In front of each tugger winch guide rollers are to be provided.

241 – LIFE SAVING APPLIANCES

1. Personal lifesaving appliances are to be furnished according to the Rules and number of crew being on board. Permanent provision for securing and deployment of lifebuoys is to be installed.
2. One (1) certified M.O.B. with dedicated davit is to be furnished and installed at B-Deck (PS aft). MOB is to be provided outboard jet drive.
3. SOLAS A-pack inflatable life rafts are to be furnished and installed on board on the B-Deck. Life rafts capacity is to be calculated for 150 percent of the crew number for each ships side. Provision is to be provided for life raft transport between PS and SB,
4. The ship's name, IMO number and home port is to be marked on M.O.B. hull with contrast color,
5. The ship's name and home port is to be marked on the lifebuoys.

251 – EXTERIOR STAIRS, LADDERS AND RAILINGS

1. The following external stairs or ladders are to be provided (see GA):

   - One (1) stairs between Main (A) Deck and B-Deck,
   - One (1) stairs between adjacent tiers of the forecastle or Deckhouse,
   - At least one ladder to the Wheelhouse Top,

2. Stairs are to be constructed as below:

  - Inclination of the stairs is to be not greater than 60 deg, width is not to be less than 650 [mm], vertical difference not greater than 3100 [mm],
  - Cheeks are to be fabricated of galvanized steel plate or profile – thickness 8 [mm],
  - Treads are to be made of prefabricated chequered plate and weld to the check plate or profile,
  - Stairs are to be secured to the hull with use of steel galvanized brackets, doubler plate, stainless steel bolts, nuts and washers.

3. Stairs railings are to be fabricated as below:

  - Two (2) tiers of railing (top rail – galvanized pipe outer diameter about 42 [mm], lower rail round bar diameter 20 [mm]).
  - Stanchions (outer diameter about 42 [mm]) distributed evenly along the stairs (gap not grater then 1200 [mm]).
  - Railing welded to the cheek plates,

4. Railings are to be located as follows:

  - Around the sheer line where bulwark is not provided,
  - Along decks walkways and edges as protection against falling out,

5. Railings are to be fabricated as below:

  - Height is to be not less than 1000 [mm].
  - Fabricated of three (3) tiers (top rail – galvanized pipe outer diameter about 42 [mm], lower rail round bar diameter 20 [mm]).
  - Stanchions distributed evenly (gap not grater then 1200 [mm]) and fabricated of galvanized steel flat bar 60x15 [mm] welded directly to the hull.

6. Vertical ladders are to be provided as substitute of stairs (i.e. to the Wheelhouse Top) and are to be designed / fabricated as below:

  - Width is not less then 300 [mm], vertical distance not greater then 3,100 [mm], treads distributed every 300 [mm].
  - Cheek fabricated of galvanized flat bar 65x10 [mm].
  - Treads made of galvanized steel square bar 20x20 [mm].

252 – GANGWAY

One (1) 6.0 [m] long aluminum gangway is to be provided. Provision for gangway storage is to be also arranged at the Main (A) Deck.

254 – BULWARK / RAILING GATES

The following bulwark or railing gates are to be provided:

1. One (1) hinged pilot door in Main (A) Deck bulwark located PS & SB in way of forward end of the working deck.

261 – SERVICE COVERS

One (1) flush, bolted type cover, located above the Engine Room is to be provided in convenient location. The following principals are to be observed:

1. Clear hatch opening is to be min. 1700 x1700 [mm],
2. Oil resistant rubber gasket and sufficient number of bolts are to be provided to prevent water entering into the compartment (hatches are to be tested by hose flushing with water pressure of 2.1 [bar], nozzle diameter 12 [mm]),
3. Bolts and nuts are to be made of stainless steel,
4. Bolts are to be screwed from the top (from deck side):

   - Cover is to be fitted with four (4) lifting eyes (screwed to the cover).
   - If cover is fitted with insulation, small legs are to be provided to prevent insulation against damages when cover is taken off.
   - Sufficient draining of the hatch is to be provided.

5. Two (2) flush, bolted type cover, located above the Liquid Mud/ORO tank no 4 are to be provided in convenient location. Clear hatch opening is to be min. 1100 x900 [mm],

273–1 – MANHOLES AND BOTTOM PLUGS

Manholes are to be arranged to provide easy access to each tank, cofferdam or void space. Manholes are to be sized according to IBC Code. The following principles are to be observed:

1. Two (2) manholes are to be provided for each tank, cofferdam or void with capacity greater than 20 [m^3],
2. Manholes are to be minimum 600x400 [mm] in size, except those where specially agreed,
3. Tank top manholes in machinery spaces are to be designed with coamings not less than 100 [mm],
4. Vertically mounted manhole covers are to be provided witch handles,
5. Horizontally mounted manhole covers are to be provided with folding handles,
6. Rubber gaskets for thanks holding fuel or oil are to be oil resistant,
7. Rubber gaskets for tanks holding potable water are to be oil resistant,
8. Each cover is to be fitted with identification marks. The following information is to be provided: tank number for which cover belongs and abbreviation of tanks fluid (for ex. WB, FO etc.),
9. Vertical ladders / climbing rugs, with apex upward and hand grab are to be provided in all necessary locations,
10. Access to the manhole shall not be obstructed by pipelines and any machinery,
11. All manhole frames and covers to be galvanized. Client will provide shipyard with details of ECO fitment.

273–2 – LM TANKS MANHOLES

Access into the LM tanks is to be provided from the open deck via flush type manholes and ladder inside the tank. The following is to be observed:

- Number of manholes per tank – one (1),
- Location – in way of cargo rail access openings,
- Opening clearance – 800x650 [mm],
- Any part of cover (cover, bolts etc) will exceed wooden deck level,
- Stainless steel bolts and oil resistant gasket are to be provided. Bolts are to be screwed from the top side,
- Each manhole cover is to be fitted with treaded brass plug of 100 [mm] in diameter for ullage sounding,
- Steel, galvanized inclined ladder is to be fitted in each tank in way of manhole,
- All manhole frames and covers to be galvanized. Client will provide shipyard with details of ECO fitment.

274 – EMERGRNCY ESCAPES AND ACCESS HATCHES

1. Emergency escape hatches are to be arranged according to the Rules. The following is to be provided:

   - One (1) from the Engine Room,

2. Access hatches are to be provided for the following compartments:

   - One (1) into Mooring Rope Storage Compartment,
   - One (1) into Bow and Retractable Thruster Compartment access trunk,
   - One (1) into the Azimuthing Thrusters Compartment.

3. The hatches are to be as follows:

   - Emergency escapes opening clearance – 800x800 [mm],
   - Access hatches opening clearance – 600x600 [mm],
   - Made of steel,
   - Watertight,
   - Fitted with central locking device operable form inside and outside,
   - Counterweight or spring is to be provided for easy hatch cover opening,
   - Fitted witch hatch cover supporting device when hatch is open,
   - All toggles and hinge pins are to be made of maker standard,
   - Hasps and padlock for "in port" securing are to be provided from the inside of the hatch,
   - Steel hand grips and access ladders are to be provided where necessary.

4. Signaling of CLOSE/OPEN position with readout at the forward bridge console is to be arranged for access and emergency escape hatches located at the Main and C-Deck.

275 – 1 – WATERTIGHT SLIDING DOORS

Class approved, watertight sliding doors are to be provided as below:

1. Number of doors – three (3).
2. Location – Bow and Retractable Thruster Compartment/Engine Room, Engine Room/Cargo Room, Cargo Room / Azimuthing Thrusters Compartment (sea GA drawing).
3. Opening clearance – min. 800x1,400 [mm].
4. Drive – hydraulic.
5. Control – local and remote from forward wheelhouse console.
6. Door status readout – from the wheelhouse forward console.
7. Visual and audible signaling of door closing.

283-1 – CARGO SECURING EQUIPMENT

The following deck cargo securing equipment is to be provided at the working deck:

1. One hundred and twelve (112) deck sockets (in twenty eight (28) transversal rows of four (4) sockets each) with removable tie-down D-rings and pipe stanchions.
2. Provision is to be provided for stanchions and D-rings storage,
3. Eight (8) D-rings tie-downs are to be mounted on cargo rail horizontal girder. Suitable openings are to be cut in closure plates. Cargo rail D-rings are to be located in way of rows of deck sockets.

283- 3 – MINOR DECK EQUIPMENT

1. Eight (8) portable stanchions witch safety wire are to be provided as a protection against falling down when deck manholes are open. Provision for stanchions storage is to be provided also.

285 – MAST

1. One (1), A-frame shape mast, prefabricated of steel pipes is to be placed on the Wheelhouse Top. All necessary fastening for cable trays, navigation equipment and ships lights are to be provided. An access ladder for those equipment services is to be provided.

291 – WORKING DECK SHEETING

Work deck is to be covered by wood as described below:

1. Pine planks size of 65x150 and length limit of 3000 [mm] are to be laid longitudinally,
2. A proper fittings for wood securing are to be installed (T and L bars),
3. A proper draining holes are to be cut in securing members,
4. Securing members will not extend above the wood,
5. The deck is to be properly coated before wood installation (according to the painting program).

294 –FENDERS

1. Tier fenders are to be provided along the ship's flat side as described below:

- Number of tiers – Ten (10) at each side,
- Tier type – air craft type,
- Securing to the hull – with use of steel, deep galvanized chains,
- Other – tiers are to be avoided in way of M.O.B. and life rafts launching course.

SECTION 300 – ACCOMMODATION AND INTERIOR FURNISHING

301 – GENERAL

The following domestic compartments and compartments for the crew accommodation, rest or entertainment are to be arranged within the ship's accommodation area:

- One (1) Galley,
- One (1) Mess Room for 30 persons,
- One (1) Cold Store,
- One (1) Freezing Store,
- One (1) Dry Provision Store
- One (1) Changing Room,
- One (1) Laundry,
- One (1) Dispensary,
- One (1) Day Room,
- One (1) Ship Office / Conference Room,
- One (1) Linen Store,
- One (1) Public Address Compartment,
- Two (2) Single cabins with bedroom,
- Fourteen (14) Single cabins,
- Ten (10) Two Men cabins,
- Four (4) Four Men cabins.

309 – LABELS AND INFORMATION SIGNS

The following information signs are to be provided:

1. Door labels – made of brass screwed plate with engraved door number and name of compartment for which the doors are giving access,
2. Self adhesive fluorescent marks, indicating escape ways, life saving appliances and fire fighting equipment,
3. Other information/warnings indicated by the Owner,
4. English language is to be used.

311 – INSULATION

Insulation is to be provided according to the following:

1. Class insulation is to be provided according to the Rules.
2. Thermal insulation is to be applied for decks and bulkheads exposed to the weather in the following compartments:

   - All crew accommodation and domestic compartments,
   - Emergency/Harbor Generator Room.

3. Thermal insulation shall have the following parameters:

   - Mineral wool density – about 32 [kg/m^3],
   - Insulation thickness – 75 [mm] at overheads (50 [mm] around beams and stiffeners), 50 [mm] at bulkheads (50 [mm] around beams and stiffeners),
   - Top side is to be covered by aluminum foil.

4. Sound insulation is to be applied where necessary. Wheelhouse is to be insulated from HVAC Room, above, to prevent noise transmission.
5. Where no sheeting, insulation is to be covered by glass laminate finished with aluminum foil.
6. Insulation for both hot and cold domestic water piping shall be provided.

312 – INTERIOR SHEETING

Living compartments are to be sheeted as written below:

1. "B" class, SOLAS approved walls and ceiling panels are to be laid in all crew accommodation state rooms, domestic space, rest rooms, corridors, staircases, offices, Wheelhouse and Switchboard Room,
2. For wet space such as: Wash Rooms, Changing Room, Laundry and Galley, water resistant panels are to be used.
3. In Galley and dry provision panels are to be finished with stainless steel sheets at outer side.
4. Minimum overhead height in living compartments is not to be less then 2,100 [mm],
5. Sufficient revision doors in wall and ceiling panels are to be provided for easy service of vent revisions and balance devices, electric boxes and etc.
6. Color and pattern of the wall and ceiling panels is to be to the Owner's choice.

331 – FLOOR COVERAGE

The following floor coverage in crew accommodation space is to be provided:

MAIN DECK	
Type	Floating floor
Thickness	About. 70 [mm]
UPPER DECKS	
Type	Concrete mass
Thickness	10 -15 [mm]
WET SPACES	
Type	Water resistant, type as per deck description
WHELHOUSE AND ECR	
Type	False floor constructed of steel angel bars and sheeted with 25 [mm] marine ply wood or adequate.
FINISHING	
Crew state rooms	Carpet in crew state rooms, 2 [mm] vinyl in remaining spaces. Wheelhouse – Amitco panels
Wet spaces	Ceramic tails in wet spaces: toilets, galley, freezer, cold and dry provision store
Remaining spaces	2 [mm] vinyl
In front of Main and Emergency switchboard	Rubber matt in front of Main and Auxiliary Switchboard
Other	Sufficient revision openings are to be provided for cable trays service in false floors in Wheelhouse and in Switchboard Room
	Any coverage is to be provided below of sanitary modules

341-1 – EXTERNAL DOORS

Builder will furnish and install external doors as below:

1. The following doors are to be provided (see GA drawing):

   - At least one (1) door giving access from outside into the ship's accommodation spaces at each of forecastle or deckhouse tier,
   - Two (2) doors giving access from outside to the Wheelhouse,
   - At least one (1) door giving access from outside into each of the auxiliary machinery compartment or store, located at the Main (A) Deck,
   - One (1) door giving access from outside into each of the funnels (at the Wheelhouse Top).

2. Door opening width is to be as below:

   - Doors into accommodation spaces – 850 [mm],
   - Doors into Main (A) Deck auxiliary machinery compartments and stores – 800 [mm],
   - Doors into small compartments and into funnels – 650 [mm].

3. Technical remarks:

- Frame and skin made of steel,
- Tightness, fire class and seal height according to the Rules,
- All toggles, hinge pins and knobs made of steel,
- All doors fitted with locking device with cylinder,
- Doors leading to the accommodation space are to be fitted with self closing device,
- Wheelhouse doors and doors into accommodation spaces fitted with square window of 300x300 [mm],
- All doors to be water tested after installation.

341-2 – INTERNAL DOORS

Builder will furnish and install internal doors as below (see GA drawing):

1. The following doors are to be provided:

- At least one (1) door into each of state room or crew rest room,
- At least one (1) door into each of domestic compartment,
- Two (2) doors into a galley,

2. Door opening width is to be as below:

- Domestic spaces (galley, cold stores) – 800 [mm],
- Crew state rooms, rest rooms, staircases – 700 [mm],
- Toilets – 550 [mm].

3. Technical remarks:

- Fire class according to the Rules,
- For freezing and cold store chambers door type is to be suitable for those type of spaces (tightness and thermal insulation),
- Self closing device for staircase doors and galley doors,
- "In open position" electromagnetic door holders for staircase and galley / mess Room doors,
- "In open position" door stoppers for all doors,
- Ventilation grid for state room doors,
- Looking device with cylinder for each door,
- "From inside" looking device for toilet doors.

Where a wash space is provided for one stateroom shares by more than one person, a lock set will provide secrecy for the washroom.
Where a wash space is shares between two staterooms the cock set will provide secrecy for the stateroom not the wash room.

341-3 – MASTER KEY SYSTEM

Keys and Master Key system is to be provided for all doors.

341-4 – WINDOWS

Builder will furnish and install windows as below:

1. Wheelhouse windows are to be arranged to provide maximum visibility around 360 deg. Ceiling windows are to be provided in front of forward and aft wheelhouse console,
2. Each of the state rooms, rest rooms or compartment frequently attended by the crew (ex galley), except those intended to be blind are to be fitted with at least two (2) windows or portholes (according to the Rules). One (1) of them is to be hinged type,
3. Glass thickness is to be determined by the Rules,
4. Technical remarks:

- Windows frame is to be made of stainless steel or brass, welded to the structure,
- Windows (except Wheelhouse windows) are to be rectangular shape of 500x700 [mm],
- Portholes are to be of 400 [mm] in diameter,
- Heating is to be provided for windows in front of the steering consoles,
- Wipers and glass heating are to be provided for windows in front of the steering consoles. Wipers and heating are to be controlled accordingly from forward and aft console. The remaining wheelhouse windows are to be fitted with anti-condensation blow down diffusers supplied from ships A/C system.
- Blind claps are to be provided according to the Rules,
- Portholes are to be provided with blind claps from the inside and with locking device in open position,
- All windows to be water tested after installation.

351-1 – ACCOMMODATION

The following equipment is to be provided in state rooms :

Furniture	Cabin with bedroom	Single Cabin	Double cabin	Four person cabin
Bed	1 x 2.1 x 0.9 m	1 x 2.1 x 0.9 m	2 x 2.1 x 0.9 m	4 x 2.1 x 0.9 m
Bed table	1	1	2	4
Ladder	-	-	1	2
Locker	1x1.95x0.6x0.5 m	1x1.95x0.6x0.5 m	2x1.95x0.6x0.5 m	4x1.95x0.6x0.5 m
Writing desk	1	1	1	1
Bookrack	1	1	1	1
Sofa	1	1	1	1
Chair	1	1	1	1
Refrigerator	1	-	-	-
Sofa table	1	1	1	-
Curtains at bed	-	1	2	4
Toilet/Shower unit	1	Acc.to GA	Acc.to GA	Common for both cabins
Safe	Captain 1 off	-	-	-

Furniture will be supplied according to yard standard.

Marine grade plywood to be utilized for furniture covered with suitable finish material where solid wood or marine manufactured furniture is not utilized.

Mess room will be fitted out as follows:

- Tables for a total of thirty (30) persons,
- Thirty (30) chairs,
- Cupboards,
- One (1) coffee machine with hot water for tea and chocolate etc.,
- One (1)) buffet table with hot wells,
- One (1) cold drink dispenser,
- One (1) refrigerator, 220 [liter].

Day Room will be fitted out as follows:

- sofas as appropriate,
- sofa tables,
- cupboards,
- shelf for television.

The **Bridge** will consist of the followings:

- Console forward for Transit operations
- Two (2) pilot chairs forward
- Navigation area with chart table, cupboards, flag locker and shelves for books and manuals,
- DP Console, dry bulk aft,
- One (1) pilot chair at aft panel,
- Coffee corner with sink, hot and cold water,
- One (1) GMDSS station,
- One (1) chart table,
- One (1) computer table,
- One (1) toilet,
- One (1) sofa with sofa table.

The **Changing Room on A-Deck** will be fitted out as follows:

- Fifty (50) clothes lockers, height about 1 [m] placed on each other, with bench in front,
- One (1) wash basin with hot and cold water,
- One Toilet,
- Coat hooks,
- One (1) washing machine, capacity 6 [kg] of dry clothes (heavy duty type),
- One (1) stainless steel laundry tub,
- One (1) dry tumbler, capacity 6 [kg] of dry clothes (heavy duty type).

The **Laundry on B-Deck** will be fitted out as follows:

- Two (2) washing machines, capacity 6 [kg] of dry clothes (heavy duty type),
- One (1) stainless steel laundry tub,
- Two (2) dry tumblers, capacity 6 [kg] of dry clothes (heavy duty type),
- One (1) iron board, shelves as appropriate.

352 – STAIRS, LADDERS AND HANDRAILS

1. Stairs in accommodation spaces are part of the hull or deckhouse structure. Te following is to be observed:

   - Inclination will not exceed 50 deg, width of the stairs is not to be less than 750 [mm].
   - Wooden handrails are to be placed at both sides of staircase.

2. Internal stairs in machinery spaces are to be designed as follows:

   - Inclination not exceeding 60 deg, width is to be 600 [mm],
   - Stairs will be the same constructed according to Chinese Standard CB/T833-1998 with possibility of stairs and rails dismounting for engine room service. Bolts, nuts and washers are to made from steel.

3. Ladders in machinery spaces are to be made according to Chinese Standard CB/T833-1998. Bolts, nuts and washers are to made from steel.
4. Wooden handrails are to be provided at least at one (1) side of corridors.

353 – GALLEY EQUIPMENT

The following equipment will be fitted in the galley:

- One (1) galley range with four (4) plates and one (1) baking oven and one (1) warming oven,
- One (1) stainless steel outlet table,
- Two (2) deep fat fryers,
- Two (2) stainless steel tables with pan-rack under,
- One (1) refrigerator cap. 300 [l],
- One (1) freezer cap. 300 [l],
- One (1) one potato-peeler,
- One (1) mixing machine with attachments,
- One (1) one slicing machine,
- One (1) stainless steel dresser with double sink,
- One (1) stainless steel dresser with single sink,
- One (1) microwave oven,
- One (1) tap 1 [m] above the floor,
- One (1) garbage compactor,
- One (1) exhaust hood with fire extinguisher,
- One (1) industrial dishwashing machine,
- One (1) garbage disposer,
- Stainless steel sinks worktops for handling the dishes,
- Cupboards for storing plates, cups, glasses and cutlery.

355 – SANITARY UNITS

Builder will furnish and install modular sanitary units as below:

1. Generally one (1) unit is to be common for two (2) adjacent state rooms,
2. Masters and Chiefs state room are to be fitted with its own unit,
3. Units are to be equipped as below:
   - One (1) lavatory bowl,
   - One (1) 400 [mm] wide sink ,
   - One (1) mirror,
   - One (1) toilet roll holder,
   - One (1) towel holder,
   - One (1) schower.

371 – FREEZING AND COLD CHAMBERS

Builder will furnish and install separate freezing and cold stores chambers of suitable capacity as below:

1. Chambers cubature – about 20 [m^3] each,
2. Location – in galley neighborhood,
3. Chambers are to be arranged within spaces bounded by steel bulkheads,
4. Chambers are to be formed of prefabricated wall, floor and ceiling marine plywood/polyurethane foam based panels joined together. All components are to be properly joined and secured to the hull,
5. Outer side of wall and ceiling panels are to be finished with stainless steel sheeting,
6. Stores are to be fitted with marine type stainless steel shelving (ss frames and shelves) properly secured to the hull,
7. Freezer of suitable capacity is to be installed in each of the store. Capacity of freezer is to be suitable to maintain the following temperatures:

   - Freezing chamber – (-20ºC),
   - Cold chamber – (+4ºC),

8. Thermometer with readout in the Galley is to be provided for both Freezer and cold store chambers,
9. Closed door alarm shall be added in Freezing and Cold chambers. Door latches can be operated from the inside. Doors are to be commercial grade cooler doors with stainless or galvanized finish.

372 – "WALK IN" DRY PROVISION STORE

Dry provision store is to be arranged in galley neighborhood as below:

1. Store cubature – about 20 [m^3]'
2. Direct access from the galley is to be arranged,
3. Store is to be fitted with marine type stainless steel shelving (ss frames and shelves) properly secured to the hull.

373 – STORES FURNISHING

1. Wooden shelves, secured by frame made of steel angel bars are to be provided in Deck Stores. Frame and shelves are to be designed for SWL up to 200 [kg] per shelf.

393 – PAINTING (Painting program according to ECO scheme)

Surface preparation and coatings to be in accordance with specification provided by Owner.
Oil and grease shall be removed by use of degreaser followed by fresh water washing.
Welding seams shall be continuous and carried out according to good practice, that is free of cracks, slag inclusions, porosity and undercut.

Rooms without lining
All lugs and lifting pads are to be removed from external surfaces.
Cuts and scars are to be repaired by welding, and the surface to be ground flush, all sharp edges shall be rounded by grinding to a minimum radius of 2 [mm].

Rooms with lining
All lugs and lifting pads are to be cut to height of no more than 10 [mm].
Sharp edges to be rounded by grinding to a minimum radius of 2 [mm]
Cuts and scars to be repaired by welding.

Tanks
Cuts shall be filled with weld, all sharp edges shall be rounded by grinding to a minimum radius of 2 [mm].

Painting General
The hull structural steel material of 6.0 [mm] and above to be shot-blasted to Sa 2½ and immediately coated with one (1) coat of inorganic zinc silicate shop primer. Hull structural steel with a thickness of less than 6.0 [mm] will be manually cleaned prior to application of the follow-up coating to St 2.
Where a particular standard is called out i.e. Sa 2½, St 2 etc. the appropriate International standard is to be referenced. (ISO 8501-1)

All painting work shall be carried out in accordance with good workmanship and according to common good practice. Painting and material protection will be carried out with brushing, rolling or spraying according to the paint manufacturer's recommendation for the different types of paint and material protection. High pressure spraying is to be applied all over where it is practical.
All areas shall be touched up with primer before subsequent coats are applied, this also applies to the equipment delivered undercoated from the subcontractors.
The paint shall be applied as received from the manufacturer. Oils, thinner and other drying liquids shall not be added, except when this is specified by the manufacturer.
After surface preparation the first coat will be applied, a repair coat of shop primer is not provided.

All internal welds and damaged primer shall be steel brushed and touched up with zinc primer.

All edges and welding seams shall be stripe coated before next coating.

SECTION – 400 ENGINE ROOM MACHINERY

401 – GENERAL

The entire propulsion plant and its components are to be suitable for Platform Supply Vessel specific operation modes (see paragraph 018). Generally the propulsion system is to be as described below:

1. Vessel is to be propelled by two (2) azimuthing thrusters with fixed pitch propellers,
2. Power to the propellers is to be delivered by four (4) marine, constant speed diesel generators,
3. Manufacturers of the main generators, azimuthing thrusters, distribution, power electronic system and control system are to work in close cooperation, to ensure torque characteristics of engines and propellers are correctly matched for all operating models, including crash stop,
4. Manufacturer of distribution and power electronic system, shall provide the following documents for class approval:
   - Short circuit calculation;
   - Selectivity & discrimination calculation;
   - Harmonic distortion calculation & measurements;
   - FMEA document and verification.
5. Propulsion control system is to be arranged so, that control may be safely put from full ahead" to "full astern" and vice versa.
6. Propulsion control system is to be arranged so, that may be controlled manually or automatically by DP system.

409 – LABELS AND INFORMATION SIGNS

1. Information labels made of screwed brass plates are to be fitted close to machinery (engines or pumps). English language is to be used.

411 – AZIMUTHING THRUSTERS

For propulsion, position keeping and transit, free sailing, two azimuthing thrusters aft will be provided. Those can also be used in combination with the transverse thrusters forward.

- Number: 2 off
- Power: 2700 [HP]; 2000 [kW];
- Propeller diameter, approx.: ~2700 [mm] in nozzle
- Number of blades: Four,
- Propeller material: Nickel Aluminum Bronze,
- Pitch: Fixed Pitch,
- Drive: Electrical, horizontal motor,
- Input speed: ~1800 [rpm],
- Steering speed, approx.: 2-2.5 [rpm],
- Hydraulics: One power pack for lubrication and steering per thruster

- Controls: Remote from the Bridge panel forward and aft, via joystick and via DP system

412 – BOW THRUSTER

1. The following auxiliary thrusters are to be furnished and installed by the Builder:

- Number: 1 off
- Power: 1200 [HP]; 910 [kW];
- Propeller diameter, approx.: ~1600 [mm]
- Number of blades: Four,
- Propeller material: Nickel Aluminum Bronze,
- Tunnel: Lined with stainless steel at propeller
- Pitch: Controllable Pitch,
- Drive: Electrical, vertical motor,
- Input speed: 1800 [rpm],
- Controls: Remote from the Bridge panel forward and aft, via joystick and via DP system

2. Hinged cover fabricated of steel deep galvanized round or flat bars are to be provided at both ends of the thruster tunnels.

413 – RETRACTABLE – "DROP DOWN" THRUSTER

1. The following auxiliary thruster is to be furnished and installed by the Builder:

- Number: 1 off
- Power: 1100 [HP]; 800 [kW];
- Propeller diameter, approx.: ~1650 [mm]
- Number of blades: Four,
- Propeller material: Nickel Aluminum Bronze,
- Tunnel: Lined with stainless steel at propeller
- Pitch: Controllable Pitch,
- Drive: Electrical, vertical motor,
- Input speed: 1,200 [rpm],
- Controls: Remote from the Bridge panel forward and aft, via joystick and via DP system

432 – EXHAUST SYSTEM

1. Each diesel engine shall have its own exhaust line. The following shall be provided for each exhaust line:

- Silencer with dumping factor of 35 [dBA] and built on spark arrestor.
- Exhaust line is to be made of black steel pipe.
- To provide thermal flexibility, stainless steel compensators are to be fitted through the exhaust lines.

- Full length insulation is to be applied. Insulation is to be covered by min.0.5 [mm] thick galvanized steel sheets.
- Dewatering cooks are to be provided in the lowest point of each line.
- Number of bends shall be reduced to minimum (due to back pressure).

441 – MAIN GENERATORS

1. Four (4) diesel engines driven marine generators are to be furnished and installed in Engine Room. Generator diesel engines are as described below:

- MCR – about 2095 [kW] each at conditions according to IACS (MCR is to be verified by an energy balance in technical stage of design process),
- Cylinders configuration – V,
- Cycle – four (4) stroke,
- Speed – high,
- Revolutions – constant,
- Fuel – MDO,
- Turbo charging – according to maker's design,
- Starting – air started,
- Cooling – fresh water (single or two circuit cooling),
- Control stations – local by built on the engine.

442 – EMERGENCY / HARBOR GENERATOR

1. One (1) diesel engine driven marine emergency/harbor generator is to be furnished and installed in Emergency Generator Room. Generator diesel engine is to be as described below:

- MCR – about 300 [kW] each at conditions according to IACS (MCR is to be verified by an energy balance in technical stage of design process),
- Cylinders configuration – V or in line,
- Cycle –four (4) stroke,
- Speed – high,
- Revolutions – constant,
- Fuel – MDO,
- Turbo charging – according to maker's design
- Starting – electric 24 [V] DC gel battery, automatically actuated in case of voltage decay at Main switchboard,
- Cooling – air cooled by built in the engine ventilator and radiator,
- Control stations – local by built on the engine.

452-1 – AUXILIARY ENGINE ROOM MACHINERY

1. Auxiliary engine room machinery is described in SECTION 500 together with system into with it belongs.

460 – WORKSHOP

1. Dedicated workshop space is to be arranged within Engine Room. The following tools are to be furnished and installed by the Builder:
   - One (1) steel work bench with adjustable light and necessary drawers,
   - One (1) 8" vice mounted on workbench,
   - One (1) pedestal grinder,
   - One (1) drill with attachments and drill bits.

481 – FLOOR IN MACHINERY SPACES

1. Raised false floor is to be provided in engine room as described below:

   - Floor height – about 500 [mm],
   - Floor plates made of 4 [mm] non skid aluminum plates, supported by frames made of steel angel bars. Some frames shall have dismounting possibility to allow pipe lines service,
   - Removable or hinged covers above valves are to be provided,
   - Retainers are to be provided at floor edges,
   - Escapes walking areas shall have steel non-skid walking plates, other areas may be aluminum.

491 – LIFTING EYES

1. Lifting eyes for machinery service and maintenance are to be provided above the main machinery.

493 – PROTECTION SCREENS AND COVERS

1. Diesel engines flywheels, shafts, shafting couplings are to fitted with dismountable covers and screens made of steel frames, sheeted with mild steel perforated sheets.

SECTION 500 – PIPINGS

501 – GENERAL

1. The following general rules are to be observed during pipelines designing:

- All pipes delivered with certificates according to class requirements.
- All pipe lines are to be tested according to class requirements.
- Pipes in all tanks to be reduced as far as possible. No bulk mud piping will be routed in tanks.
- Sufficient flexibility for thermal expansion, shock and vibrations is to be provided for all pipelines.
- Flexible connections are to be provided for connecting pipelines to a vibrating machinery.
- No flanged connections are to be allowed in tanks unless the fluid in the piping and the tank are the same and not part of the separate system.
- Amount of pipe routs in double bottom is to be reduced as far as practicable,
- Suction end of pipelines in tanks is to be located in practicable lowest point to reduce residues to a minimum amount. Suction end is to be located about 50 [mm] above the tank bottom.
- Flanged connections are to be applied at suction ends of pipes for unobstructed access for surface preparation and painting.
- Number of bends is to be reduced to minimum.
- Sea water pipe line running through fuel oil tanks are to be avoided as far as practicable. If not possible extra thick pipe is to be provided.
- Manometer and vacuum meter are to be placed accordingly at discharge and suction side of each pump.
- Sufficient filters are to be provided at suction side of each pump, flow meter, manometer, bilge water separator etc. unless stated otherwise.
- Gray and black water lines passing through potable, fresh or drill water is to be avoided. When unavoidable all piping is to be separated from the tank. The piping should use double walled pipes.
- Stainless steel deck fittings are to be provided including butterfly valves and handles,
- Piping material to be in accordance with the table below:

Group ref. to the diagrams	System / Pipelines	Pipe material	Conservation	Joints	Fittings
511	Cooling sea water	seamless steel	Galvanized	flanged	cast iron
512	Cooling fresh water	seamless steel	Black	Butt welded/flanged	cast iron
512	Fuel oil	seamless steel	Black	Butt welded/flanged	cast iron
513	Lubricating oil	seamless steel	Black	Butt welded/flanged	
514	Starting air DN≤32	precision steel	Black	butt welded	steel
514	Starting air DN≥40	seamless steel	Black	flanged	cast steel
514	Domestic air DN≤32	precision steel	Black	butt welded	bronze
521	Bilge water	seamless steel	Galvanized	flanged	cast iron
521	Water Ballast / Drill Water	seamless steel	Galvanized	flanged	cast iron
522	Fresh water	seamless steel	Galvanized	flanged	cast iron
522	Methanol	seamless steel	Stainless Steel	flanged	
531	Sounding, overflow, venting (without FO)	seamless steel	Galvanized	welded sleeves	--
531	FO sounding, overflow, venting piping led through ballast tanks	seamless steel	Galvanized	welded sleeves without dismounting joints	--
531	Drill / Ballast sounding, overflow, venting piping led through FO tanks	seamless steel	Black	welded sleeves without dismounting joints	--
531	Fuel/Oil tanks venting, filling	seamless steel	Black	flanged welded sleeves	--
531	Vents and fillers (remaining)	seamless steel	Galvanized	flanged welded sleeves	--
531	Fuel & Lubricating Oil sounding	seamless steel	Black	threaded	--
531	Other sounding	seamless steel	Galvanized	flanged	--
532	Drain piping below freeboard deck	seamless steel	Galvanized	welded sleeves	--
532	Drains/scuppers	seamless steel	Galvanized	welded sleeves	--
542	Hydraulic system	stainless steel	--	steel unions	--
542	Quick closing valves system	Copper or stainless steel	--	copper unions	--
551	Fi-Fi system	seamless steel	Galvanized	flanged welded sleeves	cast iron rubber lined
551	Water fire fighting	seamless steel	Galvanized	flanged welded sleeves	cast iron rubber lined
572	Sanitary drains above freeboard deck	seamless steel	Galvanized	welded sleeves	--
572	Sanitary drains below freeboard deck	seamless steel	Galvanized	welded sleeves	--
572	Sanitary vacuum drains	stainless steel	--	--	--
572	Sanitary cold water supply	copper	--	copper unions	--
572	Sanitary hot water supply	copper	--	copper unions	--
432	Exhaust gas system	rolled steel plates		butt welded flanged	--

509 – INFORMATION LABELS

1. Information labels made of brass plates are to be provided for each pump fixture, vent head and sounding pipe,
2. All pipelines are to be marked by self adhesive stripes. Color code is to the Owner's choice,
3. English language is to be used.

511-1 – SEA WATER COOLING SYSTEM

Sea water cooling system is to be arranged as described below:

1. The independent sea water cooling lines are to be arranged.
2. Water is to be sucked from sea water duct, connected into sea chests (see paragraph 191) via sea water filters. Independent suctions are to be arranged aft for azimuthing thrusters, frequency convertors, Dry Bulk compressors cooling line,
3. Circulation is to be made by an electric driven, centrifugal pumps,
4. Sea water circuits pumps are to be designed to provide 100% of redundancy,
5. Where possible and reasonable remaining cooling circuits may be interconnected to increase redundancy,
6. Plate coolers are to be used as a heat exchangers for Generator Sets. Remaining heat exchangers are to be as per machinery makers' supply/recommendation,
7. Coolers capacity is to be determined by a heat balance carried out by main and auxiliary machinery vendors and MMC,
8. Sea water pumps capacity and discharge pressure shall meet recommendation of main and auxiliary equipment vendors and MMC,
9. Sea water plate coolers shall be equipped with back flushing system,
10. One of sea water cooling pump can be used as a bilge pump in an emergency situation,
11. All valves through the system are to be manually operated except those obligated by the Rules to be automatically actuated.

511-2 – FRESH WATER COOLING SYSTEM

Diesel generators:

Each diesel generator will have its own independent cooling fresh water system consisting of the following components, for each engine/system:

- Built on circulating pump for the High Temperature circuit,
- Built on circulating pump for the Low Temperature circuit,
- One (1) plate cooler,
- Electrical standby heater.

Central Cooling fresh water system

The cooling water system will have one independent cooling circuit as follows:

- Electro motor for tunnel and retractable thrusters, two off,
- Generators, four off,

- A/C condenser, two off
- Freezing condenser, two off
- Cooling condenser, one off
- Condenser AC unit for switchboard room
- Circulation pumps, two off
- Header tank, one off

512-1 – SHIP'S FUEL OIL SYSTEM

Ships fuel oil system is to be arranged as described below and complies with +ACCU Class Notation:

1. Ships Fuel Oil system is to be connected to FO cargo system (see paragraph 512-2).
2. For Fuel Oil internal transfer between Fuel Oil service and Fuel Oil cargo tanks one (1) electric driven, centrifugal, self priming pump of capacity 20 [m^3/h] at 0.25 [MPa] is to be installed.
3. Two (2) deep service tanks are to be arranged. Capacity of each tank is to be enough to cover twelve (12) hours ships maximum fuel consumption.
4. One (1) Fuel Oil built in tank is to be provided for emergency/harbor generator engine feeding (located in Emergency/Harbor Generator Room). Tank capacity is to be calculated to satisfy the Rules.
5. Fuel oil separating unit of capacity about 2.0 [m^3/h] is to be installed. Unit is to be consisting of Fuel Oil separator, Fuel Oil electric pre-heater and electric driven feeding pump. The pump is to be used for Fuel Oil settling and day tanks feeding via Fuel Oil separator; suction is to be taken from Fuel Oil settling and day tanks as well as from Fuel Oil cargo main. Unit is to be operated in automatic mode.
6. Emergency/harbor generator tank is to be fed from Fuel Oil settling and day tanks with use of hand pump and via Fuel Oil separator.
7. Overflow line into an overflow tank is to be arranged for settling and day tanks and from Fuel Oil separator.
8. Fuel Oil feeding to the consumers is to be served by consumers built on gear driven pumps.
9. One (1) fuel oil filter before each consumer is to be provided.
10. Each engine is to be supplied from both settling and day tanks except emergency/harbor generator diesel engine which is to be supplied from its own tank.
11. Return line from each consumer to each service tank is to be provided.
12. Quick closing valve is to be provided at each suction on both service tanks.
13. Dewatering self closing valves are to be installed at each settling and day tank.
14. LAH and LAL sensor and alarm is to be provided for each settling and day tank.
15. Level gauge for each settling and day tank is to be provided.
16. Capacity of the day tank shall be size per regulatory body rules.

512-2 – FUEL OIL CARGO SYSTEM

FO cargo system is to be arranged as described below:

1. Fuel Oil Cargo system is to be connected to ships Fuel Oil system (see paragraph 512-1).
2. Fuel Oil cargo tank is considered each tank intended for Fuel Oil storage except Fuel Oil overflow tank and Fuel Oil settling and day tanks.
3. Piping is to be arranged so that medium can be transferred between cargo tanks and service tanks.
4. An overflow tank of capacity not less then 10 minutes rate of Fuel Oil cargo pump is to be arranged. Overflow tank is to be fitted with the sensor actuating high level alarm.
5. Tanks are to be overflowed into Fuel Oil overflow tank via two (2) overflow mains (see paragraph 531-1).
6. Fuel Oil filling/discharging main of nominal diameter not less then 150 [mm] is to be led to a Fuel Oil filling/discharging manifold which is to be branched as a filling/suction line into each of cargo tank.
7. Each filling/suction branch serving deep tank is to be fitted with quick closing valve pneumatically actuated.
8. A positive displacement Fuel Oil flow meter witch printer is to be installed at FO filling/discharging main.
9. System is to be served by one (1), two speed, electric driven, centrifugal self priming pump of capacity at second speed not less than 150 [m^3/h] at 0.9 [MPa] pressure. Pump is to be arranged for local starting/stopping and for remote stopping from deck filling/discharging station, aft wheelhouse console, and outside of machinery space.
10. Generally for internal transfer between tanks first speed of Fuel Oil cargo pump is to be used. The capacity at first speed is to be 20 [m^3/h].
11. A sampling cock is to be provided at filling/discharging main.

513-1 – LUBE OIL SYSTEM

Lube oil system is to be arranged as follows and complies with +ACCU Class Notation:

1. One (1) structural tank of capacity not less than 5.0 [m^3] is to be arranged in Engine Room space for clean lube oil storage.
2. One (1) structural tank of capacity not less than 5.0 [m^3] is to be arranged in Engine Room space for dirty lube oil storage.
3. Clean and dirty lube oil systems are to be separated.
4. Only main generators engines lube oil circuits are to be served by clean lube oil system. Remaining machinery lube oil systems are to be hand filled with use of gravity and cans.
5. Clean lube oil system is to be served by one (1) dedicated, electrically driven pump of capacity about 5.0 [m^3/h] at 0.6 [MPa].
6. The periphery components (pumps, heat exchangers, filters) of main generators, auxiliary machinery lube oil systems are to be determined by the machinery manufacturers and are to be preferred to be in scope of machinery manufacturer delivery.
7. Dirty lube oil system is to be served by one (1) dedicated, electrically driven pump of capacity about 5.0 [m^3] at 0.6 [MPa]. The pump shall serve the following machinery crank cases draining:

- Main generators engines,
- FO separator (direct line served by unit built on membrane pump).

8. Emergency/harbor generator engine will not be served by dirty oil systems. Lube oil draining is to be hand made with use of gravity and cans.
9. One (1) CC Jensen PTU type oil purifiers to be provided fot azimuthing thrusters, bow and retractable thruster.

513-2 – SLUDGE SYSTEM

Sludge system is to be arranged as follows and complies with +ACCU Class Notation:

1. One (1) free standing, made from stainless steel tank for sludge holding is to be arranged in Engine Room. Tank capacity shall be at least 6 [m^3].
2. System is to be arranged to collect sludge and oily drains form the following:

   - Main generators Fresh Water cooling system,
   - Drip trays under the emergency generator/harbor and its Fuel Oil tank,
   - FO separator drip try and Fuel Oil separator washing bowl,
   - Deck Fuel Oil filling/discharging station spill box, and drip tray under Fuel Oil transfer pump,
   - Draining of medium from A/C unit,
   - Oily water from bilge water separator.

3. Draining is to be executed by means of gravity.
4. The sludge tank is to be discharged with use of positive pressure pump serving branch bilge line (see paragraph 521-1).

514-1 – COMPRESSED AIR SYSTEM

Compressed air system is to be arranged as follows and complies with +ACCU Class Notation:

1. System is to be served by two (2) air cooled, electrically driven compressor units (one (1) as a backup) and two (2) air receivers (one (1) as a backup).
2. Air compressors and receivers capacity is to be calculated according to the Rules and engines vendors technical recommendation.
3. Compressors are to be started automatically in case of low pressure in air receivers according to the Rules.
4. System is to be split into the following subsystems:
   - High pressure system for main generators engines air starting (pressure about 30 [bar]),
   - Reduced pressure system for ships services – pressure about 8.8 [bar],
   - Reduced pressure system for quick closing valves system – pressure about 2.5 [bar].
5. Reduced pressure system shall be served to the following:
   - Sea chests, deluge / water curtain system and bridge windows washing system blowing up,
   - Ships pumps self-priming units,
   - Quick closing valves system,
   - CO_2 system release cabinet,
   - Pressure sets,
   - Compressed air deck stations,

- One (1) outlet under Engine Room false floor.

6. Two (2) compressed air deck stations are to be provided at forward end of the work deck (PS and SB). Quick closing connections for hand tools are to be installed (type is to be agreed with the Owner).
7. All valves through the system are to be manually operated except those obligated by the Rules to be automatically actuated.

521-1 – BILGE WATER SYSTEM

Effective bilge system is to be installed through the vessel according to the Rules and the following:

1. The system shall be split into direct bilge line, branch bilge line and oily bilge water line.
2. Direct and branch lines are to be discharged directly overboard in emergency situation.
3. Diameter of bilge main is to be according to the Rules,
4. The following bilge wells are to be arranged:

- Four (4) bilge wells in Engine Room (at each compartment corner),
- Four (4) bilge suctions in Cargo Room (tow (2) aft and two (2) forward).

5. The following direct suctions are to be provided:

- Two (2) in Engine Room (one (1) PS and one (1) SB),
- One (1) in Cargo Room aft.

6. The following branch suctions are to be arranged:

- Four (4) for Engine Room wells,
- Four (4) for Cargo Room wells,
- One (1) for Bow / Drop Down Thruster Room well,
- At least one (1) for each natural well or recess in remaining machinery spaces under the Main (A) Deck.

7. Each of branch suction is to be fitted with mud box.
8. Each bilge well or natural well is to be fitted with level sensor actuating bilge alarm.
9. Direct bilge suction pumps are to be electric driven self priming type of capacity according to the Rules.
10. Direct suctions are to be served by the following pumps:

- Main bilge pump – Engine Room,
- Main fire pump – Engine Room,
- Ballast pump – Engine Room.

11. Branch lines are to be served by:

- Main bilge pump,
- Main fire pump as a backup,

- Positive pressure oily bilge water pump.

12. Oily bilge water line shall consist the following:

- One (1) structural bilge holding tank of capacity about 6 [m^3], and one (1) sludge tank (see paragraph 513-2),
- One electric driven, positive pressure pump of capacity about 5 [m^3/h] at 0.4 [MPa],
- One (1) dual bilge water separator of capacity about 1 [m^3], fitted with bilge water analyzer to meet the Rules (oil contamination less than 15 [ppm]). Clean bilge water is to be discharged overboard while oily water with oil contamination greater than 15 [ppm] is to be discharged into the sludge tank,
- Two (2) deck discharge station one (1) PS and one (1) SB) arranged at open deck and fitted with international connections. Suction is to be taken from the bilge holding tank and the sludge tank.

13. Valves arrangement is so that water cannot enter the ship from outside.
14. System is to comply with +ACCU Class Notation.

521-2 –BALLAST WATER / DRILL WATER SYSTEM

Effective ballast water/drill water system is to be installed on board as described below and complies with +ACCU Class Notation:

1. Structural tanks for water ballast/drill water storage are to be arranged through the vessel.
2. Piping system is to be arranged that water can be transferred between tanks, discharged overboard or to filling/discharge station.
3. System is to be served by one (1) two speed self-priming, centrifugal, electrically driven pump of capacity about 150 [m^3] at 0.9 [MPa] pressure at second speed. The main fire pump is to be used as a backup.
4. For internal transfer first speed of the ballast pump is to be used – 80 [m^3/h] at about 0.2 [MPa].
5. Ballast pump takes suction from the following:

- BW/DR manifold,
- Sea chests.

6. The following fillings and discharges are to be arranged:

- One (1) overboard discharge,
- Two (2) deck filling/discharge stations one (1) PS and one (1) SB).

7. DW filling/discharging main of nominal diameter not less than 150 [mm] is to be led to a WB/DW filling/discharging manifold which is to be branched as a filling/suction line into each of BW/DW tank.
8. All valves are to be manually operated.
9. A collision bulkhead penetration is to be fitted with a gate valve. The valve is to be operated from the open deck at Forecastle level.

522-1 – DRY BULK SYSTEM

1. Dry bulk system is to be arranged as described below:

- Cylindrical type, about 0.55 [MPa] pressure insert tanks (max working pressure 0.68 [MPa]) are to be arranged for dry bulk storage,
- Each tank is to be fitted with one (1) inspection manhole, accessible from the Cargo Room,
- Each tank shall be fitted with local pressure relief valve near the tank access,
- Filling, discharging and transferring between tanks is to be realized with use of compressed air,
- System is to be served by two (2) electric motor driven (protection degree not les then IP56), rotary screwed, water cooled air compressors of capacity not less then 1100 [m^3/h] at pressure of about 0.55 [MPa],
- Each compressor shall be connected to an independent piping system. Compressors discharge piping shall contain crossover such that either compressor may serve either piping system,
- Piping system shall be fitted with sufficient knockdown joints (Victaulic type couplings) to facilitate routine cleaning,
- Piping passing through tanks will not to be permitted – dedicated cofferdam has to be arranged,
- All valves through the system are to be pneumatically actuated and controlled remotely from the aft Wheelhouse console dry bulk system control panel, except stated otherwise (see paragraph 531-1),
- Filling/Discharge stations are to be fitted with manually operated test cooks (ball valves DN 25 [mm]).

522-2 – CARGO FRESH WATER SYSTEM

1. Cargo fresh water system is to be arranged as follows:

- Piping is to be arranged that water can be transferred between tanks and discharged to the filling/discharge station,
- Cargo FW filling/discharging main of nominal diameter not less then 150 [mm] is to be led to a cargo FW filling/discharging manifold which is to be branched as a filling/suction line into each of cargo FW tank,
- System is to be served by one (1) electric driven, two speed, centrifugal, self priming pump of capacity not less than 150 [m^3/h] at 0.9 [MPa] pressure at second speed,
- For internal transfer first speed is to be used – 80 [m^3/h] at 0.2 [MPa].
- Pump takes suction from Cargo FW manifold,
- All valves are to be manually operated.

522-3 – LIQUID MUD SYSTEM

1. Liquid mud system is to be arranged as described below:
   - System is to be designed for oil based mud and brines of gravity factor 2.4 [t/m^3] and flash point above 60ºC. System is to designed for oil recovered according to ABS Class notation +A1 Oil Recovery Class 2.
   - Pairs (PS and SB tank) of dedicated tanks for LM storage are to be arranged. Tanks are to be rectangular shape with no stiffening inside the tank (except main deck stiffening),
   - Each tank pair is to be served by one (1), electrically (or hydraulically) driven, two speeds (first speed for circulation), self priming, centrifugal, horizontally mounted pump of capacity not less than 150 [m^3/h] at 1.4 [MPa] pressure (calculated for mud) for LM specific of gravity 2.4 [t/m^3]. Pumps are to be capable to operate with recovered oil with specific of gravity 1.0 [t/m^3].
   - Pumps electric motors are to be IP55 protection grade minimum,
   - Piping is to be arranged so that circulation between tanks is to be possible. Pipes nominal diameter is to be not less than 8",
   - Flushing connection (same as from fire hydrants) is to be arranged at each of LM suctions (close to a suction end),
   - Filling/discharge stations are to be arranged as in paragraph 531-1,
   - All valves are to be manually operated,
   - "Flipping" of each individual tank is to be possible.

522-4 – LIQUID MUD TANK CLEANING SYSTEM

1. LM tanks cleaning system is to be arranged as described below:

   - Tanks are to be cleaned with use of cold sea water with chemical cleaning agent,
   - Only one (1) tank is to be cleaned at a time,
   - Cleaning residues are to be pumped to one of the LM tanks and then discharged to deck filling/discharge station,
   - Each of LM tank is to be fitted with dual nozzles cleaning machines. Nozzles are to be made of stainless steel,
   - Clean sea water with cleaning agent is to be supplied to each of cleaning machines by one (1) electrically driven cleaning pump of capacity 10 [m^3/h] at 1.0 [MPa],
   - Cleaning agent is to be supplied to the system before cleaning pump suction by dedicated, electric driven cleaning agent dosing pump of capacity about 0.6 [m^3/h],
   - For cleaning medium recirculation and discharge, dedicated re-cleaning/discharge electric driven pump of capacity not less than 12 [m^3/h] at 0.3 [MPa] is to be used,
   - Cleaning agent is to be hold in 100 [l] plastic tank located in Cargo Room. Tank is to be filled with use of gravity and cans.

522-5 – METHANOL SYSTEM

1. The methanol system consists of triple purposes Methanol /Liquid Mud/ORO tanks indicated on General Arrangement. The tanks and pipes shall be made of stainless steel. The tanks shall be surrounded by water filled cofferdams and water ballast tanks.
2. System is to be served by one (1) pump of capacity not less than 75 [m^3/h] at 0.9 [MPa].

3. The tanks shall be without any obstruction inside the tanks as far as practicable. The tanks bottom shall have sufficient inclination towards the tanks discharge well.
4. One (1) submerged pump for discharging of methanol. Methanol system shall be ventilated to sea level and monitors and controlled from the tank tender system.

531-1 – FILLS, VENTS AND SOUNDS

1. The following filling/discharge stations are to be arranged:

- Two (2) fuel oil filling/discharge stations located PS&SB – one (1) each side,
- Two (2) cargo fresh water filling/discharge station located PS&SB – one (1) each side,
- Two (2) potable water filling stations PS&SB – one (1) each side,
- Tow (2) drill water filling/discharge station located PS&SB – one (1) each side,
- Two (2) liquid mud filling/discharge stations for each LM tank pair located PS&SB – three (3) each side,
- Four (4) filling/discharge dry bulk stations located PS&SB – Two (2) each side serving each compressor,
- One (1) lube oil filling station located PS or SB,
- Two (2) common dirty oil, bilge water and sludge discharge station located PS&SB – one (1) each side.

2. LM, FO, FW and DB fills are to be fitted with butterfly valves accessible from outside.
3. Deck connections are to be according to the Rules or to be agreed with the Owner where applicable.
4. Vents are to be arranged as described below:

- Each tank, cofferdam and void space is to be fitted with independent vent pipe and head,
- Fuel Oil tanks (except of Fuel Oil overflow tank and Fuel Oil service tanks) are to be vented through two (2) common overflow/vent mains (PS tanks into the PS overflow/vent main, SB tanks into the SB overflow/vent main) led to overflow tank. The overflow/vent mains are to be slopped towards FO overflow tank and are to be fitted with its own vent at its highest point,
- Size of vent pipes and its height above the open deck according to the Rules,
- Vent heads with closing device (ball) for all vent pipes are to be provided, Flame arrestors are to be arranged for fuel oil, lube oil, bilge and sludge. Anti insects screens are to be provided for Fresh water tanks vents. No screen is to be provided for LM vents,
- Cargo fresh water vent heads are to be an angle type with overflow overboard. Electric overflow sensors actuating audible alarm and disengaging cargo fresh water pump are to be provided for each of fresh water vent head,
- Vents from black water tank and sewage treatment plant are to be led above the Wheelhouse Top.

5. Spill tray ise to be arranged below the following:

- Fuel Oil vent heads,
- Common dirty oil, bilge water and sludge discharge deck connections,
- FO, LM, LO filling/discharge deck connections.

6. Manual sounding pipes are to be installed for each tank, cofferdam and void space as described below:

- Sounding pipes are to be installed at the lowest tank point, are to be fitted with striking plate and 10 [mm] vent hole located 150 [mm] below the tank top,
- Sounding pipes at open deck are to be fitted with bronze plug,
- Sounding pipes in machinery spaces are to be fitted with counterweight plug and self closing test cock.

7. Fluid level in LM tanks is to be measured my means of ullage (see paragraph 273-2).

531-2 – DECK DRAINS

1. Suitable decks draining pipes are to be arranged as presented below:

- Drains are to be located in strategic positions for proper deck draining,
- Main Deck is to be drained overboard and are to be supplied with removable wood or rubber plugs,
- Upper decks are to be drained to the deck below,
- All scuppers are to be fitted with scupper grating.

551-1 – FIRE FIGHTING AND DECK WASH SYSTEM

Water fire fighting system is to be arranged on board according to the Rules and the following:

1. Main fire fighting system of ring type is to be installed through the vessel according to the Rules. The following is to be served by the system:

- Engine Room,
- Cargo Room,
- Azimuthing Thrusters Compartment,
- Accommodation spaces,
- Working Deck,
- Sewage treatment plant flushing connection,
- Black and grey water tank flushing connection,
- LM tanks flushing connections – with use of fire hoses.

2. The water mist system is required to extinguish each Main Generator Set.

3. Emergency fire fighting system is to be installed. The following is to be served by emergency system:

- Bow and Retractable Thruster Compartment,
- Anchor and its chine washing – three (3) nozzles per hawse,
- Two (2) deck washing stations located at the C-Deck,
- Chain lockers draining ejector.

4. The firefighting system is to be served by one (1), self-priming, centrifugal, electrically driven pump located in the Engine Room.
5. The emergency firefighting system is to be served by one (1) emergency firefighting pump located in Bow and Retractable Thruster Compartment. The emergency pump is to have the same parameters as the main pump.
6. The main fire pump takes suction from the sea water crossover, while the emergency pump will have its own bottom suction.
7. The fire main diameter and pump capacity is to be calculated according to the Rules.
8. The fire fighting system is to be branched so that main firefighting pump can serve ballast system and direct bilge line in Engine Room.
9. Sufficient number of hydrant stations fitted with 15 [m] long fire hose and 12 [mm] spry/jet nozzles are to be provided through out the vessel.
10. Fire fighting pipes are to be avoided in accommodation spaces as far as possible.
11. All valves through the system are to be manually operated,
12. One (1) Fire Fighting Station is to be provided.

551-2 –FIRE FIGHTING SYSTEM (FFV CLASS 1)

Class fire fighting system is to be provided as follows to meet fire fighting Class notation (see paragraph 016-1):

1. Two (2) centrifugal, electrically driven pumps are to be installed. Pumps capacity is to be sufficient to meet Class notation requirements monitors and deluge system). The pumps shall be supplied on the common frame together with generator sets to avoid misaligning.
2. Each of the pumps takes suction from its own dedicated bottom sea chest.
3. Two (2) water monitors of capacity required by class notation are to be installed at the Wheelhouse Top. Fife righting monitors are to be located in such a way to allow fire fighting from the stern and from the bow.
4. Monitors are to be remotely operated from the forward bridge console (portable control panel).
5. Deluge / water curtain system is to be provided through the open decks and is to be fed from fire fighting pumps. Nozzles are to be made of stainless steel.
6. Connections for compressed air blowing and fresh water flushing are to be installed.
7. The system is not to be interconnected with fire fighting system.
8. Over board discharge is to be provided for flow regulation in the system.
9. Eight (8) one way open deck heads are to be fed from the system as per Class notation requirements.
10. All valves are to be manually operated except butterfly valve at suction side of the pump which are to be electrically actuated.

551-3 – CO_2 EXTINGUISHING SYSTEM

CO_2 fire-extinguishing system is to be provided as a fixed fire-extinguishing system as described below:

1. The following spaces are to be served by the system:

- Engine Room,
- Emergency/Harbor Generator Room,
- Paint store.

2. CO_2 bottles are to be stored on Main Deck in dedicated CO_2 Room.
3. Bottles capacity is to be according to the Rules and vendors calculation.
4. Release cabinet is to be located in CO_2 Room.
5. A separate CO_2 circuit with bottle is to be provided for Galley exhaust duct extinguishing. Release cabinet is to be located outside the Galley (close to Galley access doors).

562 -1 – ENGINE ROOM VENTILATION

Engine Room will be provided with independent ventilation as follows:

1. Air supply is to be forced by two (2) one speed axial fans. One of them can be reversed type.
2. Fans capacity is to be adequate to limit Engine Room temperature 12ºC higher then ambient temperature.
3. Air exhaust is to be executed by means of gravity through the funnels.
4. The air velocity in duct is to be limited up to 10 [m/s] and up to 6 [m/s] at louvers.
5. Sufficient deck closures are to be provided according to the Rules.
6. Louvers lower edge location is to be according to the Rules.
7. Engine Room ducting is to be made of galvanized mild steel sheets.
8. Electrically actuated fire dampers are to be installed according to the Rules.
9. Louvers shall be protected against water entering, during Fi-Fi operations, by means of protections huts.

562 -2 – COMMON VENTILATION

Common ventilation system is to be arranged as below:

1. The following machinery/domestic spaces are to be served by mechanical ventilation:

   - Cargo Room (Mechanical supply and gravity exhaust),
   - Switchboard Room (Mechanical supply and natural exhaust),
   - Emergency/Harbor Generator Room (supply – emergency generator not in operation), Fore emergency/harbor generator in operation condition, air intake is to be forced by built on engine air cooling fan. Adequate air intake louvers are to be arranged,
   - Bow and Retractable Thruster Compartment (supply),
   - Azimuthing Thrusters Compartment (supply and exhaust),
   - FO separator (natural supply and mechanical exhaust) – branch of main supply duct to the Engine Room,
   - Workshop and welding gas area (mechanical supply),
   - Galley (supply and exhaust),
   - Fi-Fi locker (supply),
   - Toilets (exhaust),
   - Changing Room (supply and exhaust).

2. The remaining compartments are to be gravity ventilated.
3. Open deck closures are to be arranged according to the Rules.
4. Lower edges of the louvers are to be located according to the Rules.
5. Fire dumpers are to be installed and actuated according to the Rules.
6. Ducting is to be made of galvanized mild steel shits or steel pipes.

7. Fans capacity is to be calculated to meet ISO standards.

562-3 – AIR CONDITIONING AND HEATING

Air conditioning system is to be installed and adjusted on board as below:

1. A/C plant shall be adequate to maintain temperature of 22ºC and humidity max. 60% at the following ambient conditions:

<u>Summer:</u>

Outside temperature	40ºC	80% RH
Inside temperature	22ºC	35% RH
Seawater	32ºC	

<u>Winter:</u>

Day outside temperature	-20ºC	20% RH
Inside temperature	22ºC	35% RH
Seawater	1ºC	

2. The following spaces are to be air conditioned:

- Wheelhouse (common ship system),
- Switchboard Room (via separate system),
- Crew state rooms,
- Mess Room,
- Day Room,
- Galley,
- Corridors within the accommodation spaces,
- The A/C system is to be a single ducting air conditioning / mechanical ventilation with central control of temperature and humidity.

3. Humidity level control in compartments will be arranged via central sensor located within the Mess Room or return duct.
4. Amount of fresh make up air is to be acc ISO standard,
5. Conditioned air is not to be re-circulated from the following spaces:

- Galley,
- Mess Room,
- Crew rest rooms,
- Toilets.

6. Redundant overpressure air is to be exhausted outside via toilets exhaust system.
7. System is to be designed to provide appropriate positive pressure within vessel to prevent air infiltration from outside.
8. Two (2) refrigeration units are to be located in Engine Room (each 60% capacity is to be provided).

9. Air handling unit is to be located in machinery space in dedicated compartment located at the Wheelhouse Top.
10. All A/C ducting shall be fabricated of pre-insulated, galvanized mild steel ducts properly secured to the hull.
11. Air conditioned air shall be supplied to the spaces through sound attenuating adjustable ceiling diffusers,
12. Balancing dampers are to be provided through the system as necessary, to balance the system,
13. Ductless fan heaters are to be provided to maintain temperature of 5 [ºC] at winter conditions in the following spaces:

- Emergency/Harbor Generator Room,
- Bow and Retractable Thruster Room,
- Azimuthing Thrusters Compartment.

571-1 – POTABLE WATER SYSTEM

Potable Water system is to be arranged as described below:

1. Two (2) structural tanks, for Potable Water to be arranged.
2. The following consumers are to be supplied with Potable Water:

- Galley lavatory (cold and hot),
- Showers and wash basins (cold and hot),
- Taps in common wash rooms (cold and hot),
- Two (2) taps on the working deck (cold),
- Two (2) taps in Engine Room (cold),
- Two taps in Cargo Room,
- Washing machines (cold).

3. Potable water is to be supplied from Potable water tank to the consumers via:

- One (1) Potable water pressure set of capacity 1000 [l]. The pressure set is to be served by two (2) electric driven pumps (one as a standby) taking suction directly from potable water tanks,
- UV lamp,
- One (1) electric heater of capacity 300 [l] and one (1) hot water, electrically driven circulating pump (for consumers supplied with hot water).

4. Toilet bowls are to be flushed as described below:

- Toilet bowls are to be fresh water flushed,
- One (1) fresh water pressure set of capacity 300 [l]. The pressure set is to be served by one (1) electric driven pump.

5. Fresh Water system and Potable Water system can be inter connected with use of flexible hoses (in normal operation disconnected).

6. All valves are to be manually operated.

572 – SANITARY SYSTEM – OUTLETS

Sanitary drains are to be arranged as described below:

1. A structural tank is to be arranged for holding / Grey Water.
2. Grey Water from lavatories, wash basins, washing machines, etc. is to be drained by means of gravity into the Gray Water tank or sewage treatment plant. Grey Water line from Galley sink is to be led via grease traps to Grey Water tank.
3. Lavatory bowls are to be Sea Water gravity flushed and drained into the sewage treatment plant.
4. A sewage treatment plant of adequate capacity (according to the crew number) is to be installed. The unit is to be as described below:

- The main tank is to be split into an integral aeration, a settling and an chlorinating chamber,
- Fitted with discharge pump. Treated water is to be discharged directly overboard, to the Grey Water tank, or a shore via deck discharge station (according to MARPOL),
- An connection is to be provided for sea water cleaning (see paragraph 551-1),
- The unit is to be fitted with vent line (see paragraph 531).

5. The sewage treatment plant overflow is to be connected into the Black (Sludge) Water tank.
6. Connections for sewage tanks sea water flushing are to be provided (see paragraph 551-1).
7. The sewage tanks are to be fitted with float operated high level alarm, connected to Alarm Monitoring System.
8. A MARPOL sewage discharge station is to be arranged on the Main (A) Deck.
9. One (1) electrically driven pump is to be installed for sewage tanks discharge into the MARPOL deck station.
10. All valves are to be manually operated.

580 – PIPING FOR FREEZING/COLD STORE CHAMBER AND A/C

1. Proper R404 piping installation for stores freezing devices and A/C plant is to be provided. Arrangement is to be according to the Rules. Necessary gauges are to be provided. Valves are to be manually operated,
2. Provision stores freezing system is to be served by two (2) water cooled, electric driven compress.

594-1 – RECOVERED OIL SYSTEM

1. System is to be designed according to the rules to meet notation +OIL RECOVERY CLASS 2 and vessel is to be intended for recovery of oil with a flash point above 60℃ (140℉).

2. Fixed recovered oil system is to be arranged on board as described below:

- Three (3) combined LM/ORO structural tanks for recovered oil holding are to be arranged.
- System is to be served by three (3) LM pumps, electric (or hydraulically) driven pumps of the capacity of 150 [m^3/h]@1.4 [MPa].

- Transfer between tanks and to shore is to be possible with use of the pump.
- High Level Alarm is to be installed in each of O.R.O. tank.
- Tanks are to be filled by R.O. deck equipment through flexible hose and deck hatches.
- Oil recovery equipment is to be provided by the Owner.

SECTION 600 – ELECTRICAL PLANT AND RADIONAVIGATION

600 – GENERAL

The following general rules are to be observed through the electric system:

1. All electric consumers, wires and system design are to be according to Class Rules and IEC 60092 standards.
2. All cable cores entering the distribution equipment, consoles, terminal boxes of generators are to be marked on both ends according to a technical documentation.
3. Total Harmonic Distortion (THD) will be less than 5 % in the voltage wave form and for any single order harmonics will be less than 3 %.
4. Name plates are to be provided at/on all electric equipment. Labels are to be made of plastic laminate; black letters on white background are to be engraved. English language is to be used.

Main distribution voltage:	480 [V], 3 phase, 60 [Hz]
Lighting and distribution panels:	110 [V] AC, 60 [Hz]
Alarms and controls:	24 [V] DC.

Note: Main distribution voltage (480 [V] or 690 [V]) is to be confirmed by chosen Vendor and short circuit calculation calculation

Shore power supply to be confirmed via load analysis.

601-3 – MAIN GENERATORS

1. The main power generation will be provided by the following equipment:

- Number: (4) Four
- Output: 2500 [kVA]
- Power factor: 0.8
- Voltage : 480 [V] AC, 3 phase, 60 [Hz]
- Speed: 1800 [rpm]
- Enclosure: IP 23
- Cooling : Water cooled
- DEP gen set alternators; two (2) bearing, free standing type.

601-5 – EMERGRNCY/HARBOUR GENERATOR

1. One emergency / harbor generator with the following rated data will be installed:

- Capacity: ~375 [kVA],
- Power factor: 0.8
- Voltage : 480 [V] AC, 3 phase, 60 [Hz]
- Speed: 1800 [rpm]

2. The generator will be able to run in parallel with the main distribution system for load transferring duties only.

601-6 – TRANSFORMERS

Lighting transformers:

Number:	2 off
Rating:	TBC ~80 [kVA]
Input:	480 [V]
Output:	220/110 [V]
Frequency:	60 [Hz]
Stand by heating	

Emergency transformer:

Number:	(2) two off
Rating:	TBC ~80 [kVA]
Input:	480 [V]
Output:	220 [V]
Frequency:	60 [Hz]
Stand by heating	

601-7 – SHORE SUPPLY

1. Special shore connection box is to be provided and connected to the MSB via ESB with suitable interlocking device. Shore connection box is to be equipped as follows:

- Shore power connection rating is to be 400 [A],
- Voltmeter and phase sequence is to be installed,
- 100 [m] of shore cable is to be provided.

601-8 – BATTERY CHARGES FOR 24 [V] DC

Battery Chargers and battery capacity:

Engine Room:

Number:	(1) one off
Primary voltage:	220 [V] - 60 [Hz]
Secondary voltage:	24 [V] DC

For each room, no-maintenance / gel cell batteries 24 [V] DC, for engine starting and alarm purposes, etc.

Navigation Bridge:

Number:	(1) one off
Primary voltage:	220 [V] - 60 [Hz]
Secondary voltage:	24 [V] DC

Battery charges / Power supplies are to be fitted with dead battery alarms.

610-2 – POWER MANAGEMENT SYSTEM

1. The PMS shall handle the entire control of the ship's switchboards and include the following functions:
    - Control of main and harbor generators,
    - Operating modes including:
        - Sailing (main generators and coupled bus bar),
        - DP-2 (main generators and open bus bar),
        - Fire fighting,
        - Harbor generator mode,
        - Shore supply mode,
        - Seamless transfer between modes.
    - Power limitation to propulsion (e.g. when D-G set fails)
    - Automatic load-dependent start-stop.

610-3 – SWITCHBOARDS

All switchboards will be suitable for mounting against a bulkhead. Switchboards will have handrails in front and internal lighting. All cable terminals will be permanently and properly marked. Switchboards will be foreseen with appropriate instrumentation like kW meters, Ampere meters, Volt meters and Frequency meters.

When four generators and/or in DP-2 operations are on the board the bus-tie breaker in the switchboards will be open. This will decrease the possibility of failure and total shutdown in case of overload or short circuit. In this case there will be two separate distribution systems. If three generators, or less, are on the board, then the bus-tie breaker will be closed. In case of fault in one of the two switchboards, the bus-tie breaker will open within milliseconds, if closed. The faulty part of the switchboard will then be shut down. The healthy part will continue.

The following switchboards 480 [V] are included in the vessel:

- One (1) Main Switchboard,
- Two (2) Motor Control Centers / Distribution boards,
- One (1) Harbor/Emergency switchboard,
- One Shore connection box.

Main Switchboard 480 [V]:
The main switchboard will contain the following sections:

- (4) four generator panels: ~2500 [kVA],
- (1) one bus-tie breaker panel: ~4000 [A],
- (1) one tunnel thrusters panel: 910 [kW],
- (1) one retractable thruster panel: 800 [kW],
- (2) two azimuthing thrusters panels: 2000 [kW],
- (2) two MCC / DP groups: ~500 [kVA],
- One (1) breaker: 600 [A]

Motor Control Centers / Distribution Panels:
Each MCC / DP will contain the following sections:

- Circuit breakers and starters for the 480 [V] consumers,
- Feeder for 80 [kVA] transformer,
- One Harbor/Emergency group.

Harbor / Emergency switchboard:
Each MCC /DP will contain the following sections:

- One Generator panels, 450 [kW],
- Two supply groups from MCC / DP,
- Circuit breakers and starters for the 480 [V] emergency consumers,
- Feeders for 80 [kVA] transformers.

When Harbor mode is selected or shore power is connected the Harbor switchboard can supply power to both MCC / DP panels.
In normal operation only one MCC / DP is supplying the Harbor/Emergency switchboard.
In emergency mode the interconnections with the MCC / DP are opened.

Lighting distribution board:
Three lighting distribution boards will consist of the following sections:

- Transformer breaker 80 [kVA], 480 [V] / 220/110 [V]
- Feeders for lighting distribution panels,
- Feeders for navigation equipment.

610-4 – STARTERS AND CONTROL BOXES

1. For motors up to and including 0.5 [kW] motor protection switches will be applied, provided with thermal/maximal protection. All other electro-motors will be provided with a "direct on line" or, when the capacity of the motor requires, a "star delta" type of starter.
2. Starters above 1 [kW] will comprise at least: main switch, contactor(s), thermal protection, control fuses (if necessary) and pushbuttons.
3. For automatic operating motors an extra selector switch manual - 0 - automatic will be added.
4. Starters for essential consumers, such as ballast-, tunnel thruster motors, standby-pumps and engine room-fans, will be executed with Amp. meter and running hour counter.
5. In general the starters will be grouped and put together in starter-panels. The starter-panels are placed in the switchboard-room near the main switchboard.
6. If practicable for use, separate and local mounted starters will be applied.
7. All motor-starters will be of the drip water-proof type (IP 22), except where necessary at special circumstances, for which the housing will be adjusted to the circumstances.
8. As a rule the supply cables will be directly connected to the main switch, whereas the motor cables will be directly connected to the thermal relay or the contactor.
9. In general the control current will be 480 [V] directly from the main supply. In case of remote control the control current, however, will be 220 [V] by means of a transformer with isolated windings.

10. Anti-condensation heating will be used for motors above 7.5 [kW] and they will be switched up by the contactor and indicated by a indicator light.
11. Electrical motors will be of marine type, enclosed squirrel cage type. Anti-condensation heating will be used for exposed motors above 7.5 [kW].

610-6 – SWITCHBOARD ROOM CONTROL CONSOLE

1. Switchboard Room control console is to be made of steel, wall standing type and located in Switchboard Room space. Color is to be arranged according to maker's standard.

610-7 – FORWARD WHEELHOUSE CONSOLE

1. One central console for vessel transit mode will be located **forward** on the bridge. The console will be equipped with, but not limited to:

- Independent joystick control, portable with extension cable to the bridge wings
- Joystick control for thrusters including heading control (from DP system), portable,
- Autopilot,
- Alarm panel for the machinery plant including all thrusters,
- Echo sounder repeater,
- Gyro compass repeater,
- Doppler speed repeater,
- Radar displays and controls,
- Anemometer display,
- AIS,
- Load indicators for thrusters and diesel-generators,
- Start and stop of diesel-generators,
- Manual thruster controls for all thrusters,
- Central dim arrangement,
- Loud-hailer installation,
- General alarm panel,
- Typhoon panel and push button,
- Communications, external and internal,
- Fire alarm panel,
- Watertight door panel with indication lights and remote closing of all doors,
- Controls for window wipers and window-heating (fan-heater),
- Controls for window washing system,
- Start and stop of fire pumps, own firefighting,
- Remote control searchlight forward.

610-8 – AFT WHEELHOUSE CONSOLE

One central console will be fitted **aft** with the following controls:

- Emergency stops of all thrusters, close to DP panels,
- Manual controls for all thrusters, close to DP panels,
- Echo sounder repeater,
- Gyro compass repeater,
- Doppler speed repeater,
- Slave Radar display,
- Anemometer display,
- Alarm panel for the machinery plant including all thrusters,
- Communications, internal and external,
- Controls for window washing, window wipers and window-heating,
- Remote controls for searchlights aft,
- DP controls,
- Independent joystick controls, portable with extension cable to the bridge wings.

Cargo operator console:

- Dry bulk system control panel,
- Control (start/stop) of the cargo pumps,
- LM, FO, FW, Methanol cargo pumps emergency stops,
- VHF telephone,
- Aft deck illumination controls,
- Aft flood light controls,
- Aft search light control panel,
- Three (3) 110 [V] electric sockets.

611 – ELECTRIC PROPULSION / DP SYSTEM

The electric propulsion system consists of the following items:

Propulsion transformers:

- Number: Two (2) off
- Rating: approx.2,500 [kVA]
- Input: 480 [V]
- Output: 2 x 690 [V] (12-pulse rectifier)
- Cooling Fresh Water: 37 [ºC]
- Frequency: 60 [Hz]
- Stand by heating: yes

Aft Azimuthing Thrusters frequency converters:

- Number: Two (2) off,
- Type: 12 pulse,
- Rated Power: 2000 [kW],

- Voltage : 480 [V],
- Cooling Fresh: water,
- Protection: IP 23,
- Stand by heating: yes,
- Auxiliary supply: 24 V UPS,
- Controls: Manual control / local control, DP control, joystick control and remote control.

Thruster motors aft:

- Number Two (2) off,
- Type Induction motor, Horizontal shaft
- Power 2000 [kW]
- Speed 1800 [rpm]
- Supply voltage 480 [V]
- Power factor at full load 0.85
- Cooling Water / Air (IC86W)
- Protection IP 44
- Stand by heating yes

Starters thruster motors

The thrusters motors will be provided with auto transformer in order to facilitate start of one electro motor when at least two generators are on the board.

- Number: two (2) off,
- Type: auto transformer,
- Rated Power: 910 [kW] / 800 [kW] for Retractable Thruster,
- Voltage: 480 [V],
- Cooling: Air cooled
- Protection: IP 23, preferably build-in Main Switchboard,
- Controls: Manual control / local control, DP control, and remote control,

Thruster motors forward:

- Number: two (2) off,
- Type: Induction motor, Vertical shaft
- Power: 910 [kW] / 800 [kW] for Retractable thruster,
- Speed: 1800 [rpm]
- Supply voltage: 480 [V]
- Cooling Water / Air (IC81W)
- Protection: IP 44
- Stand by heating: yes

621 – GENERAL LIGHTNING SYSTEM

The general lighting is to be designed in such a way as to ensure that following average lighting levels are obtained:

- Cabins: about 100 [lux],
- alleyways in accommodation: about 100 [lux],
- wheelhouse: about 150 [lux],
- mess room, day-room: about 100 [lux],
- office: about 100 [lux],
- galley: about 100 [lux],
- engine room, machinery spaces: about 100 [lux],
- switchboard room, workshop: about 150 [lux],
- open decks, store rooms etc.: about 20 [lux].

In general the ship will be illuminated by fluorescent lighting. The fixtures will be of the marine type suitable for mounting on board of ships.

All lighting will be switched by double pole switches (built on). Each room or space will be divided into two separate lighting groups, as far as practicable.

Fluorescent fixtures of the watertight (IP 54) type provided with a clear shade, 2 x 18 or 2 x 36 [W] are to be installed for lighting the following:

- Engine Room and machinery spaces,
- workshops, stores, etc.,
- mooring areas forward and aft,
- outside decks around accommodation.

Fluorescent fixtures of the non watertight (IP 20) type provided with an opal shade, 2 x 18 or 2 x 36 [Watt] are to be installed for lighting the following:

- accommodation throughout.

Incandescent lights with E27 lamp holders are to be installed for bulkhead mounted berth-, spot- and desk lighting.
Additional decorative lamps are to be installed in public rooms as well as in the one-persons cabins.

In control rooms, offices and on the bridge at working places 110 [V] AC receptacles will be fitted. All cabins will also be fitted with dual 110 [V] AC receptacles.

622 – WORKING DECK LIGHTING

The working deck will be illuminated by floodlights, which will be located as follows:

- 1 floodlights 1000 [W] on D-Deck facing forward,
- 2 floodlights 1000 [W] on B-Deck at M.O.B. boat and life-raft embarkation stations,
- 4 floodlights 1500 [W] facing A-Deck / Main deck aft of Deck house,
- Floodlights will be fitted along the working areas on the Main Deck.

Working areas on Main Deck will be covered by 500 [W] Halogen lights in a grid of approximately every 10 [m].

623 – SEARCHLIGHTS

Two (2) searchlights will be located on the wheel house top facing forward and two (2) searchlights will be located on the Wheelhouse Top facing aft. Search lights will be remotely controlled from inside the bridge.
The searchlights will be made of corrosion resistant brass housing with a 1,000 [W], halogen lamp and manual below-deck operation. Switches will be placed in bridge console forward and aft.

626 – EMERGENCY LIGHTNING SYSTEM

Lighting fixtures, connected to the emergency distribution system, will be at least:

- one fixture at every entrance/exit to escape routes,
- one fixture in every corner of a corridor,
- one fixture in Wheelhouse,
- one fixture at exits from cabins with bedroom,
- one fixture in staircase on each deck level and every landing,
- lights at embarkation stations for Life rafts and M.O.B. boat,
- 25% or more of the fixtures in:
  - Engine Room,
  - machinery spaces,
  - workshops / stores,
  - Switchboard Room,
- open decks leading to embarkation stations for M.O.B. boat and Life rafts.

631 -1 – FIRE AND GENERAL ALARM SYSTEM

A central fire detection and fire alarm system will be installed. The system will consist of the following components:

- Central alarm panel located on the bridge with eight groups,
- General alarm bells located throughout the vessel in all corridors in accommodation, in Emergency/Harbor Diesel Generator Room, Thruster Rooms forward and aft (common with general alarm installation),
- Smoke detectors and flame detectors in Engine Room,
- Smoke detectors in all corridors and stairs in the accommodation as well as in sleeping rooms,
- Manual call points at exits from accommodation, control rooms and at working areas on deck,

- Temperature sensors in galley and provision rooms,
- Alarm to engine room alarm panel,
- Acoustic and visual alarm in main engine room (common with general alarm and engine room alarm and monitoring system).

General

One central alarm system will be fitted consisting of the following equipment:
- One central station on the bridge forward station,
- Alarm bells in all corridors in the accommodation, diesel generator room, Switchboard Room, Cargo Room and Thrusters Room forward and aft.

Sirens / horns will be instated in high noise areas such as the Engine Room.

631-4 – ENGINE ROOM ALARMS

Engine Room alarm installation is to be arranged as described below:

1. Signaling and warning alarm system to be provided in engine room, alarming engine room staff if any alarm condition may happen or telephone calling in Engine Room or Switchboard Room,
2. In Engine Room suitable amount of signaling boxes is to be installed, with the following illuminated visual signaling alarm identification signs:
   - Fire alarm – red globe with black FIRE sign,
   - General alarm – white/green globe with BOAT sign,
   - CO_2 alarm – red globe with black CO_2 sign,
   - Engine room failure alarm – white globe with black FAILURE sign,
   - Sound powered telephone – milky white globe with black TELEPHONE sign,
   - "Dead man" alarm – amber globe with black MAN sign,
3. Simultaneously with alarm display in signaling boxes in Engine Room flashing light operate with red or amber or white/green globe, electronic sirens for CO_2, Engine Room failure, internal communication is to be actuated.
4. Intercommunication alarm calling signal to be stopped automatically if no acknowledgment follows in two (2) minutes.
5. "Dead man" alarm installation with adjustable alarm period is to be provided in Switchboard Room, activating an alarm in engine room alarm monitoring system in case the "Dead man" alarm is not reset within preset time during manned engine room operation.

631-3 – CO_2 ALARM

CO_2 audible and visual alarm installation is to be installed as follows:

1. In engine room and other spaces where CO_2 may be used CO_2 alarm is to be automatically actuated before CO_2 release.

631-4 – COLD PROVISION STORE ALARM

1. In each refrigerated provision stores chamber a permanently illuminated push button to be fitted. Signaling with red lamp close to galley, bell actuated by the bottom is to be provided.

633 – NAVIGATION LIGHTS

Navigation lights will be fitted according regulations. NUC lights will be installed in the main mast on top of the wheelhouse.

1. PS side light: double
2. SB side light: double
3. Masthead light fore ship, mast: double
4. Masthead light, fore ship: double
5. Stern light aft : double
6. 1 anchor light : single
7. 3 NUC. Lights: single
8. 2 passing lights: green PS/SB
9. 2 passing lights: red PS/SB

641-1 – RADIOCOMMUNICATION DEVICES

Equipment will be installed in compliance with the GMDSS regulations for area A-3. All equipment will be built into a console.

- GMDSS portable VHF radio, full duplex: 3 off,
- SART Radar transponders: 2 off,
- Epirb, hydrostatic release: 1 off,
- Marine VHF with DSC modem / watch keeping receiver: 2 off,
- Marine VHF receiver : 1 off,
- One (1) V-SAT
- Radio telephony installation, 150 [W], DSC 60 MF/HF DSC modem / watch keeping receiver.

641-2 – NAVIGATION DEVICES

The following equipment will be provided:

- Two (2) Radars, 21" PPI, diagonal color screen, 4/10 ft scanner,
- Two radar formats to be install on "X" (25 kW) and one on "S" (25 kW) band,
- Magnetic compass,
- Auto pilot,
- Navtex – Weather Fax Reciever,
- Echo sounder, 200 / 50 [kHz] transducer,
- Doppler log, with bottom track and water track,
- Day signaling lamp,
- Air whistle,
- Voyage Data Recorder (IMO A.861 (20)),
- AIS, Automatic Identification System (IMO MSCRES 36(63)),
- One gyro repeater at console forward and one at console aft,
- One gyro repeater at the emergency steering position.

The devices are to be supplied together with proper antennas, transducers and supply units.

641-2B – CENTRAL AERIAL SYSTEMS

A central antenna system will be fitted with outlets for radio and television in all cabins and Mess Room / Dayroom.

643 – INTERNAL COMMUNICATION DEVICES

- Automatic telephone exchange system with built in public address and alarm system with about 40 connections and six simultaneous calls.
- About 40 telephones spread over cabins, Mess Room, Day Room, Ship's Office, Bridge, machinery spaces, etc.
- Public address system will be arranged with loudspeakers in all corridors, public spaces, machinery spaces and open decks. This may be combined with the telephone system as appropriate.
- Talk back system Bridge forward and aft to mooring stations.

663 – DYNAMIC POSITIONING SYSTEM

One Duplex Dynamic Positioning System will be fitted. The system will control all thrusters forward and aft or a selected number of these. The system will consist of two computers with interface to all thrusters, the two main switchboards and all generators.
The system will consist of the following main components:

- One operator panels on bridge aft and one panel with manual thrusters controls with indications on display of DP operators panel,
- One operator panel for independent joystick on bridge aft
- One operator panel for independent joystick on bridge forward and with manual thrusters controls and indications on display panel,
- Independent joystick panels (portable) with one plug / docking station for the bridge consoles, fixed in panel, and two connections / docking stations on the bridge wings,
- One (1) Printer for alarms and event recording,
- Two (2) **U**ninterrupted **P**ower **S**upplies, 30 [min] backup,

Reference systems:
- Three (3) gyro compasses,
- Three (3) vertical reference units,
- Three (3) wind sensors,
- Three (3) DGPS with reception via WASS,
- One (1) radar based reference system.

The interfaces to the following equipment will be done by four outstations:
- Four (4) generators,
- One (1) off switchboards,
- One (1) off bus breaker,
- Two (2) thrusters/frequency drives,
- One (1) tunnel thruster & one (1) retractable thruster, electro motors and pitch-settings.

Other interfaces will be:

- Reference systems,
- VDR.

Modes:

- Training mode,
- ROV mode,
- Manual joystick mode,
- Independent joystick mode
- Auto pilot mode,
- Auto position mode,
- Auto heading mode,
- Auto track mode,
- Auto speed mode,
- DP minimum power mode,
- Dead reckoning mode,
- Simulation mode for training purposes.

The system will be according IMO DP Class 2 and ABS DPS-2.

670 – ALARM MONITORING SYSTEM

1. Alarm monitoring system is to be installed on board. List of alarms and measuring points is to be according to the Rules, Class notation requirements and main machinery vendor's technical recommendation.
2. System is to be supplied from Main, Emergency Switchboard and its own uninterrupted power source.
3. Two Operator stations with key board and track ball are to be installed in Switchboard Room console for the system operation.
4. Two Alarm panels are to be placed in the bridge consoles.

681/690 – MAIN CABLEWAYS AND CABLES

Cables

All cables for power and lighting will be of the cross linked polyethylene (XLPE) insulated stranded copper cores, with a chlorosulphonated polyethylene (CSP) sheath and a polyvinylchloride (PVC) covering.

Cables for control current, (inter)communication and measuring etc. will be of the cross linked polyethylene (XLPE) insulated stranded copper cores, cable core provided with a polyester tape, sheath PVC (flame retardant) and a covering of PVC (flame retardant).

Cable-trays

For supporting of cables following systems will be used:

- ladder type trays,
- strip- or rod type steel,
- steel tubing.

Cable-trays will be welded against beams or deck-heads at such a distance as to permit laying of cables on top of the trays as far as practicable. Cables are to be placed below of the cable tray as far as practicable. Minimum bending radius of the cables is not be less than manufacturer's recommendation.

Steel ducting (A-60 isolated) will be used mainly for running cables under the Engine Room ceiling and steel tubing for cables on open deck. Temperature rise in the cable and ventilation of the steel ducting shall be provided. Cables also to be securely fastened in the steel tubing.
Furthermore these tubes and ductings are to be fitted with inserts at the ends in order to prevent the cables from damage.

Cable routing will in general be along SB side and along PS, of the vessel, in order to have as much separation as possible with respect to distribution to main consumers.

Power cables and signaling cables will be well separated and are not to be on the same cable tray.

Cable penetrations

Watertight cable penetrations will be performed as follows:

- single passing transits by means of cable glands,
- multiple cable transits by means of multiple cable penetration.

Non watertight cable penetrations through decks and bulkheads will be made by means of steel rings, welded into the deck or bulkhead.

SECTION 900 – INVENTORY AND SPARE PARTS

910 – FIREFIGHTING EQUIPMENT

Portable firefighting and escape equipment is to be furnished and installed according to the SOLAS.

920 – SPARE PARTS/TOOLS – YARD SUPPLY

Spare parts are to be provided according to the Rules and as per vendor's standard.

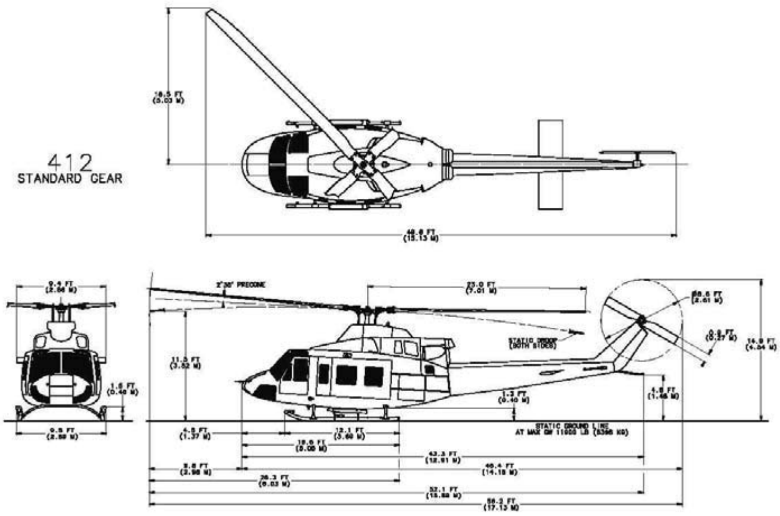
Helicopter – BELL 412SP, N142PH, S/N 33150

INSTRUMENT PANEL – Actual photo

INTERIOR – Actual photos

Bell 412
Heliport Design Data and Dimensions

Bell Helicopter
A Textron Company



LANDING GEAR LOADING AT MAXIMUM GROSS WEIGHT (11,900-POUNDS), BASED ON 1G STATIC CONDITIONS AT AFT-MOST STRUCTURAL CG LIMIT

Gear Type	Loading (lb)		Contact Area (in^2)		Contract Pressure (lb/in^2)	
	Forward	Aft	Forward	Aft	Forward	Aft
Standard Skid	2356	9544	24.0 x 2.0	24.0 x 2.0	49	199
High Skid	2386	9514	24.0 x 2.0	24.0 x 2.0	50	199
Emergency Floats	2486	9514	24.0 x 2.0	24.0 x 2.0	50	199

February 13, 2008

Appendix K

Modeling of Drilling Mud and Cuttings Discharges

(Pending final report)

13 Av, 5775
July 29, 2015

To
Dr. Gil Zeidner
Noble Energy Ltd.

Dear Sir,

<u>Re: Approval of MUDMAP Contaminant Dispersal Model – Development of Leviathan Field</u>
Ref: Your letter NEM-OP-NEM-MOE-LTR-0075 of May 14, 2015

The following is an approval for use of a digital hydrodynamic model for the dispersal of contaminants (MUDMAP) which Noble Energy Ltd. intends to use for the purpose of examining the environmental impact of drilling in the seabed, for production tests and completion of wells in the Leviathan Field (Leases I/14; I/15). This approval does not include the dispersal of contaminants for the production process.

However, you must complete the following:

1. Since no timetable has yet been set for effecting operations in the territory of the Field, please prepare a document describing the dispersal of contaminants during at least one calendar year (4 consecutive seasons).

2. The cutting discharge and drilling mud data that is required to be fed into the model must accord with the actual work conditions that will arise following treatment of the drilling mud and the cutting discharge and in accordance with the approval for use of the type of mud (oil / water) by the Ministry for Environmental Protection and the Ministry of National Infrastructure.

3. An updated table must be submitted to the Ministry for Environmental Protection setting out an estimate of the quantity of cutting discharge and drilling mud intended for use and treatment, and the characteristics thereof, prior to activation of the model and preparation of the environmental document.

4. In the event that drilling is effected in a number of wells at the same time, dispersal of the contaminants from the relevant number of sources must be set out.

5. An dispersal model for the accidental release of oil-based mud must be presented.

6. Set out the thickness of the cumulative layers on the seabed, in addition to the contaminant concentrations.

Yours sincerely,

Yevgeni Malkin
Head of Marine Environment Energy Resources

CC:
Mr. Rani Amir, Director, National Marine Environment Protection Unit, here.
Mr. Fred Erzuan, Deputy Director, National Marine Environment Protection Unit, here.
Dr. Iris Safrai, Commissioner of Prevention of Sea Pollution by Industrial Effluent, here.
Dr. Dror Zurel, Scientific Center for Maritime Monitoring and Research, here.
Dr. Dov Zvieli, Ministry for Environmental Protection Consultant on Marine and Coastal Processes
Mr. Ilan Nissim, Head of Environment Division, Ministry of National Infrastructure, Energy and Water.
Mrs. Orna Primor, Environment Manager, Noble Energy Ltd.

CSA Israel | Drilling Discharges Modeling Results, Offshore Israel

ASA Team: Nathan Vinhateiro, Tatsu Isaji, Yong Kim, Eric Comerma

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Executive Summary

CSA Ocean Sciences Inc. contracted with Applied Science Associates, Inc. (dba RPS-ASA) to evaluate seabed deposition associated with development drilling in the Leviathan South and North lease blocks, offshore Israel. Numerical modeling was conducted to predict cuttings dispersion for a representative drilling site located near the western boundary of the Levant Basin. The site chosen for modeling is approximately 150 km west of Haifa at a water depth of 1649 m. Modeling was conducted to simulate the release of drill cuttings and drilling mud using varying current conditions over a period of approximately 2 months.

Discharge simulations were completed using ASA's MUDMAP modeling system. The MUDMAP model predicts the transport of solid releases in the marine environment and the resulting seabed deposition. The model requires information regarding the discharge characteristics (release location, rate of discharge, etc.), the properties of the sediment discharged (particle sizes, density), and environmental characteristics (bathymetry and ocean currents), to predict the transport of solids through the water column.

Simulations were performed to predict the fate of discharges from six individual drilling sections. Drilling operations are expected to utilize water based mud (WBM) for the riserless phase of drilling (sections 1-2) and mineral oil based mud (MOBM) for the intermediate and main hole sections. Prior to their discharge, cuttings generated during the MOBM drilling will be treated with a thermo-mechanical Cuttings Cleaner (TCC) to reduce retained oil on cuttings to <1%. Although drilling is expected to occur between the months of December and February, MUDMAP simulations were performed for two periods to examine the potential effect of seasonal circulation patterns within the lease block: December-February (Scenario 1) and July-September (Scenario 2). Wave and ocean current measurements from an ongoing metocean study in the Levantine Basin (Mudge et al., 2014) indicate that currents in the upper water column are generally stronger during the former (winter) period.

Overall, both scenarios result in a generally rounded deposit that surrounds the well and remains within 1 km of the discharge site. Differences in the extent of deposition between each season are nominal and are limited to thicknesses below 1 mm; the extent of deposition above 5 mm is nearly indistinguishable between the two release periods. Considering both scenarios, thicknesses at or above 1 mm extend up to 149 m from the discharge site and occupy a maximum areal extent of 0.0348 km^2; thicknesses greater than 10 mm extend up to 47 m with a maximum footprint of 0.0061 km^2; and thickness at or above 100 m are limited to 21 m from the well head and an aerial extent of 0.0012 km^2. Burial thresholds estimated by Smit et al. (2008) for the 50% hazardous effects level (54 mm deposition) and the 5% hazardous effects level (6.3 mm deposition) do not vary significantly between drilling periods or as a function of drilling program.

1. Project Background and Geographic Location

CSA Ocean Sciences, Inc. has contracted Applied Science Associates, Inc. (dba RPS ASA) to evaluate seabed deposition from drilling discharges associated with development of the Leviathan South and North lease blocks, offshore Israel. Numerical modeling was conducted to predict cuttings dispersion for a representative drilling site located near the western boundary of the Levant Basin, a deep and elongated sedimentary basin in the eastern Mediterranean Sea. The Levant Basin Province is an approximate 83,000 square kilometer region situated between Cyprus and the Eratosthenes Seamount to the north and west, the Levant Transform Zone to the east, and the Nile Delta Cone to the south (Roberts and Peace, 2007).

Up to eight offshore wells may be drilled within the licence areas as part of the Leviathan development. Dispersion modeling was conducted to evaluate impacts of drilling discharges for one representative location (within the Leviathan South block). The site is approximately 150 km west of Haifa at a water depth of 1649 m (Table 1; Figure 1).

Table 1. Location of the discharge site selected for modeling, offshore Israel.

Block Name	Latitude (N)	Longitude (E)	Water Depth (m)
Leviathan South			1649

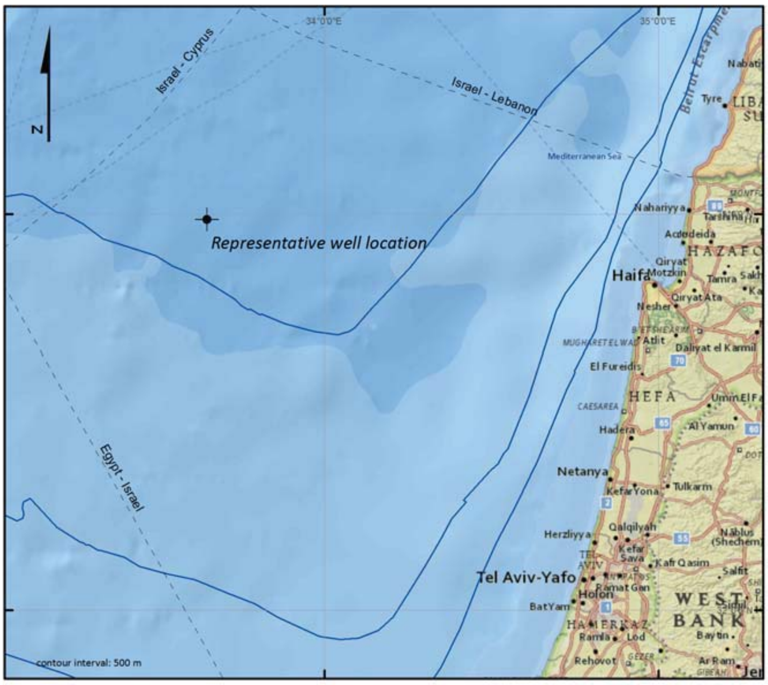


Figure 1. Location of the representative drilling site; eastern Mediterranean. Dashed line shows Israel's maritime boundaries with Egypt (SW), Cyprus (NW) and Lebanon (NE). The Eratosthenes Seamount is located approximately 140 km northwest of the drilling site.

Cuttings dispersion was simulated at the site using ASA's MUDMAP modeling system (Spaulding et al., 1994). The MUDMAP model predicts the transport of solid releases in the marine environment and the resulting seabed deposition. The model requires information regarding the discharge schedule (release location, rate of discharge, etc.), the properties of the effluent (particle sizes, density), and characteristics of the receiving environment (bathymetry and ocean currents), to predict the transport of solids through the water column. A technical description of the MUDMAP model is included in Appendix A.

Drilling operations are expected to utilize water based mud (WBM) for the riserless phases, and mineral oil based mud (MOBM) for the intermediate and main hole sections. Surface returns of MOBM cuttings will be treated with a Thermo-mechanical Cuttings Cleaner (TCC) prior to discharge. This technology uses frictional heat generated by crushing the cuttings to thermally separate oil and water that are adhered to drill cuttings. The liquid phase vaporizes/condenses and is separated into dedicated tanks for water and oil; the solid phase is then discharged overboard. The characteristics of particle settling used for model inputs account for the TCC treatment of cuttings.

Client-provided data indicates that drilling is expected to take place intermittently during the months of December 2015 through February 2016. However, because the drilling schedule may change as a result of rig availability and regulatory approvals, MUDMAP simulations were also run to examine the dispersion of mud and drill cuttings for an alternate seasonal period. A total of two scenarios were modeled: December-February (Scenario 1) and July-September (Scenario 2). Wave and current measurements collected by ASL for Noble (Mudge et al., 2014) indicate that the former period (winter) is characterized by generally stronger currents in the upper water column in both the Leviathan and (adjacent) Tamar license blocks. For each period, the MUDMAP model was applied to predict: (i) deposition associated with each phase of drilling, and (ii) the cumulative seabed impact of all drilling discharges.

2. Model Inputs

2.1. MetOcean Data

Ocean circulation in the Levant Basin is complex, consisting of multiple jets and gyres that evolve on seasonal and interannual time scales. Because the Mediterranean is surrounded by land with only narrow connection to the Atlantic Ocean, tidal currents are limited. Instead, winds are the major forcing for ocean currents, with the secondary influence from the basin topographic structure.

Simulations of cuttings dispersion at the well utilized measurements from an ongoing metocean study in the Levantine Basin (Mudge et al., 2014) to represent regional current forcing. For nearly five years, Noble has contracted the collection of oceanic current, wave, and water level measurements at different locations within the Leviathan and (adjacent) Tamar blocks for use in design criteria and modeling studies. Specific to this study, a long mooring (LV1-1) was deployed near the drilling between July 2011 and April 2014 in order to collect flow velocities at depths through the water column. Instrumentation along the mooring included the following current meters:

- an upward looking Workhorse 300 kHz at ~55 m,
- an upward looking Long Ranger 75 kHz at ~250 m,
- an upward looking Workhorse 300 kHz at ~350 m,
- three to five Doppler Volume Sampler (DVS) 6000 at 450 m, 700 m, 950 m, 1200 m, and 1450 m, and
- a downward looking 150 kHz QuarterMaster near the seafloor

LV1-1 was deployed approximately 20 km east of the site chosen for modeling, at a water depth of ~1650 m (Figure 2). Instruments along the mooring were rotated or maintained every 3 to 6 months during quarterly cruises. Mudge et al. (2014) and references therein provide further details to describe the instrument specifications, deployment and recovery periods, and data QA/QC.

Figure 2. Location of the LV1-1 mooring in relation to the representative well site used for modeling; eastern Mediterranean.

Time-stamped current measurements (velocities at various depths) from LV1-1 were provided to RPS ASA from Noble Energy. The data were binned to 13 vertical layers through the water column. Vertically and time varied currents for two potential drilling periods (beginning in December and July, respectively) were subset from the full dataset and used as forcing for the MUDMAP simulations. Following a qualitative review, data from deployments in 2013 and 2014 were selected for use in the dispersion model due to more frequent instrument malfunction and/or missing data during earlier periods. A series of processing steps were then used to resample currents to a common (1-hour) time step; flagged or missing data for periods of less than 10 hours were interpolated.

The following figures correspond to current measurements at LV1-1 during the 2013-2014 deployment:

- Stick plot showing current speeds and directions with depth at LV1-1.
- Vertical profile of current velocity based on hourly data at LV1-1.
- Current roses showing the distribution of current speed and direction for select depths in the water column.
- Monthly averaged current speeds at the sea surface and near the seabed.
- Current roses showing the distribution of surface current speed and direction (by month) at LV1-1.

All figures display current data in the oceanographic convention (stick vectors/roses indicate the direction *toward* which currents are flowing).

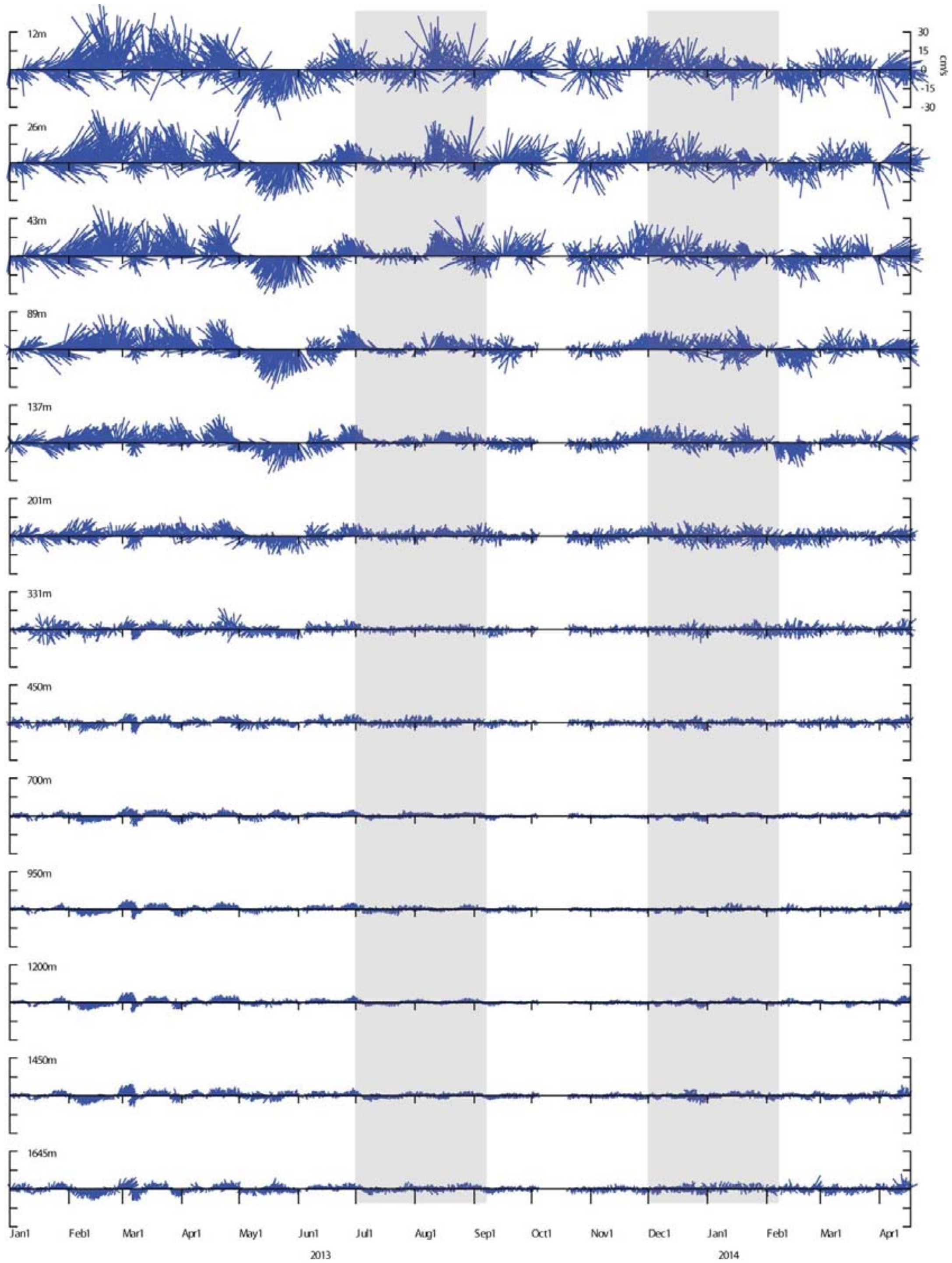


Figure 3. Time series of measured currents with depth at the LV1-1 mooring site. Shading shows the proposed (Dec-Feb) and alternate (Jul-Sep) periods selected for cuttings dispersion simulations.

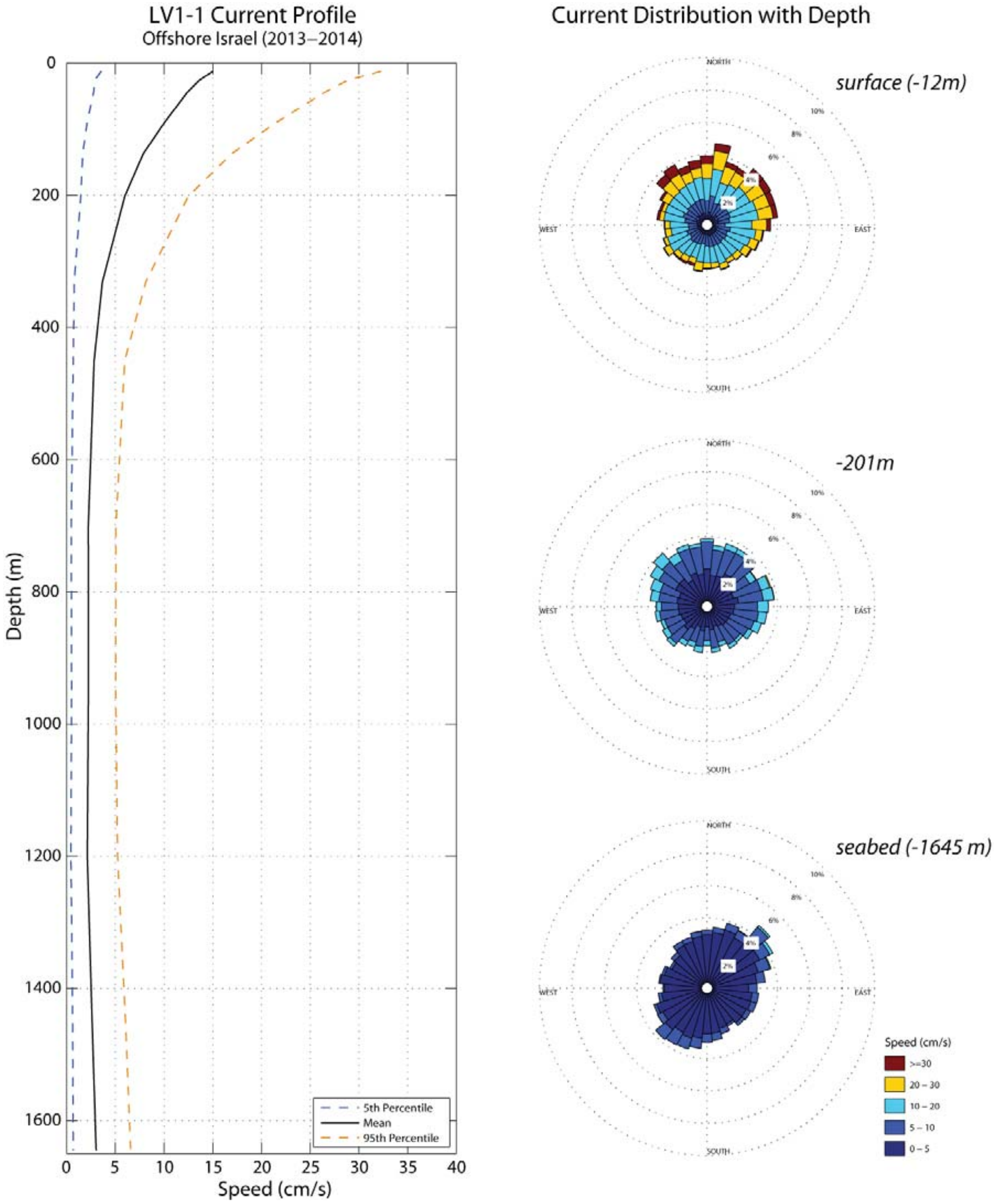
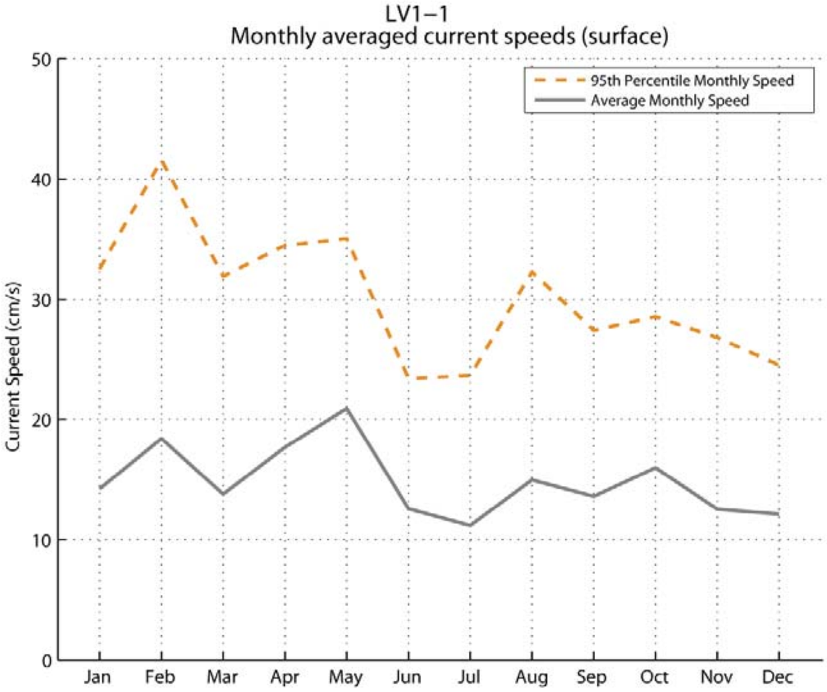


Figure 4. Vertical profile (left) and current roses showing annual distribution of current speeds (right) at the LV1-1 mooring between 2013 and 2014.



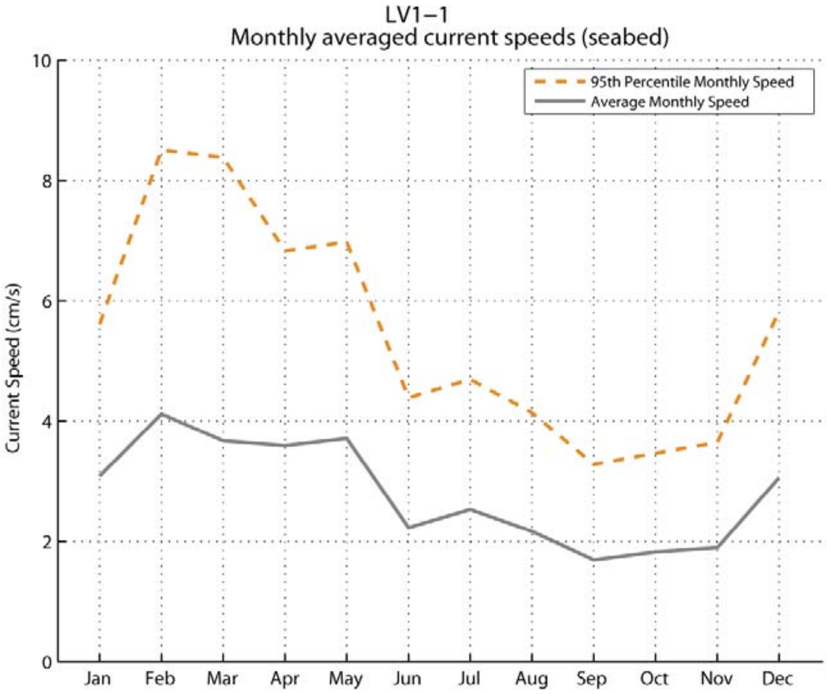


Figure 5. Monthly averaged current speeds at LV1-1 derived from measurements between 2013 and 2014 at the sea surface (top) and seabed (bottom).

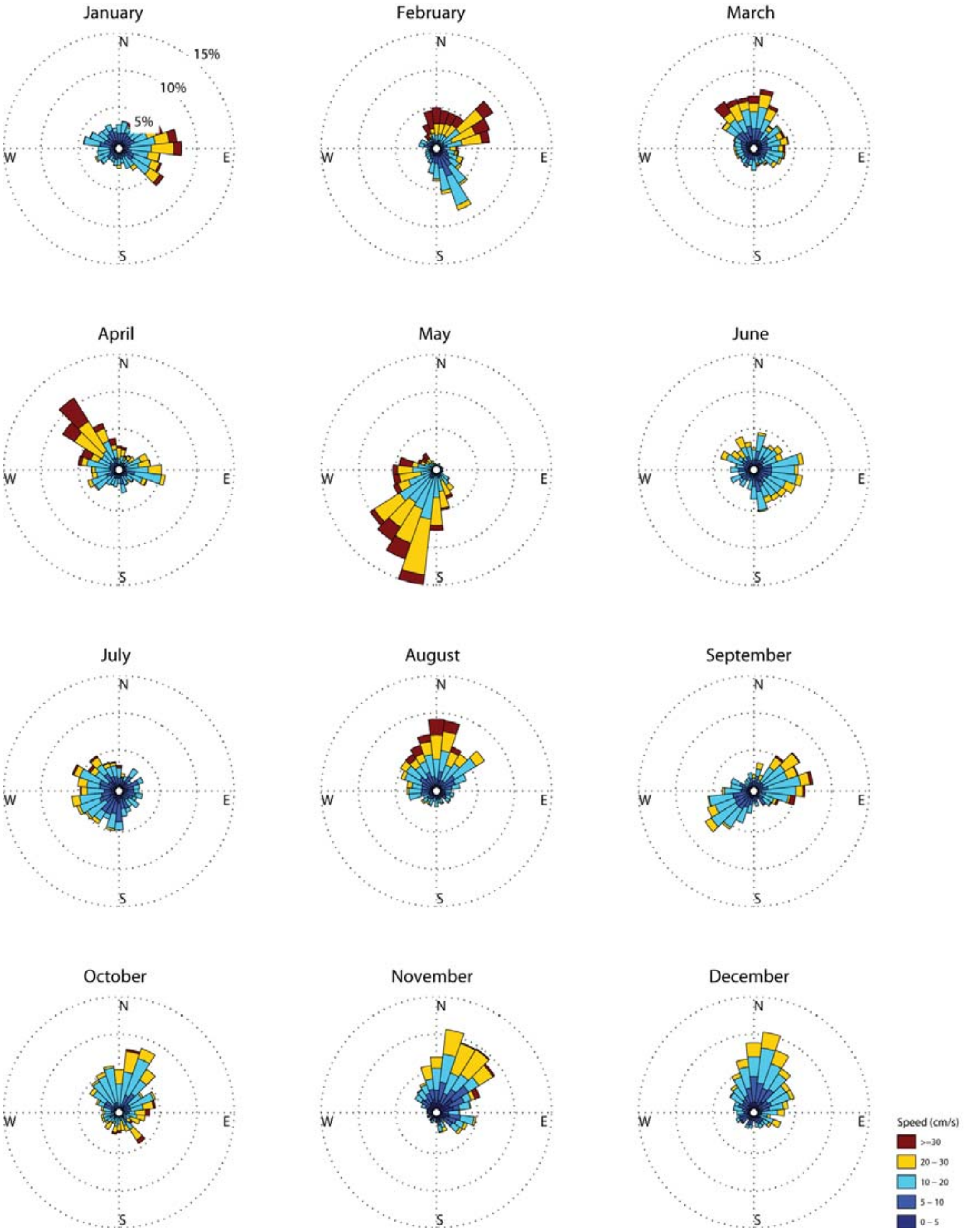


Figure 6. Rose plot (polar histogram) showing the distribution of surface current speed and direction by month at LV1-1 between 2013 and 2014.

2.2. Drilling Schedule

The drilling schedule provided to RPS ASA (Table 2) is based on previous operations at the Leviathan 5 well, which included drilling of 6 sections ranging from 36” to 12 ¼” (inches) in diameter. The mud and cuttings volumes were calculated (estimated) for Leviathan 5 from the approximate depth and diameter of each section. As shown below, each section includes an approximate 4-10 day period associated with casing, cementing, and logging the drill hole.

During the riserless phase of drilling (sections 1-2), all cuttings and water based mud (WBM) are expected to be released directly at the seabed (5 m above the wellhead on the seafloor). Subsequent sections will be drilled using a mineral oil based mud (MOBM) and returned to the surface for treatment. Noble has requested approval from the Ministry of Environmental Protection (MOEP) to discharge the MOBM cuttings onsite. Surface returns of MOBM cuttings will first be treated with a Thermo-mechanical Cuttings Cleaner (TCC) to reduce retained oil on cuttings to <1% prior to discharge. The MOBM phase will be reclaimed and recycled for future drilling operations (i.e. no bulk discharge of MOBM will occur).

Table 2. Drilling discharge program used for model simulations (based on Leviathan 5 drilling program).

Section	Diameter	Drilling period		Drilling duration[1] (days)	Cuttings Discharge[2]		Drilling Fluid (Mud) Discharge		Mud Type	Release Depth[3]
					vol (m^3)	rate (m^3/d)	vol (m^3)	rate (m^3/d)		
1	36”				54	45.76	48	40.68	WBM	seabed
2	26”				478	90.36	2980 4070	1332.72	WBM Brine	seabed
Run 20" casing and riser										
3	20”				189	35.73	N/A	N/A	MOBM	sea surface
Log & Run 16-inch liner										
4	17.5”				181	34.22	N/A	N/A	MOBM	sea surface
Log & run 13-5/8" casing										
5	8.5”				21	1.98	N/A	N/A	MOBM	sea surface
Log/abandon pilot hole										
6	12.25”				18	7.66	N/A	N/A	MOBM	sea surface
Run production casing										
End of well discharge					N/A	N/A	192	3815.00	Brine	sea surface

Notes:
1. Table includes non-drilling days; based on target days plus 15% non-productive time.
2. Assumes MOEP approval of onsite discharge of TCC-treated cuttings during MOBM phase.
3. Releases were simulated at 5 m above seabed and 12 m below sea surface.

Drilling activities at the site are expected to occur between Dec 2015 and Feb 2016. However, as described above model simulations were performed for two periods (seasons) in order to evaluate the influence of potential variability in ocean currents in the region. Operational releases were first simulated between December and February (Scenario 1), in accordance with the scheduled drilling plan. An additional simulation was conducted to compare impacts of drilling during summer months (July-September; Scenario 2), when depth averaged currents are generally weaker in both the Leviathan and Tamar licence areas.

2.3. Discharged Solids Characteristics

Operational discharges at the site are expected to include WBM cuttings and bulk WBM (released directly to the seabed during riserless drilling) and MOBM cuttings released from the drilling platform. As described above, surface returns will be processed with a TCC unit prior to discharge. Settling velocities used as model inputs are a combination of values from literature and client-provided data. The particle sizes used to characterize TCC-treated cuttings (sections 3-6) were provided by Noble's drilling contractor. The data were directly measured by laser diffraction of TCC cuttings powder (see Appendix B). Conversion from particle size to settling velocity (required for MUDMAP) was based on Stokes Law and assumed a specific gravity of 2.5 for the solid fraction of cuttings.

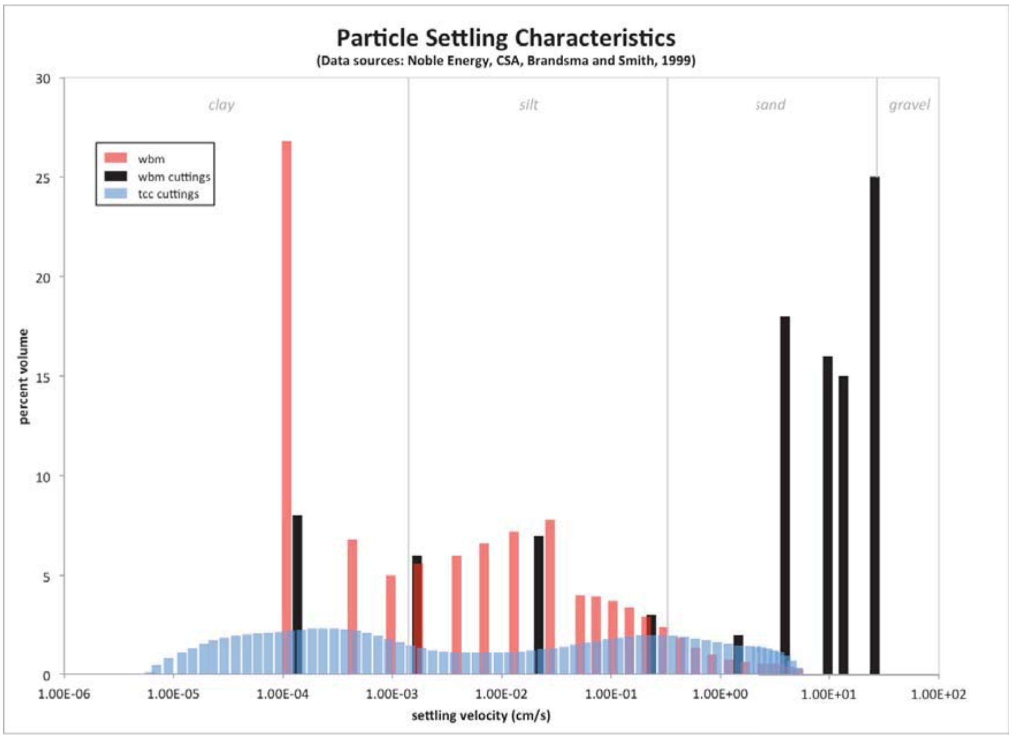


Figure 7. Comparison of settling velocities for solid discharges used in the modeling study. Size class divisions are from Gibbs et al. (1971).

Table 3. Composition of drilling discharges used for modeling (estimated WBM formulations from Leviathan 5 drilling; data provided by Noble Energy).

Discharged material	Bulk density (ppg)	Bulk density (kg/m^3)	Percent solid by weight	Average SG of solid fraction
WBM cuttings (section 1-2)	22.1	2,650	100	2.65
WBM (section1)	8.6	1,030	22	4.48
WBM (section2)	12.5	1,500	22	4.48
MOBM cuttings (section 3-6)	20.9	2,500	100	2.5

Table 4. WBM cuttings settling velocities used for simulations (Brandsma and Smith, 1999).

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	8.00	1.350E-04	0.12
2	6.00	1.686E-03	1.46
3	7.00	2.182E-02	18.86
4	3.00	2.328E-01	201.14
5	2.00	1.447E+00	1250.37
6	18.00	4.011E+00	3465.65
7	16.00	9.796E+00	8463.98
8	15.00	1.352E+01	11679.45
9	25.00	2.598E+01	22442.45

Table 5. WBM settling velocities used for simulations (provided by CSA for Cyprus drilling site; ASA 10-262).

Mud Particle Size (microns)	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
1	26.8	0.000108	0.093312
2	6.8	0.000431	0.372384
3	5	0.00097	0.83808
4	5.6	0.001724	1.489536
6	6	0.003878	3.350592
8	6.6	0.006894	5.956416
11	7.2	0.013	11.232
16	7.8	0.0276	23.8464
22	4	0.0521	45.0144
26	3.92	0.0728	62.8992
31	3.72	0.1035	89.424
37	3.39	0.1475	127.44
44	2.94	0.2086	180.2304
53	2.41	0.3026	261.4464
63	1.86	0.4276	369.4464
74	1.36	0.5899	509.6736
88	0.97	0.8342	720.7488
105	0.72	1.188	1026.432
125	0.59	1.683	1454.112
149	0.55	2.392	2066.688
177	0.55	2.997	2589.408
210	0.52	3.617	3125.088
250	0.43	4.381	3785.184
297	0.28	5.296	4575.744

Table 6. TCC-treated MOBM cuttings settling velocities (data provided by Noble Energy; see Appendix B).

Size Class	Percent Volume	Settling Velocity	
		(cm/s)	(m/day)
0.399	0.560	0.00001	0.00637
0.502	1.900	0.00001	0.01009
0.632	2.920	0.00002	0.01599
0.796	3.630	0.00003	0.02537
1.002	4.010	0.00005	0.04020
1.262	4.200	0.00007	0.06377
1.589	4.390	0.00012	0.10109
2.000	4.600	0.00019	0.16015
2.518	4.690	0.00029	0.25385
3.170	4.520	0.00047	0.40233
3.991	4.080	0.00074	0.63772
5.024	3.480	0.00117	1.01056
6.325	2.870	0.00185	1.60172
7.962	2.410	0.00294	2.53810
10.024	2.190	0.00466	4.02297
12.619	2.150	0.00738	6.37550
15.887	2.240	0.01170	10.10528
20.000	2.410	0.01854	16.01490
25.179	2.640	0.02938	25.38290
31.698	2.950	0.04656	40.22797
39.905	3.320	0.07379	63.75569
50.238	3.700	0.11700	101.04830
63.246	3.970	0.18540	160.15130
79.621	4.050	0.29380	253.81630
100.237	3.890	0.46560	402.27260
126.191	3.570	0.73790	637.56010
158.866	3.220	1.17000	1010.47700
200.000	2.940	1.85400	1601.49000
251.785	2.770	2.44700	2113.80600
316.979	2.570	3.15200	2723.11400
399.052	2.090	4.06000	3508.04200
502.377	1.060	5.23100	4519.23600
563.677	0.010	5.93700	5129.39000

3. Model Results

The fate of mud and cuttings released from development drilling were assessed through two discharge model scenarios corresponding to the drilling schedule and release volumes described in Table 2. MUDMAP was used to predict the resulting bottom deposition from individual drilling intervals (sections) and the results (thickness grids) were aggregated outside of the model to produce maps of cumulative deposition for each drilling season. Following the simulated release of each drilling section in MUDMAP, the model continued to track the far field dispersion for a minimum of 72 hours, to account for settling of very fine material (e.g. TCC cuttings) from the water column. Figure 8 and Figure 9 show the plan view extents of the model-predicted seabed deposition during the winter (Scenario 1) and summer (Scenario 2) periods, respectively. Figure 9 compares the areal coverage of deposition for each scenario. For all results, deposit thicknesses were calculated based on mass accumulation on the seabed and assume a sediment bulk density of 2,500 kg/m^3 and no void ratio (zero porosity).

As illustrated in the figures below, the extent of deposition at the well site does not change substantially as a result of the drilling season. Both scenarios result in a fairly concentric pattern of deposition that surrounds the well and extends approximately 700-800 m from the discharge site. Simulations performed during the winter period produce a cumulative deposit that is slightly elongated toward the southwest, while during the summer period similar elongation is predicted toward the southeast. Overall however, these differences are limited to intervals below 1 mm in thickness. For both scenarios, the broad blanket of sediment that extends beyond ~200 m results from the accumulation of very fine particles (e.g. WBM particles and TCC cuttings), which experience more variation in the current regime as they settle and from discharges that originate at the sea surface (which disperse widely while settling in deep water). By comparison, the gradient of contours at or above 10 mm is uniform and concentric around the well, which indicates that dispersion processes are nearly as influential as advection from currents due to the settling characteristics of material being released and the release depths.

Table 7 summarizes the area of seabed covered by the deposition blanket and Table 8 lists the maximum distance that individual thickness contours extend from the site for each of the model scenarios. Both tables include burial thresholds identified by Smit et al. (2008) for the 50% hazardous effects level (54 mm deposition) and the 5% hazardous effects level (6.3 mm deposition). For Scenario 1 (Dec-Feb), the discharge program results in deposition of 100 mm up to 20 m from the well and an aerial extent of 0.0012 km^2; deposition at 10 mm extends a maximum of 45 m and covers an area of 0.006 km^2; and deposition at thickness of 1 mm extends a maximum of 136 m and covers 0.0327 km^2 of the seabed. For Scenario 2 (Jul-Sep) thicknesses of 100 mm or greater are confined to a distance of 21 m from the discharge site and an aerial extent of 0.0012 km^2; deposition at 10 mm extends a maximum of 47 m and covers an area of 0.0061 km^2; and deposition at thickness of 1 mm extends 149 m and covers up to 0.0348 km^2 of the seabed.

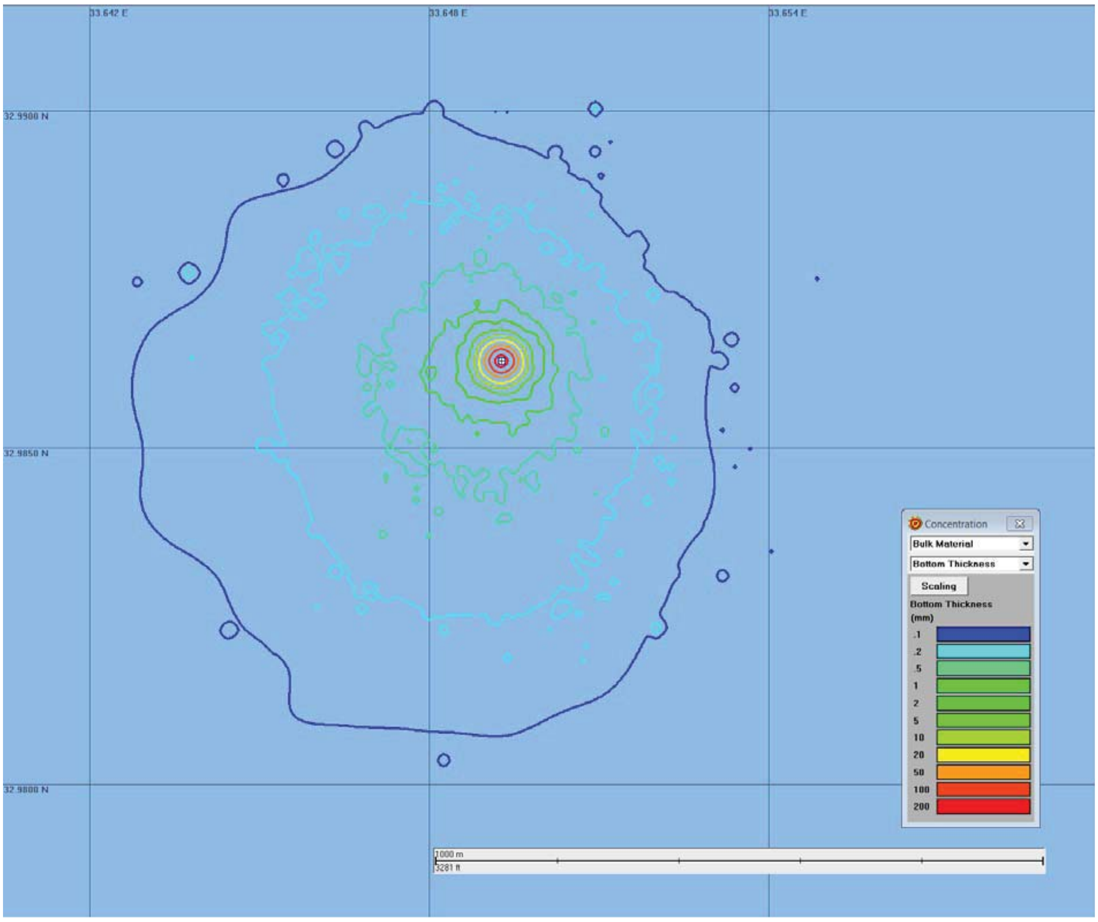


Figure 8. Cumulative deposition thickness (cuttings and mud) from operational drilling discharges at the representative drilling location (Scenario 1: Dec-Feb).

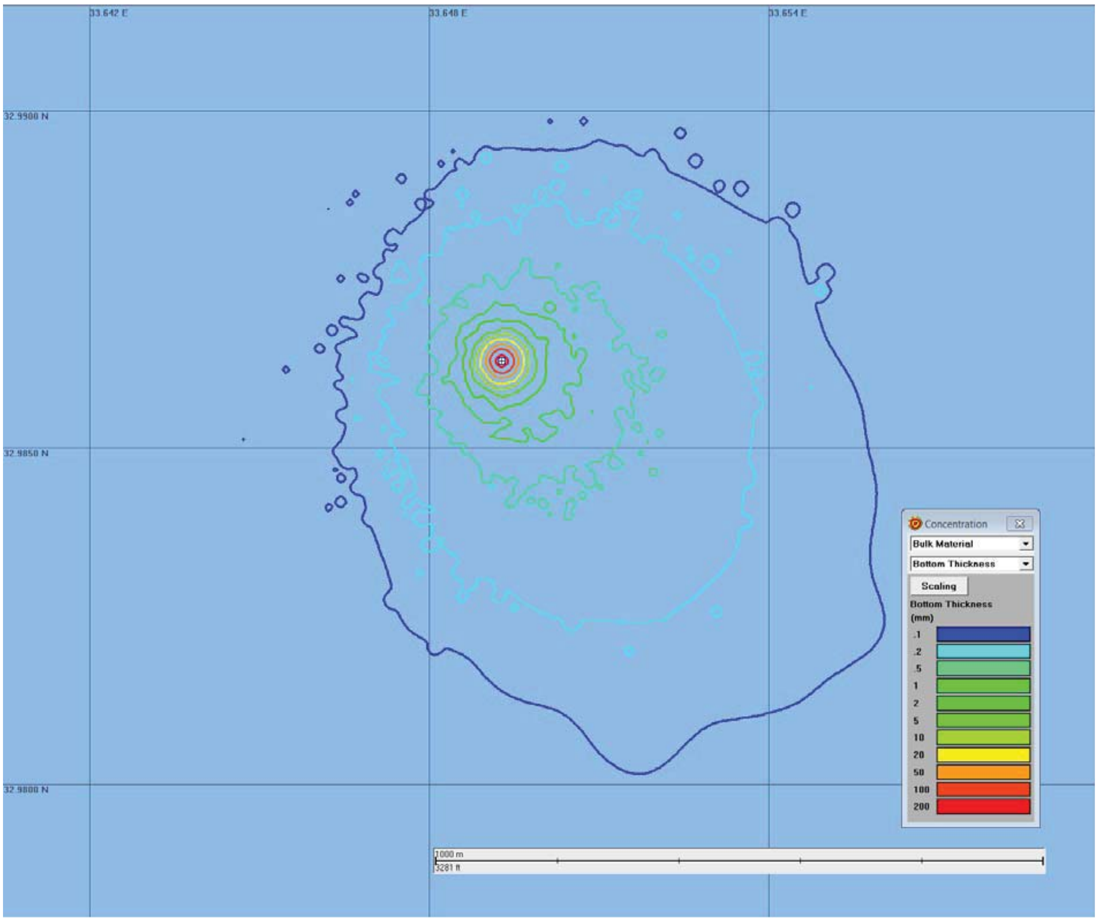


Figure 9. Cumulative deposition thickness (cuttings and mud) from operational drilling discharges at the representative drilling location (Scenario 2: Jul-Sep).

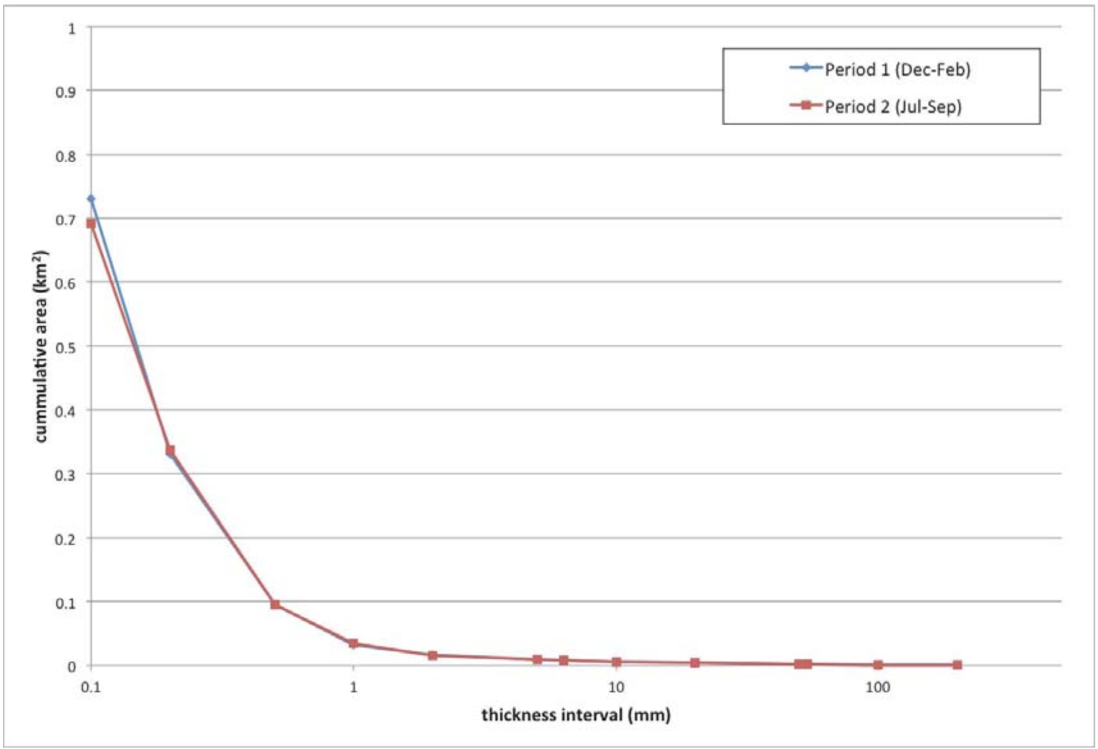


Figure 10. Comparison of seabed deposition (by thickness interval) for discharges originating from the representative drilling location. Blue – discharges during the (planned) Dec-Feb period, Red – discharges during the (alternate) Jul-Sep period.

Table 7. Areal extent of seabed deposition (by thickness interval) for each model scenario. Burial thresholds from Smit et al. (2008) are shown in bold.

Deposition Thickness (mm)	Cumulative Area Exceeding (km^2)	
	Scenario 1	Scenario 2
0.1	0.7309	0.6913
0.2	0.3316	0.3365
0.5	0.0951	0.0958
1	0.0327	0.0348
2	0.0159	0.0158
5	0.0090	0.0092
6.3	**0.0079**	**0.0080**
10	0.0060	0.0061
20	0.0041	0.0041
50	0.0023	0.0023
54	**0.0021**	**0.0021**
100	0.0012	0.0012
200	0.0003	0.0003

Table 8. Maximum extent of thickness contours (distance from release site) for each model scenario. Burial thresholds from Smit et al. (2008) are shown in bold.

Deposition Thickness (mm)	Maximum extent from discharge point (m)	
	Scenario 1	Scenario 2
0.1	676	775
1	136	149
6.3	**54**	**55**
10	45	47
54	**27**	**27**
100	20	21
200	11	11

4. References

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Appendix A: MUDMAP Model Description

MUDMAP is a personal computer-based model developed by ASA to predict the near and far-field transport, dispersion, and bottom deposition of drill muds and cuttings and produced water (Spaulding et al; 1994). In MUDMAP, the equations governing conservation of mass, momentum, buoyancy, and solid particle flux are formulated using integral plume theory and then solved using a Runge Kutta numerical integration technique. The model includes three stages:

Stage 1: **Convective decent/jet stage** – The first stage determines the initial dilution and spreading of the material in the immediate vicinity of the release location. This is calculated from the discharge velocity, momentum, entrainment and drag forces.

Stage 2: **Dynamic collapse stage** – The second stage determines the spread and dilution of the released material as it either hits the sea surface or sea bottom or becomes trapped by a strong density gradient in the water column. Advection, density differences and density gradients drive the transport of the plume.

Stage 3: **Dispersion stage –** In the final stage the model predicts the transport and dispersion of the discharged material by the local currents. Dispersion of the discharged material will be enhanced with increased current speeds and water depth and with greater variation in current direction over time and depth.

MUDMAP is based on the theoretical approach initially developed by Koh and Chang (1973) and refined and extended by Brandsma and Sauer (1983) and Khondaker (2000) for the convective descent/ascent and dynamic collapse stages. The far-field, passive diffusion stage is based on a particle based random walk model. This is the same random walk model used in ASA's OILMAP spill modeling system (ASA, 1999).

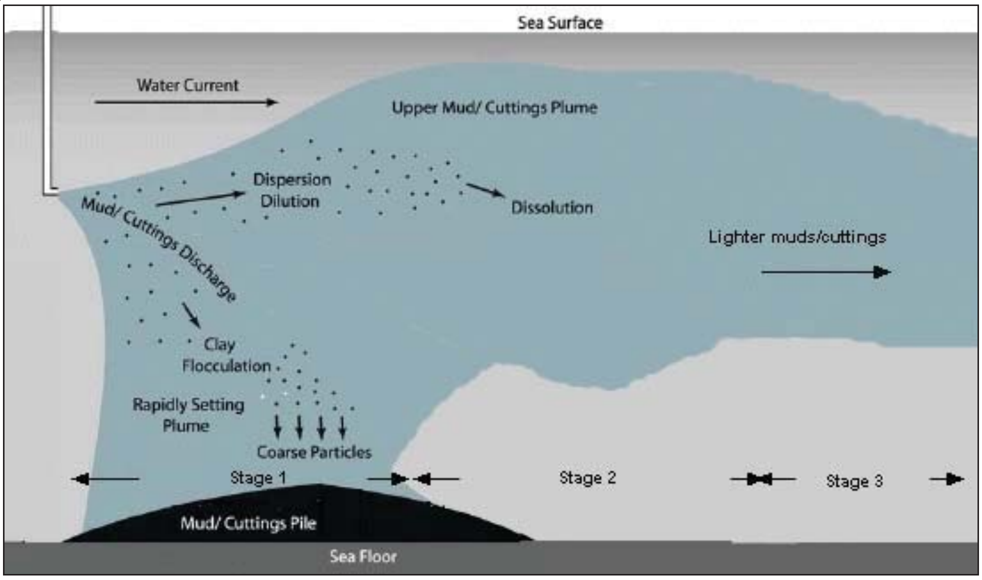

Figure A1. Conceptual diagram showing the general behavior of cuttings and muds following discharge to the ocean and the three distinct discharge phases (after Neff 2005).

The model's output consists of calculations of the movement and shape of the discharge plume, the concentrations of soluble (i.e. oil in produced water) and insoluble (i.e. cuttings and muds) discharge components in the water column, and the accumulation of discharged solids on the seabed. The model predicts the initial fate of discharged solids, from the time of discharge to initial settling on the seabed As MUDMAP does not account for resuspension and transport of previously discharged solids, it provides a conservative estimate of the potential seafloor concentrations (Neff 2005).

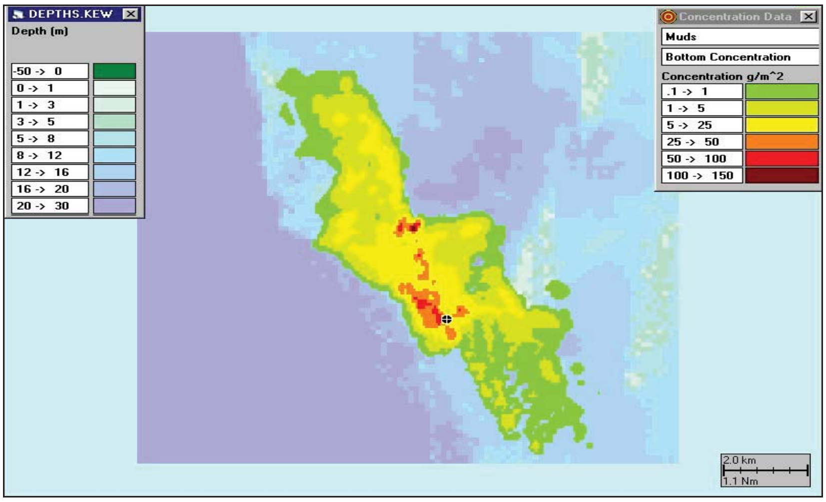

Figure A2 Example MUDMAP bottom concentration output for drilling fluid discharge.

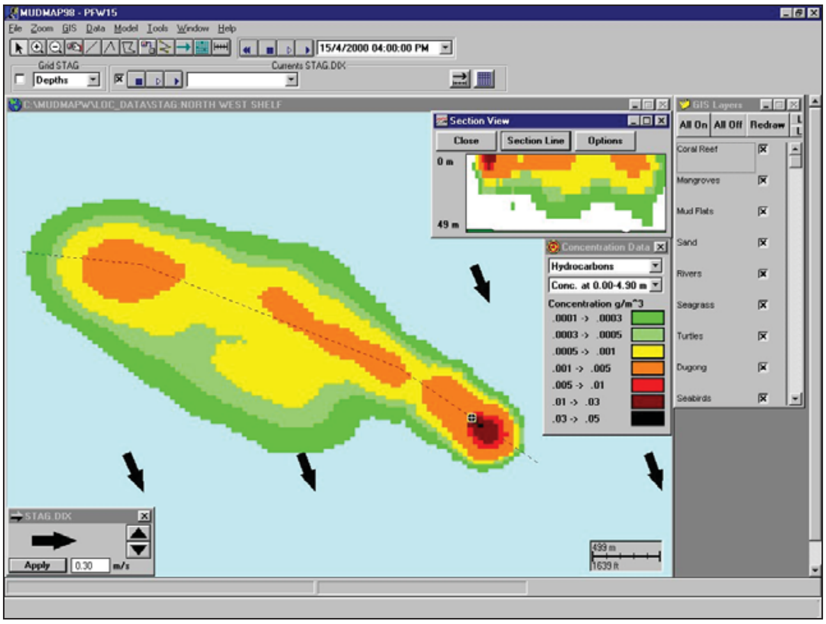

Figure A3. Example MUDMAP water column concentration output for drilling fluid discharge.

MUDMAP uses a color graphics-based user interface and provides an embedded geographic information system, environmental data management tools, and procedures to input data and to animate model output. The system can be readily applied to any location in the world. Application of MUDMAP to predict the transport and deposition of heavy and light drill fluids off Pt. Conception, California and the near-field plume dynamics of a laboratory experiment for a multi-component mud discharged into a uniform flowing, stratified water column are presented in Spaulding et al. (1994). King and McAllister (1997, 1998) present the application and extensive verification of the model for a produced water discharge on Australia's northwest shelf. GEMS (1998) applied the model to assess the dispersion and deposition of drilling cuttings released off the northwest coast of Australia.

MUDMAP References

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Appendix B: Particle Size Measurements of TCC cuttings

R.U.M. CONSULTANCY LTD.
GC/MS SPECIALISTS

Analysis Report

Report number 2014-0189

Client: Halliburton Manufacturing and Services Ltd

Date Samples Received: 30/10/2014

Number of samples received: 1

Date Report Completed: 18/11/2014

P/O: 4201051236

Note: Samples analysed as received. Results expressed as mg/kg for soils & mg/L for water unless otherwise stated.

Laboratory Reference	Sampling Date	Sample ID
1410300751	N/A	Dust sample

Particle Size Distribution by Laser Diffractometry

The samples were then analysed for particle size distribution by a Malvern Laser Diffractometer.
The results are shown in Figure 1

Analyst Signature...

Validator Signature...

R.U.M. CONSULTANCY LTD.
GC/MS SPECIALISTS

FIGURE 1 - 2014-0189

Result Analysis Report

Laboratory Code
1190817 1410300751

Measured:
14 November 2014 11:32:47

Sample Source & type:
Supplier = RUM Consultancy Ltd

Measured by:
analy

Analysed:
14 November 2014 11:32:48

Sample bulk lot ref:
1190817 = Run 1

Result Source:
Measurement

Particle Name: Default
Accessory Name: Hydro 2000G (A)
Analysis model: General purpose
Sensitivity: Normal

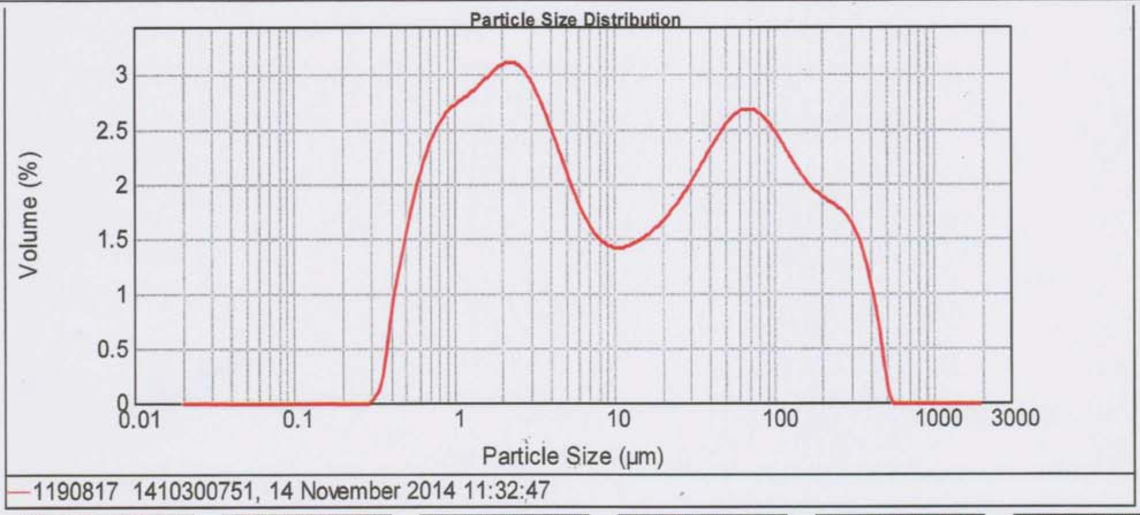
Particle RI: 1.520
Absorption: 0.1
Size range: 0.020 to 2000.000 um
Obscuration: 11.29 %

Dispersant Name: Water
Dispersant RI: 1.330
Weighted Residual: 2.324 %
Result Emulation: Off

Concentration: 0.0054 %Vol
Span : 18.528
Uniformity: 5.46
Result units: Volume

Specific Surface Area: 2.27 m²/g
Surface Weighted Mean D[3,2]: 2.639 um
Vol. Weighted Mean D[4,3]: 54.677 um

d(0.1): 0.843 um   d(0.5): 9.538 um   d(0.9): 177.564 um



Size (µm)	Volume In %
0.020	0.00
0.022	0.00
0.025	0.00
0.028	0.00
0.032	0.00
0.036	0.00
0.040	0.00
0.045	0.00
0.050	0.00
0.056	0.00
0.063	0.00
0.071	0.00
0.080	0.00
0.089	0.00
0.100	0.00
0.112	0.00
0.126	0.00
0.142	

Size (µm)	Volume In %
0.142	0.00
0.159	0.00
0.178	0.00
0.200	0.00
0.224	0.00
0.252	0.00
0.283	0.02
0.317	0.11
0.356	0.45
0.399	0.82
0.448	1.08
0.502	1.35
0.564	1.57
0.632	1.75
0.710	1.88
0.796	1.97
0.893	2.04
1.002	

Size (µm)	Volume In %
1.002	2.08
1.125	2.12
1.262	2.17
1.416	2.22
1.589	2.28
1.783	2.32
2.000	2.35
2.244	2.34
2.518	2.30
2.825	2.22
3.170	2.11
3.557	1.97
3.991	1.82
4.477	1.66
5.024	1.50
5.637	1.37
6.325	1.25
7.096	

Size (µm)	Volume In %
7.096	1.16
7.962	1.11
8.934	1.08
10.024	1.07
11.247	1.08
12.619	1.10
14.159	1.14
15.887	1.18
17.825	1.23
20.000	1.29
22.440	1.35
25.179	1.43
28.251	1.52
31.698	1.61
35.566	1.71
39.905	1.81
44.774	1.89
50.238	

Size (µm)	Volume In %
50.238	1.96
56.368	2.01
63.246	2.03
70.963	2.02
79.621	1.98
89.337	1.91
100.237	1.83
112.468	1.74
126.191	1.65
141.589	1.57
158.866	1.50
178.250	1.44
200.000	1.40
224.404	1.37
251.785	1.32
282.508	1.25
316.979	1.14
355.656	

Size (µm)	Volume In %
355.656	0.95
399.052	0.70
447.744	0.36
502.377	0.01
563.677	0.00
632.456	0.00
709.627	0.00
796.214	0.00
893.367	0.00
1002.374	0.00
1124.683	0.00
1261.915	0.00
1415.892	0.00
1588.656	0.00
1782.502	0.00
2000.000	

Operator notes: *2014-20517*

Appendix L

Toxicity Expert Opinion

A REVIEW OF TOXICITY TESTING EVALUATING APPLICABILITY OF INDIGNEOUS AND FOREIGN TEST SPECIES

INTRODUCTION

Toxicity testing has been used for several decades as a tool for researchers to evaluate the effects of contaminants in both aquatic and terrestrial environments. The techniques were standardized and adopted in the 1980's in the U.S. as a tool for the Environmental Protection Agency (EPA) to monitor effluents from a wide range to municipal and industrial dischargers as a way to establish water quality limits to meet the goals of the Clean Water Act. In the early 1990's, the EPA began requiring testing of discharges from offshore drilling operations to limit the discharge of toxic materials into the marine environment. The use of toxicity testing to monitor offshore oil and gas operations has subsequently been adopted by numerous countries and are now widely applied in areas such as the North Sea, Canada, Australia, and South America.

Toxicity testing can be done for both individual compounds as well as complex mixtures (Whole Effluents) of contaminants. Single component tests are useful to establish the relative toxicity of a single compound compared whereas complex mixture testing (Whole Effluent Toxicity tests – WET) measures the toxicity of multiple compounds in a mixture. The single chemical tests are useful to manufacturers who are looking to develop compounds that will have the lowest possible toxicity to the environment when used or discharged. Most municipal and industrial discharges are a complex mixture of chemicals in which toxicities of individual compounds are difficult to distinguish. In some cases, more than one chemical can contribute to a discharges toxicity. This is particularly important where additive and/or synergistic toxicity can be manifested in complex mixtures. In such cases, numerical standards by themselves do not provide sufficient protection. The toxicity tests allow for such discharges to be evaluated and compared to other similar types of discharges where contaminant concentrations can vary depending on chemical usage and other conditions of use.

Over the years, the offshore oil and gas industry has conducted extensive research and product development to be able to produce the least harmful products for use in its operations. This has resulted from such programs as REACH (Registration, Evaluation and Authorization of Chemicals) which focuses on development of products that have low toxicity, are readily biodegradable and do not bioaccumulate. Through the CHARM process, products used in the industry are given rankings with regards to their suitability for use and discharge offshore. Toxicity testing is a major tool in the development of these rankings.

Noble is being requested to perform toxicity testing in conjunction with its drilling and production operations in Israel. At this point in time, there are no existing laboratories in Israel that have the needed facilities, resources or training to conduct such tests. As a result, it will be necessary to utilize laboratories outside Israel for such tests. Noble's intent will be to contract with laboratories in the United States to perform the needed testing. This document describes the proposed tests and their applicability to the Israel offshore environment.

METHODOLOGY

Use of acute and sublethal endpoints for assessment of contaminant risk is not unique to toxicity testing with either water or sediments. Many international regulatory programs require the use of either acute or sublethal endpoints in their decision-making processes. In the U.S., these programs are adopted to achieve (1) Water Quality Criteria (and State Standards); (2) National Pollution Discharge Elimination System (NPDES) effluent monitoring (including chemical-specific limits and sublethal endpoints in toxicity tests); (3) Federal Insecticide, Rodenticide and Fungicide Act (FIFRA) and the Toxic Substances Control Act (TSCA, tiered assessment includes several sublethal endpoints with fish and aquatic invertebrates); and under the (4) Superfund (Comprehensive Environmental Responses, Compensation and Liability Act; CERCLA). Internationally, this regulatory tool is applied through the Organization of Economic Cooperation and Development (OECD, sublethal toxicity testing with fish and invertebrates); the European Economic Community (EC, acute and sublethal toxicity testing with fish and invertebrates); and the Paris Commission (behavioral endpoints). In 1995 OSPAR adopted a Harmonised Offshore Chemical Notification Format (HOCNF) as a first step towards a harmonised mandatory control system for the use and the reduction of the discharge of offshore substances/preparations. Table 1 references the methodologies that have adopted for performance of the tests.

Table 1. Summary of standardized toxicity testing methods which have been implemented around the world for both regulatory and research testing of discharged chemicals in marine environments.

Organization	Test	Reference
OSPAR	A Sediment Bioassay Using an Amphipod *Corophium sp* Protocol for a Fish Acute Toxicity Test	Protocols on Methods for the Testing of Chemicals Used in the Offshore Oil Industry *(reference number: 2005-11 (a revised version of agreement 1995-07))* ISO 16712 / OSPAR 2006 OSPAR 2006
ISO	Growth Inhibition Test Using the Marine Alga *Skeletonema costatum* Acute Toxicity Test Using the Marine Copepod *Acartia tonsa*	ISO/DIS 10253 ISO 14669
OECD	Harpacticoid Copepod Development and Reproduction Test with *Amphiascus tenuiremis* RECOMMENDED SPECIES: Marine algae test (*Skeletonema*, *Phaeodactylum*, etc.) Marine crustacean test (*Acartia*, *Tisbe*, *Mysisdopsis*, etc.) Marine annelid acute test (*Arenicola*) Marine crustacean acute test (*Corophium*) Sea urchin acute test (*Lytechinus*, *Echinocardium*)	Draft New Guidance Document, December 2013 OECD SERIES ON TESTING AND ASSESSMENT Number 11 Detailed Review Paper on Aquatic Testing Methods for Pesticides and Industrial Chemicals, ENV/MC/CHEM(98)19/PART1 (1998)

USEPA	Crustacea: Mysids (*Mysidopsis bahia* and *Holmesimysis costata*) Fish Sheepshead minnow (*Cyprinodon variegatus*) Silversides: Inland Silverside (*Mendia beryllina*), Atlantic Silverside (*M. menidia*), and Tidewater Silverside (*M. peninsulae*) Amphipods *Ampelisca abditu, Eohaustorius estuarius, Leptocheirus plumulosus,* and *Rhepoxynius abronius* *Mysidopsis bahia* (Mysid shrimp *Menidia beryllina* (Inland Silverside minnow)	Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms Fifth Edition October 2002 Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods. EPA 600/R-94/025 June 1994 Drilling Fluids Toxicity Test at 40 CFR Part 435, Subpart A, Appendix 2; Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, EPA-821-R-02-012;
ASTM	Standard guide for conducting 10-day static sediment toxicity tests with marine and estuarine amphipods (*Rhepoxynius abronius, Eohaustorius estuarius, Ampelisca abdita, Grandidierella japonica* , and *Leptocheirus plumulosus)*	ASTM (1993). In 1993 Annual Book of American Society for Testing and Materials (ASTM) Standards: E 1667-92, pp. 1138-1163

In general, it is clear that the accepted testing protocols have been developed such that there are standardized procedures across all regulatory regimes. The procedures tend to focus on species that primarily focus on well-known invertebrate and well-studied fish species.

TEST STRATEGIES AND OBJECTIVES

While toxicity testing has generally been accepted worldwide as a means to evaluate and regulate the discharge of materials in fresh and marine waters, the objectives of such testing in different regulatory regimes has different application strategies. In the North Sea, OSPAR adopted the Harmonised Mandatory Control System (HMCS) as a way to reduce the discharge of offshore chemicals across the Northeast Atlantic region. The objective of the HMCS is akin to an upfront approach to protect the marine environment by identifying those chemicals used in offshore oil and gas operations with the potential for causing an adverse environmental impact (Payne and Thatcher, undated), and restricting their use and discharge to the sea. This is generally done by using the toxicity testing in combination with tests that rank hazards of the individual chemical according to its persistence in the environment and tendency to bioaccumulate. This approach has led to the development of the CHARM assessment where chemicals are graded by color according to their persistence, bioaccumulation and toxicity (PBT) characteristics. Through this approach it is possible to regulate toxic chemicals at their source in terms of acceptability for discharge into the environment.

In Norway, further development of this approach led to the development of the DREAM Model (Rye et al 2006) which uses toxicity data based on the PEC (Predicted Environmental Concentration)/PNEC (Predicted No Effect Concentration) to calculate an EIF (Environmental Impact Factor) for the individual components contained in a discharge. This measure provides an estimate of risk from discharges of these effluents.

In the Gulf of Mexico, the U.S. Environmental Protection Agency (USEPA) regulates all offshore discharges from the oil and gas industry through a General Permit (USEPA 2012) which requires frequent toxicity testing during drilling operations and on produced water discharges from production operations. Because these discharges are usually complex mixtures of chemicals, the Agency chose to regulate the discharges at the "end of the pipe" as a means to monitor discharges that could be affected by additive or synergistic effects through toxicity limits. Bioassays of whole drilling fluids permit the assessment of potential effects of materials actually discharged from drilling operations. Research has shown that bioassay test results for individual components might be considerably different from bioassay test results obtained on those same components in an actual drilling fluid (Sprague and Logan, 1979). The General Permit, therefore, is used to monitor complex mixtures as opposed to single compounds. Toxic discharges are prohibited under this scenario. This is an approach that is also used in many other areas of the world.

By comparison, the Gulf of Mexico and North Sea strategies provide obvious near term and long term benefits to meeting environmental objectives. Through the North Sea approach, the industry has been incentivized to develop the most environmentally friendly products for use in the drilling and production of hydrocarbon resources. This has led to the development of low toxicity products being available for use in the offshore operations. Because of the regulatory that exists today, operators are incentivized to use products that meet REACH and/or CHARM criteria. When the Gulf of Mexico approach is used in conjunction with products that have low toxicity CHARM or REACH rankings, the highest level of environmental protection is applied. While environmental protection is applied in the selection of products for use offshore, the real time toxicity testing also provides monitoring to insure no unintended toxicity is introduced into the ongoing operations. If such risk exists, immediate mitigation can be applied to reduce impacts.

Table 2 compares the test parameters between OSPAR and Gulf of Mexico. While these differences are most evident in the length of the test, the actual test procedures themselves follow fairly similar protocols. However, the protocols established under the USEPA General Permit system for the Gulf of Mexico are specific for the testing of produced water, drilling muds, and drill cuttings with attached muds during actual operations. By comparison, the OSPAR guidelines are in general designed for the testing of single compounds that are present in a discharge with the intent to develop an estimate of risk associated with the specific contaminant. These data are used in conjunction with tests to characterize biodegradability and bioaccumulation potential of individual products to establish a risk model for discharges.

Table 2. Comparison of test conditions between OSPAR and Gulf of Mexico.

TEST	OSPAR	Gulf of Mexico
Alga	*S. costatum* - 72 hr EC50	Not required
Invertebrate	*A. tonsa* - 48 hr LC50	*M. bahia* 96 hr LC 50 – drill muds 7 day NOEC – Produced water
Fish	*S. maximus* – 96 hr LC50	*M. beryllina* 7 day NOEC – Produced water
Sediment	*Corophium volutator* - 10 day LC50	*Leptocheirus plumulosus* – 96 hr LC50 – Drill cuttings 10 day LC50 – Base fluid

TEST SPECIES SELECTION

There is general agreement among researchers as to the criteria to be used to select toxicity test species. For example, in its Standard Method for sediment toxicity testing for estuarine and marine invertebrates, the ASTM (2014) used the following criteria were considered when selecting test: (1) have a toxicological database demonstrating relative sensitivity to a range of contaminants of interest in sediment, (2) have a database for interlaboratory comparisons of procedures (for example, round-robin studies), (3) be in direct contact with sediment, (4) be readily available from culture or through field collection, (5) be easily maintained in the laboratory, (6) be easily identified, (7) be ecologically or economically important, (8) have a broad geographical distribution, be indigenous (either present or historical) to the site being evaluated, or have a niche similar to organisms of concern (for example, similar feeding guild or behavior to the indigenous organisms), (9) be tolerant of a broad range of sediment physico-chemical characteristics (for example, grain size), and (10) be compatible with selected exposure methods and endpoints. Ultimately, it was decided that a database demonstrating relative sensitivity to contaminants, contact with sediment, ease of culture in the laboratory or availability for field-collection, ease of handling in the laboratory, tolerance to varying sediment physico-chemical characteristics, and confirmation with responses with natural benthic populations were the primary criteria used for selecting *A. abdita*, *E. estuarius*, *L. plumulosus*, and *R. abronius* for the standard for 10-d sediment tests.

Rand et al (1995) had similar though a smaller list of criteria: 1) because sensitivities vary, a group of species should be used representing a broad range of sensitivities; 2) be widely available and abundant; 3) be indigenous or representative of the ecosystem being tested; 4) be recreationally, commercially, or ecologically important; 5) have standardized methods for both acute and chronic tests; 6) have adequate background data (e.g. physiology, genetics, behavior). In the opinion of these authors, Items 1, 5 and 6 were the most critical criteria for test species selection.

In their studies looking at exposures of marine organisms to oil and treated oil, Word et al (2014) indicated that whenever possible, test species for toxicity studies should be valuable ecosystem components (VECs) that represent the relevant environmental components potentially exposed to oil or treated oil. However, they add that species that are VECs do not necessarily lend themselves to toxicity studies. The authors suggest that characteristics for suitable test organisms would include the following:

- A sensitivity to oil and treated oil;
- Relative abundance and an availability for collection or culture;
- The ability to withstand laboratory handling;
- Meaningful and measurable endpoints over the time period of the study;
- Native to the site--specific conditions (e.g. cold water).

Numerous species have been used in testing over the years. ASTM has indicated in their toxicity testing standard that species are generally selected on the basis of availability, commercial recreational, and ecological importance, past successful use and regulatory use. The National Research Council (1983) reviewed the toxicity testing literature dealing with drilling mud effects and reported that 62 different marine species had been used in testing water based muds from the Gulf of Mexico, Pacific and Atlantic Oceans, and the Beaufort Sea. This included five major animal phyla including 12 species of fish, 30 species of crustaceans, 12 species of molluscs, 6 species of polychaetes, and 1 sea urchin species. Larval and early life stages were the most sensitive (Table 3). The copepods *Acartia tonsa* and *Centropages typicus* were the most sensitive species tested. Other relatively sensitive species included larvae of the dock shrimp *Pandalus danae*, pink salmon fry *Oncorhynchus gorbuscha*, larvae of the lobster *Homarus americanus*, juvenile ocean scallops *Placopecten magellanicus* and mysid shrimp (*Mysidopsis*, *Neomysis*, *Acanthomysis (Holmeimysis*), and *Mysis*). Crustaceans as a group, and in particular, copepods, mysids, and shrimp, were more sensitive than other major taxa to drilling fluids. There were no discernible differences in tolerance to drilling fluids among animals from the Atlantic Ocean, Gulf of Mexico, Pacific Ocean, and Beaufort Sea.

Table 3. Number of LC50 values reported for each group of organisms in each toxicity range when tested against drilling muds (from National Research Council 1983).

	LC50 (mg/l)					
Organism	**Not Determinable**	**100**	**100-999**	**1,000 - 9999**	**10,0000 – 99,999**	**100,000**
Phytoplankton	5	6	0	7	0	0
Crustaceans						
Copepods	4	2	11	15	7	0
Isopods	0	0	0	0	1	5
Amphipods	0	0	0	0	5	14
Mysids	1	0	1	0	21	18
Shrimp	0	0	12	15	31	18
Crabs	1	0	0	5	16	13
Lobsters	0	0	0	1	3	3
Molluscs						
Gastropods	0	0	0	0	2	8
Bivalves	0	0	0	1	15	17
Echinoderms Sea Urchins	0	0	0	0	1	3
Polychaetes	0	0	0	0	9	19
Finfish	0	0	0	3	52	35
TOTAL	**11**	**2**	**24**	**47**	**163**	**153**

Other researchers have also demonstrated that the sensitivities of animals from different geographic regions do not differ greatly. For example, Hansen et al (2014) tested the sensitivity of five marine species (alga *Skeletonema costatum*, the planktonic copepod species *Acartia tonsa* (temperate), *Calanus finmarchicus* (boreal), and *Calanus glacialis* (Arctic), and the benthic copepod *Corophium volutator*) to eight oil spill response chemicals. The copepod species showed a relatively similar sensitivity to all of the products. Single-species acute toxicity data and (micro) mesocosm data collated for 16 insecticides by Maltby et al (2009) provided similar results. These data were used to investigate the importance of test-species selection in constructing species sensitivity distributions (SSDs) and the ability of estimated hazardous concentrations (HCs) to protect freshwater aquatic ecosystems. Species sensitivity distributions for specific taxonomic groups (vertebrates, arthropods, non-arthropod invertebrates), habitats (saltwater, freshwater, lentic, lotic), and geographical regions (Palaearctic, Nearctic, temperate, tropical) were compared. The taxonomic composition of the species assemblage used to construct the SSD had a significant influence on the assessment of hazard, but the habitat and geographical distribution of the species did not. Moreover, SSDs constructed using species recommended in test guidelines did not differ significantly from those constructed using non-recommended species.

Currently, the author is not aware of any ecotoxicology studies having dealt with deep sea species. In recognizing the challenges of developing environmental risks of oil and gas operations in the Arctic, Word et al (2014) commented that "*because of the relative difficulty in conducting Arctic toxicology studies at extremely low temperatures with authentic Arctic species, there are relatively few comprehensive investigations. However, relatively recent attention has focused on the issue of relative sensitivity of Arctic species to temperate species and several assessments have similarly concluded that arctic and temperate species show little difference in relative sensitivity when toxicity studies were conducted with similar methodologies*".

Olsen et al. (2011) ran acute toxicity tests with Arctic and temperate species with a single PAH (2--methyl naphthalene) and concluded that median estimates for the hazardous concentrations affecting 5 and 50 percent of the species (HC5 and HC50) based on both the NOEC and LC50 estimates were less than a factor 2 higher for temperate species than for Arctic species and were not statistically different (Figure 1). The authors concluded that there was no regional differences in tolerance to 2--methyl naphthalene either at the species level (LC50 and NOEC) or at the aggregated species level (HC5 and HC50). Further they conclude that the values of survival metrics established for temperate regions are transferrable to the Arctic. These findings are supported by Word et al. 2014 who compare the relative sensitivity of Arctic and non--Arctic species using measured and literature data. They come to a similar conclusion for parent naphthalene, WAF (water accommodated fraction), and CEWAF (chemically enhanced water accommodated fraction) in spiked exposures (Figure 2).

In another study looking at species sensitivities, Roberts et al (1982) compared the acute toxic response of species pairs tested simultaneously to three toxicants: sodium lauryl sulfate, cadmium, and Lannate® (methomyl). One species in each test was that recommended by the U.S. Environmental Protection Agency (EPA), the other a closely related species. Species-pairs included *Prorocentrum minimum* - *Pseudoisochrysis paradoxa* - *Skeletonema costatum* (phytoplankters); *Neomysis americana*-*Mysidopsis bahia* (mysid shrimp);

Eurytemora affinis-Acartia tonsa (copepod); and *Menidia menidia-Cyprinodon variegatus* (fish). For each

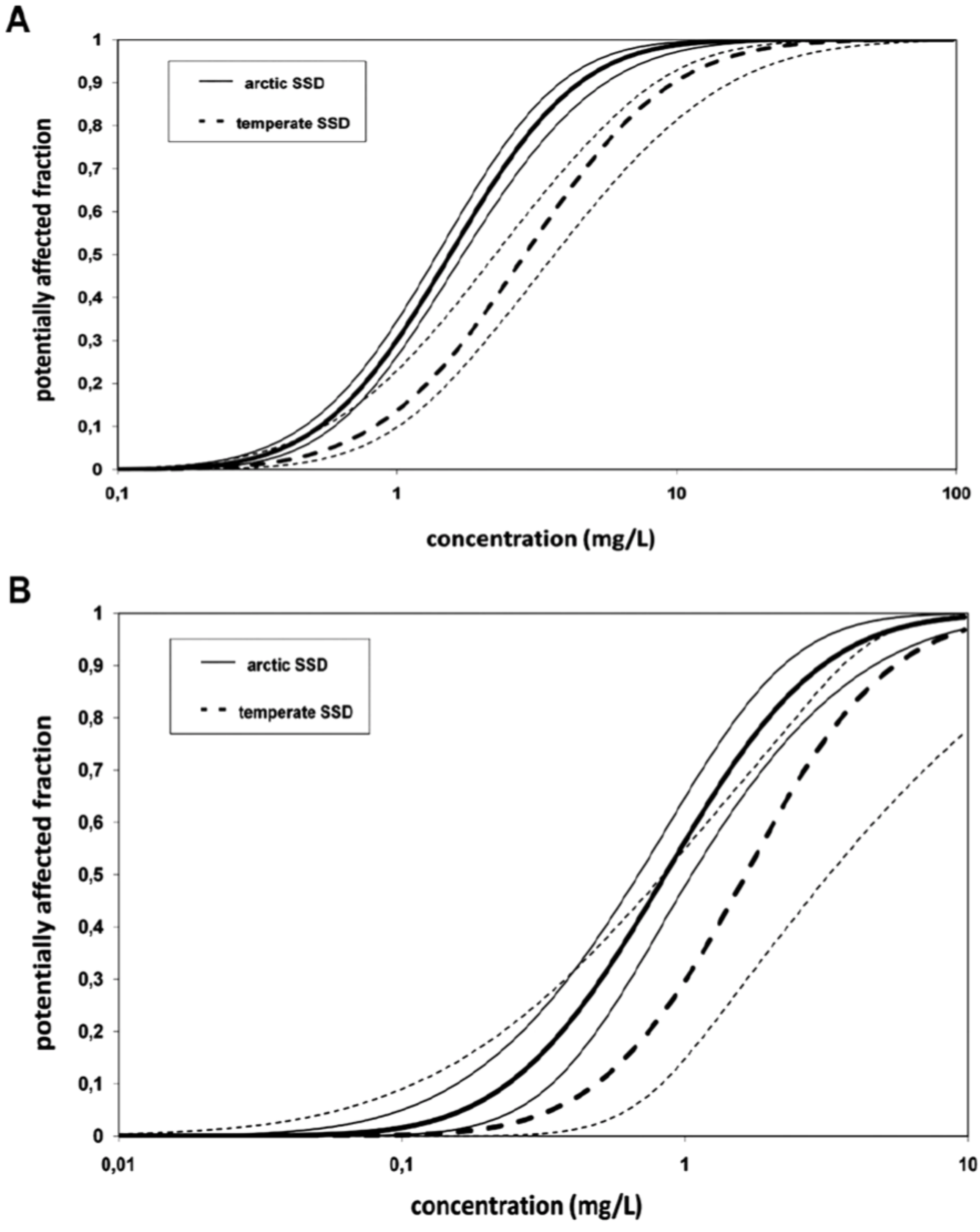


Figure 1. Species sensitivity distribution curves comparing the relative sensitivity for Arctic (solid line) and temperate (dashed line) species to 2-methylnaphthalene based on (A) LC50s and (B) NOEC (no effect concentration. This dashed lines represent 95% confidence intervals (from Olsen et al (2011)).

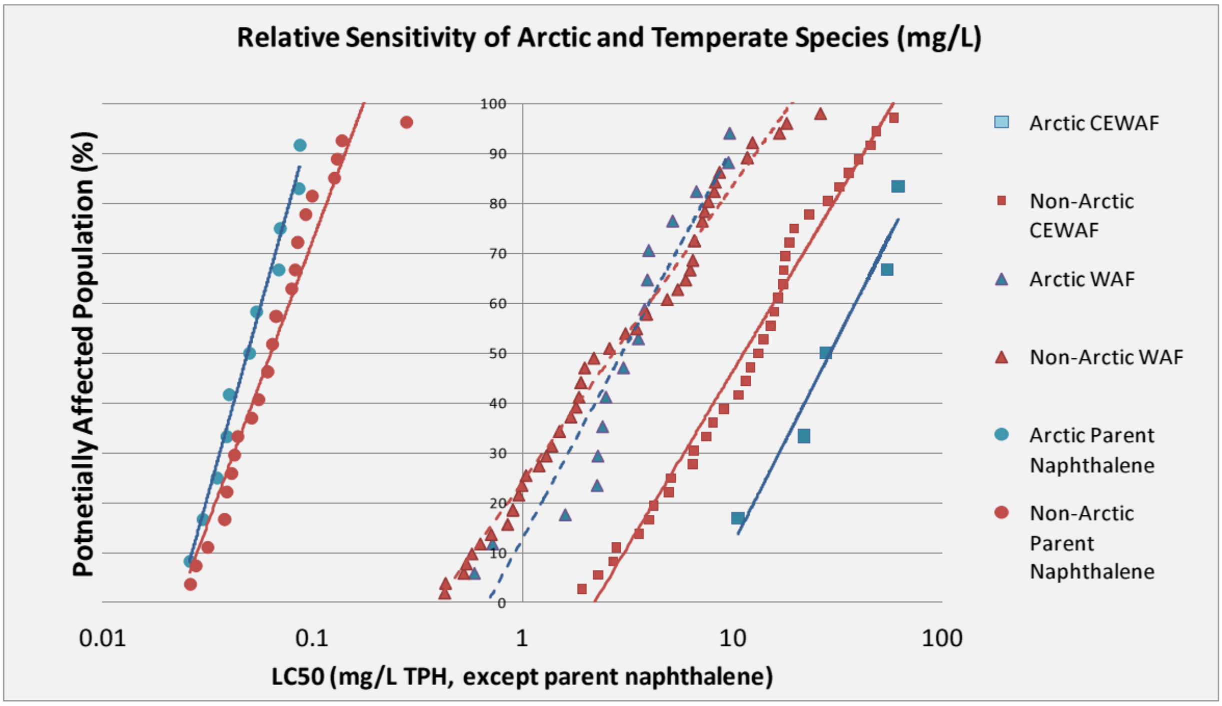


Figure 2. Relative sensitivity of Arctic and Temperate species to naphthalene, WAF, and CWAF exposures (from Word et al 2014).

toxicant, the species pairs yielded similar lethal (effective) concentrations for 50% of the test animals [LC (EC) 50s]. The LC (EC) 50s differed by no more than 4.7 with the exception of the phytoplankton response to cadmium, in which case *Prorocentrum minimum* was more sensitive than the other phytoplankton species.

Raimondo et al (2008) noted that assessments of the ecological risks of chemical exposures to listed species often rely on the use of surrogate species, safety factors, and species sensitivity distributions (SSDs) of chemical toxicity while addressing the uncertainty in protectiveness of these approaches. They evaluated the protectiveness of SSD first and fifth percentile hazard concentrations (HC1, HC5) relative to the application of safety factors using 68 SSDs generated from 1,482 acute (lethal concentration of 50%, or LC50) toxicity records for 291 species, including 24 endangered species (20 fish, four mussels). Their results showed that crustaceans were generally the most sensitive taxa when the relative sensitivity (SSD percentiles) of broad taxonomic groups was compared and that taxa sensitivity was related to chemical mechanism of action. Comparison of relative sensitivity of narrow fish taxonomic groups showed that standard test fish species were generally less sensitive than salmonids and listed fish. They concluded that the use of SSDs as a distribution-based risk assessment approach that is generally protective of listed species and recommended its use.

LOCAL VS FOREIGN SPECIES

Certainly, because of the long history with the use of toxicity testing in the Gulf of Mexico and North Sea, these areas have the greatest volume of background ecotoxicological data relating to offshore oil and gas drilling. Both of these regions have adopted standard test species for their regulatory needs. OSPAR protocols for toxicity testing of discharges from the offshore oil and gas industry focus on the alga *Skeletonema costatum,* the copepod *Acartia tonsa* and a fish, *Scophthalamus maximus* for water column impacts and on the amphipod, *Corophium volutator,* for sediment. In the Gulf of Mexico, protocols to test for possible water column impacts use the crustacean *Mysidopsis bahia* (Mysid shrimp) and the fish *Menidia beryllina* (Inland Silverside minnow). Sediment testing uses the amphipod *Leptocheirus plumulosus.* While none of these species can be considered as indigenous to the deep ocean environments (with the possible exception of the *Acartia*), the USEPA for one has accepted the use of the mysid, silverside minnow, and the *Leptocheirus* as acceptable species to monitor drilling mud and produced water discharges. Given the difficulties inherent in providing sufficient organisms from the deep water environments that meet specified criteria for testing (described earlier in this report), use of these standard test organisms satisfies the objectives of the monitoring goals. This is based on the fact that research, as described in this report, has tended to show that geographic differences do not have a marked effect on the sensitivities within species groups.

This brings back the question in regards to a preference for the use of local species for toxicity testing in Israel. While this may be the preferred strategy, a short term solution may be impractical. As mentioned previously, the volume of ecotoxicology information on deep sea species such as would occur in the Eastern Mediterranean is minimal at best and more likely non-existent. As described in the above report, much of this can be attributed to the logistical problems associated with capturing sufficient test organisms, being able to maintain such organisms in culture where they would be readily available, and lastly with a paucity of data on their physiology. Additionally, one of the biggest hindrances at the present is the lack of a local laboratory engaged in toxicological testing in Israel. Until such lab is available, any toxicity test that will be undertaken will have to be shipped to a foreign lab. At the present, most of those options reside in the areas around the North Sea or the Gulf of Mexico. This is not to rule out the potential for ultimately having test species that are indigenous to the Mediterranean. For example, Perez and Beiras (2009) tested the effects of reference toxicants, three trace metals (Copper, Cadmium and Zinc), and one surfactant, sodium dodecyl sulfate (SDS) using the mysid *Siriella armata* (Crustacea, Mysidacea). This species is a component of the coastal zooplankton that lives in swarms in the shallow waters of the European neritic zone, from the North Sea to the Mediterranean. In the testing, *S. armata* showed higher sensitivity than the freshwater model organism Daphnia magna suggesting that this validated the use of *Siriella* mysids as model organisms in marine acute toxicity tests.

Using the criteria described earlier in this report, Table 4 compares the situation as it applies to the use of local versus out of area species for testing.

Table 4. Comparative applicability for using local versus foreign species for toxicity testing in Israel.

CRITERION	LOCAL	FOREIGN
(1) have a toxicological database demonstrating relative sensitivity to a range	Non-existent in Israel, probably limited in Mediterranean	Well established species with history of testing and extensive database

of contaminants of interest in sediment		
(2) have a database for interlaboratory comparisons of procedures (for example, round-robin studies)	Non existent laboratories in local region	Well established labs in North Sea and Gulf of Mexico regions
(3) be in direct contact with sediment	Likely to be suitable local species from coastal areas	*Leptocheirus* from Gulf of Mexico and *Corophium* from North Sea
(4) be readily available from culture or through field collection	Unknown capability	Standardized methodologies for lab culture and field collection
(5) be easily maintained in the laboratory	Unknown, procedures would need to be developed	Culture techniques and success ratios are known and understood
(6) be easily identified	Should not be an issue	Already established taxonomies
(7) be ecologically or economically important	Determined based upon species selection	Life cycles and trophic structures are known
(8) have a broad geographical distribution, be indigenous (either present or historical) to the site being evaluated, or have a niche similar to organisms of concern (for example, similar feeding guild or behavior to the indigenous organisms)	Likely to be available species to satisfy this criterion	Standard species from Gulf of Mexico and North Sea are not indigenous to Eastern Mediterranean. Some data exist to measure sensitivities against species from other geographic regions. Species are known to be sensitive
(9) be tolerant of a broad range of sediment physico-chemical characteristics (for example, grain size)	Will be determined on the basis of a selected species which is currently unknown	Standard species have been tested against ranges of grain sizes and sensitivities are understood
(10) be compatible with selected exposure methods and endpoints	Selected species would need to be adapted to standard methods unless additional methods development tis required	Already adapted to wide range of selected exposure methods and endpoints; in some cases, are used in both acute and chronic tests with endpoints including survival, growth, and reproduction

CONCLUSIONS

The following conclusions can be drawn from the above report:

1) Currently the Eastern Mediterranean lacks the structure needed to conduct toxicity testing. This lack exists for both available labs with needed expertise and experience as well as any prior history of testing with local species;
2) While there may be some data available for Mediterranean species, it is limited and additional methods and species testing is required to establish suitable local standard test species;

3) Well-established laboratories exist in both the North Sea and Gulf of Mexico experienced in conducting toxicity testing using internationally accepted methods for oil and gas operations and chemicals;
4) Standard test organisms from these regions are not indigenous to the Eastern Mediterranean. Gulf of Mexico uses temperate species, North Sea testing uses boreal species.
5) Research has indicated that sensitivities within species groups tends to be similar across geographic regions (i.e. temperate, Arctic and boreal species show similar sensitivities to chemical exposures).
6) North Sea testing focuses more on toxicity testing against individual compounds while Gulf of Mexico focuses on whole effluent toxicities.
7) Testing regimes adopted in the North Sea and Gulf of Mexico both use invertebrates and fish. Invertebrate tests include pelagic and sediment dwelling organisms.
8) Crustaceans, particularly copepods and mysids have generally been shown to be the most sensitive species; the copepod *Acartia* in the North Sea and the mysid *Mysidopsis* in the Gulf of Mexico are the standard species used in their respective regions.

RECOMMENDATIONS

Since there are no labs currently established in Israel that have capabilities to conduct toxicological testing, outside labs will be needed at least for the foreseeable future to conduct any required toxicity tests. In the past, Noble has used laboratories in the U.S. to conduct toxicity tests on produced water and drilling samples from its operations in Israeli waters. It is recommended that this practice continues since the species used in the Gulf are temperate and from similar environmental conditions as experienced in Israel. This may not be entirely significant given that the data tend to show similar sensitivities across geographic regions. However, of potentially more significance in that the testing procedures from the Gulf are more specialized towards the testing of whole mixture drilling muds and cuttings and produced waters as opposed to the focus of single compound tests from the North Sea. This will provide a larger database to compare against when evaluating Israeli test results as compared to North Sea data. One potential drawback is that the components of the drilling mud being proposed for use in Israel has previously been tested against species from the North Sea (Table 5). However, this can be mitigated by similar testing of these individual components using the Gulf of Mexico species. While such testing will be of interest, it must also be recognized that such individual compound testing, as stated before, will not reflect the toxicity of a mixture of these compounds in a drilling mud or to a mud that has been used downhole in a well.

Table 5. Summary of OCNS CHARM data for the proposed drilling mud system.

Product name	OSPAR derived data			Toxicity data		
	OCNS (UK) Registered	OCNS Rating	Substitution Warning	Toxicity (worse case)	Toxicity Sediment reworker	Comments
	No					Likely to pass pre-screening and the final rating would depend upon the *Corophium* toxicity. Expected to be an OCNS C or D rating.
	Yes (NON CHARM)	C	No	1000 mg/l (96 hr LC50) *Onchorhyncus mykiss)*		Readily biodegradable, does not bio-accumulate (69% in 28 days)
	PLONOR	E	No	n.a.	n.a.	
	PLONOR	E	No	n.a.	n.a.	
	PLONOR	E	No	n.a.	n.a.	
	Yes (NON CHARM)	B	Yes	237.1 mg/l EC 50 72 hr (*Skeletonema costatum*)	8872 mg/kg (LC50 *Corophium volutator*)	
	Yes (NON CHARM)	E	Yes	>1000 (mg/l limit test*) Scophtalmus maximus)*	105000 (LC50 *Corophium volutator*)	
	Yes (NON CHARM)	D	No	23. mg/l EC 50 72 hr (*Skeletonema costatum*)	10000 mg/kg (LC50 *Corophium volutator*)	SPP in generic @ 15.0 lbs/bbl: 64,600 ppm SPP
	Yes (NON CHARM)	E	No	5600(mg/l limit test) *Scophtalmus maximus)*	13662 mg/kg (LC50 Corophium volutator)	SPP in INNOVERT @ 5.0 lbs/bbl: 68,100 ppm SPP

The recommended protocols would be those laid out in the NPDES General Permit for the Gulf of Mexico (USEPA 2012). The proposed testing is summarized in Table 6. It includes testing of the base fluid, a suspended particulate phase of the used mud, and tests with the solid phase. A schedule for each type of testing is included.

Table 6. Schedule of toxicity testing of drill muds and cuttings (from USEPA 2012).

DISCHARGE	MONITORED PARAMETER	SPECIES	DISCHARGE LIMITATION	TEST FREQUENCY	METHOD
Drilling Fluid	96 hr LC50	*Mysidopsis bahia*	30,000 ppm	Once/month Once/end of well	Drilling Fluids Toxicity Test at 40 CFR Part 435, Subpart A, Appendix 2.
Drill Cuttings	96 hr LC50	*Mysidopsis bahia*	30,000 ppm	Once/week when drilling	USEPA 1993. *Mysidopsis bahia* Acute Static 96 hr Toxicity Test, FR58 (41): 12507-12512
Stock Limits for Drill Cuttings Generated using Non aqueous Based Drilling Fluids (base fluid blend)	10-day LC50	*Leptocheirus* sp.	The ratio of the 10-day LC50 of C16 - C18 internal olefin divided by the 10-day LC50 of the base fluid shall not exceed 1.0	Once/year on each base fluid blend	ASTM method E1367-99
Discharge Limits for Cuttings Generated using Non aqueous Based Drilling Fluids (drilling fluids, removed from cuttings at the solids control equipment)	4-day LC50	*Leptocheirus* sp.	The ratio of the 4-day LC50 of C16 - C18 internal olefin divided by the 4-day LC50 of the base fluid shall not exceed 1.0	Once/month.	Modified ASTM Method E1367-99

MONITORING

The reality of laboratory toxicity testing is that it does not absolutely reflect actual conditions in the environment but is simply an indicator of a potential impact. One must really interpret toxicity data as a measure of risk. On a relative basis, discharge which show high levels of toxicity provide the higher level of potential risk to the environment bit for numerous reasons the reality may be less or more that indicated by the test. As the OSPAR approach is meant to identify toxic chemicals early in the process of product formulation and reduce their eventual release into the environment, the real time testing of drilling muds and cuttings in the field is to identify actual operating conditions and reduce the risk that materials are being discharged. Toxicity data which suggest regulatory parameters are being exceeded would disallow the discharge of such materials. Ultimately, if the goal is achieved, discharged materials would optimally not produce impacts related to toxicity. However, this would not completely eliminate the possibility that residual or artifactual effects could be observed. For instance, it is impossible to eliminate the impacts of the deposition of drill cuttings on the ocean floor. This would be a physical effect that should be short term depending upon how quickly recolonization would occur. Similarly, some compounds when deposited on the bottom could lead to oxygen depletion in bottom sediments due to biodegradation. One of the parameters by which chemicals are ranked through the REACH/CHARM process is biodegradability. Impacts from readily biodegraded products will be short term, longer in the case of those materials which tend to persist. It is intended that there will be long term monitoring of the Tamar and Leviathan fields that will address such impacts with field surveys targeted to determining the extent of such impacts. By using the data on the chemicals found in the drilling fluids and looking at the toxicity data, monitoring can be focused on any expected impacts that will be due to suspected toxicity or physic-chemical impacts. However, as stated earlier, the intent of implementing the programs described above, the ultimate objective is to be able to mitigate against most of these impacts before they occur.

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Appendix M

Fuel Spill Trajectory Analysis

Dispersion Modeling of a Fuel Spill in the Leviathan Field

Steve Brenner

Report submitted to Noble Energy Mediterranean Ltd.

HYDRODYNAMIC MODEL

The currents used to drive MEDSLIK were generated using an expanded domain version of the model developed for the southeastern Levantine basin within the framework of the Mediterranean Forecasting System (MFS). The model is based on the Princeton Ocean Model (POM) which is a time dependent, three dimensional primitive equations ocean model. For the scenarios considered here, the model domain covers the entire Levantine basin east of 30°E. The horizontal resolution is 1' (~1.7 km) and the water column is divided into 30 unevenly spaced sigma layers. The bathymetry was extracted from the General Bathymetric Chart of the Oceans (GEBCO) global 1' data set. The model is nested in the daily MFS reanalysis fields (1/16°, ~6.5 km horizontal resolution) for the relevant period following the methodology of Brenner (2003) and Brenner et al. (2007). These models and the nesting methodology have been extensively tested and validated for this region within the framework of MFS. The domain and the bathymetry for the model are shown in **Figure A1**. The location of the ML-1X drilling site is indicated by the red dot.

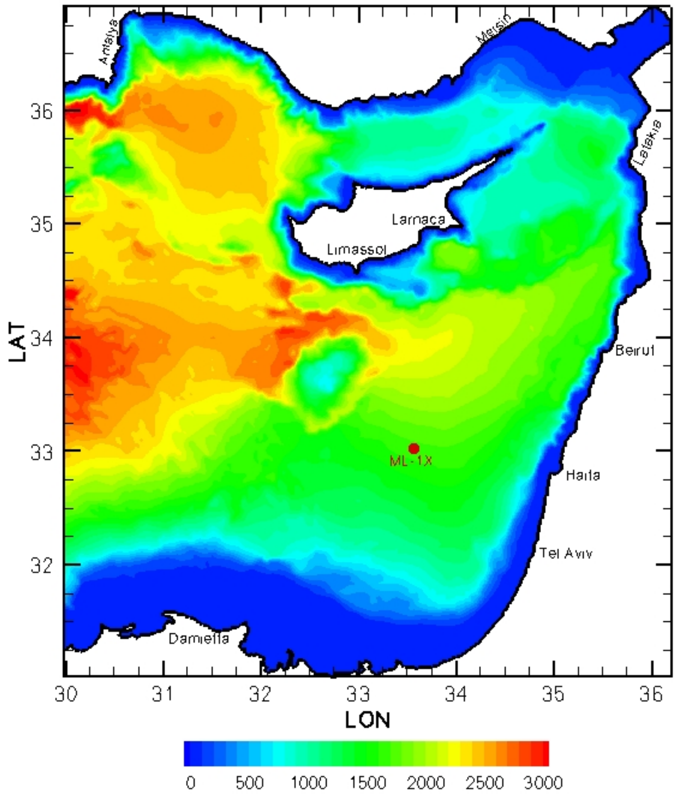

Figure A1: Domain and bathymetry for the circulation model.
The red dot indicates the location of the ML-1X drilling site.

OCEANOGRAPHIC AND METEOROLOGICAL CONDITIONS

The hydrodynamic model requires initial conditions as well as time dependent lateral boundary conditions at the open (western) boundary and surface foricing. The initial and lateral boundary conditions were extracted from the daily reanalysis fields produced by hindcasts and retrospective analyses within the framework of the operational MFS. Daily averaged fields of temperature, salinity, currents, and sea level are available beginning from 1999. The spatial resolution is 1/16° (~6.5 km) horizontal and 72 fixed depth levels in the vertical.

For surface forcing, the 10 m winds were extracted from the NCEP reanalysis data sets. These data are available with a frequency of 6 hours. Surface heat and fresh water fluxes were approximated by relaxing the model's surface temperature and salinity to the MFS reanalysis fields with a relaxation time scale of 2 days. All data were spatially and temporally interpolated to the model grid and time step as necessary. In order to eliminate the initial mismatch between the original reanalysis fields and the interpolated values, each simulation was started three days before the desired data to allow for model spin up.

OIL SPILL MODEL

The oil spill model used for these simulations is MEDSLIK Version 5.3.6. MEDSLIK was developed by the Cyprus Oceanographic Center and is currently the model of choice that is used by the MFS community. An oil spill is treated as a collection of tens of tounsands of particles which are dispersed using a Lagrangian particle tracking scheme and a random walk diffusion scheme. It also includes processes of physio-chemical weathering such as evaporation and emulsification.

SCENARIOS

Four time periods representative of various climatic conditions over the eastern Mediterranean were considered.

- Scenario 1 – 9 Dec 2010 – 8 Jan 2011, a period that included an extreme winter storm;
- Scenario 2 – 26 Jan – 25 Feb 2008, typical winter conditions;
- Scenario 3 – 17 Jul – 16 Aug 2008, typical summer conditions with persistent northwesterly winds and swell; and
- Scenario 4 – 25 Sep - 25 Oct 2007, autumn conditions typical of the trnasition seasons and including at least one episode of strong easterly to northeasterly wind.

For each period, an instaneous discharge of 8,4215.6 m^3 barrels of diesel fuel from the drilling rig was simulated.

RESULTS

The set of simulations presented in this section includes four scenarios of an instantaneous spill of 8,415.6 m^3 (52,932.5 bbl) of operational diesel fuel from stoarge tanks on the drilling rig. In contrast to the 30 day continuous discharges, in all of the instantaneous spill simulations, except for the extreme winter case, there is a strong tendency for the oil to spread as a coherent slick and for a significant amount to be deposited on the coast.

9 Dec 2010 – 8 Jan 2011

The oil fate parameters for the extreme winter scenario are shown in **Figure A2**. The diesel fuel is relatively light (API 35) and therefore a significant amount evaporates rather quickly. Within 42 hours, 45% of the oil has evaporated. The final balance at the end of 30 days is mainly between evaporation and oil remaining on the surface with 45.6% and 42.5%, respectively. Roughly 11.9% of the oil is dispersed in the water column and only a very negligible amount (0.003% or 0.25 m^3) is deposited on the coast. The length of impacted coastline is 1 km in the vicinity of Paphos on the southwestern coast of Cyprus.

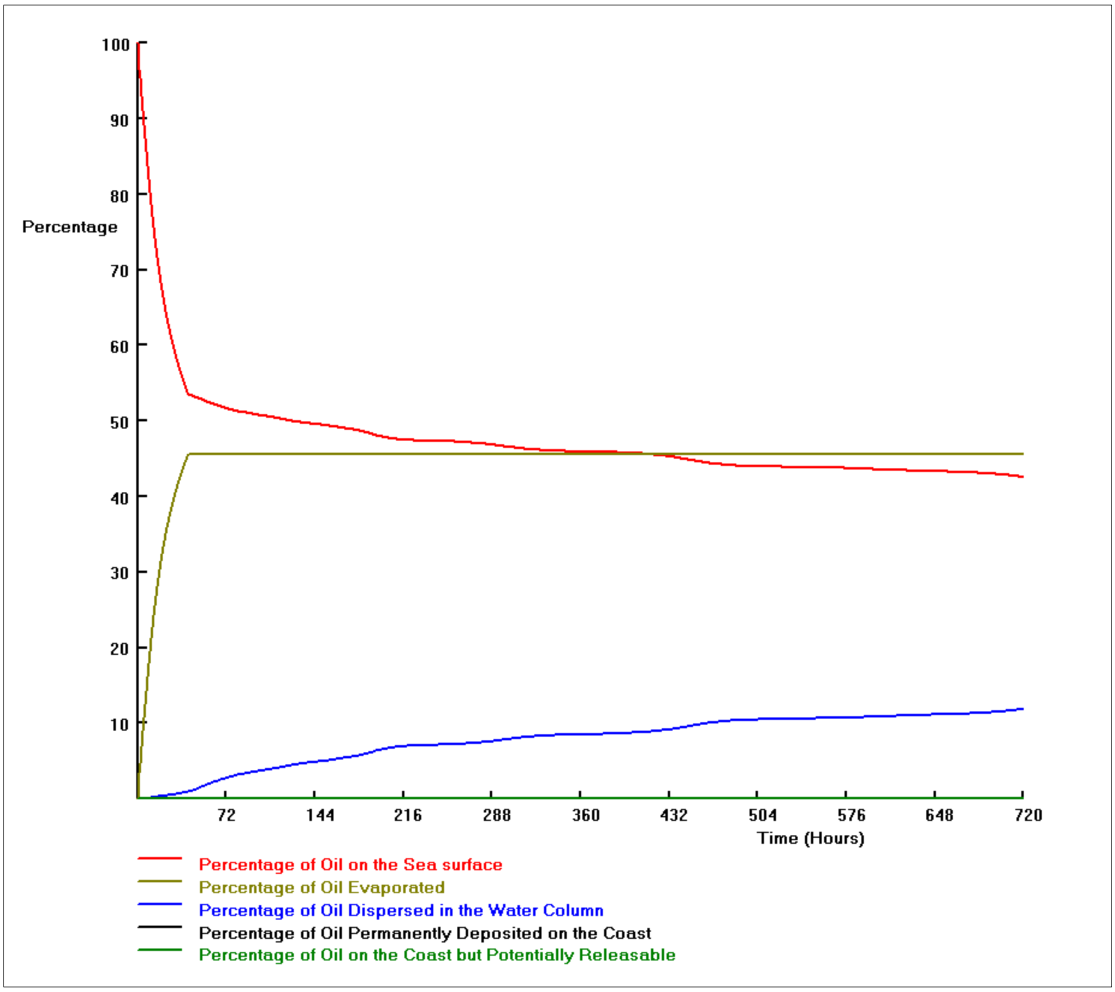

Figure A2: Oil fate parameters for the instantaneous diesel fuel spill on 9 Dec 2010

The diesel fuel remaining on the surface after 30 days is shown in **Figure A3**. The main part of the slick circulates around the large anticyclonic eddy located south of Cyprus and eventually drifts to the east. Some of the oil continues to spirals clockwise around this eddy and a very small amount is transported to the northwest and eventually reaches the southwestern cost of Cyprus. The slick spreads over a relatively large area (in contrast to the next three scenarios) due to the highly energetic currents and strong winds.

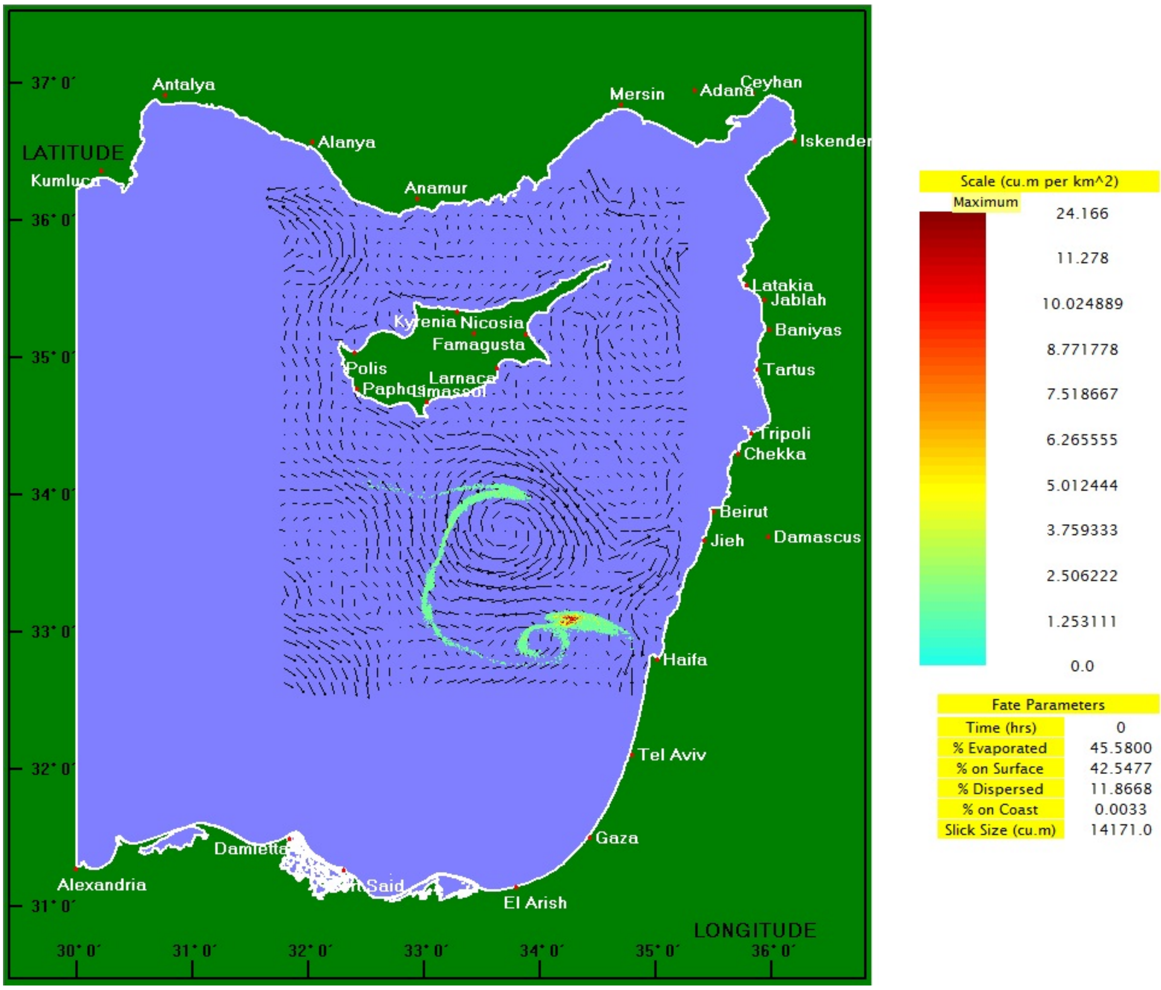

Figure A3: Diesel fuel remaining on the surface at the end of 30 days
after an instantaneous diesel fuel spill on 9 Dec 2010.

26 Jan – 26 Feb 2008

Figure A4 shows the oil fate parameters for the typical winter case for a spill on 26 Jan 2008. As with all other scenarios, evaporation occurs very quickly with more than 45% of the diesel fuel evaporated by 46 hours after the spill. The slick spreads as a coherent mass with minimal dispersion for a few days. On day 7 it approaches the coast but then begins to spread northward and southward due to the shelf current and the winds. Significant coastal deposition does not begin until day 20 which continues until the end of the simulation at which time slightly more than one quarter of the diesel fuel reaches the coast. A rather long section of the coast, 220 km, is potentially affected (see discussion of Figure 18). After 30 days, the balance is mainly between evaporation, diesel fuel deposited on the coast, and fuel remaining on the surface with 45.6%, 27.2%, and 18.8%, respectively. Only 8.2% is dispersed in the water column.

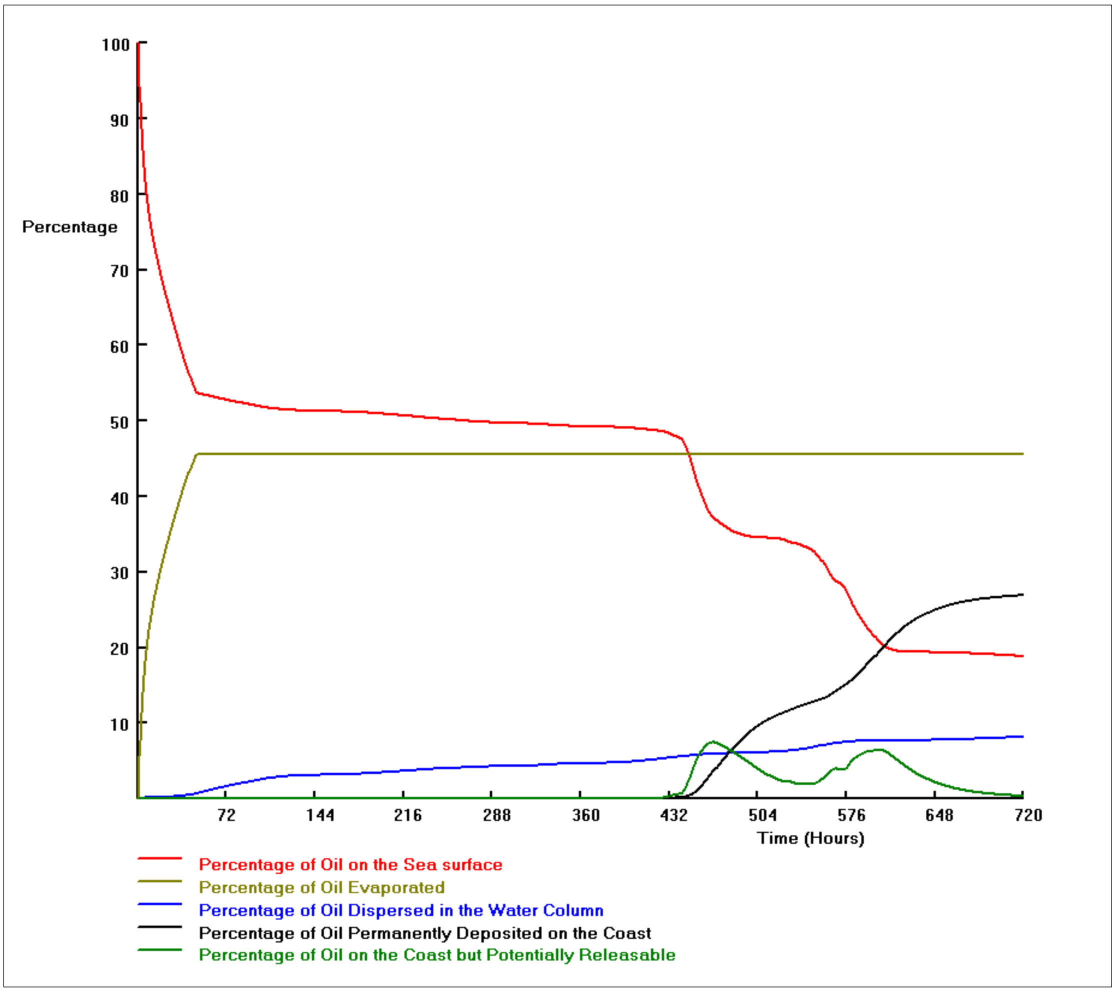

Figure A4: Oil fate parameters for the instantaneous diesel fuel spill on 26 Jan 2008

The diesel fuel remaining on the surface at the end of 30 days is shown in **Figure A5**. As noted above, the diesel fuel is transported as a coherent slick which approaches the coast during the first week. However before reaching the coast it spreads to the north and south by the combined effects of the currents (northward) and the winds which have a strong northerly component during part of this period. By day 17 the wind becomes westerly again and forces the slick towards the coast. Coastal deposition begins on day 20 and proceeds rapidly until the end of the 30 day period.

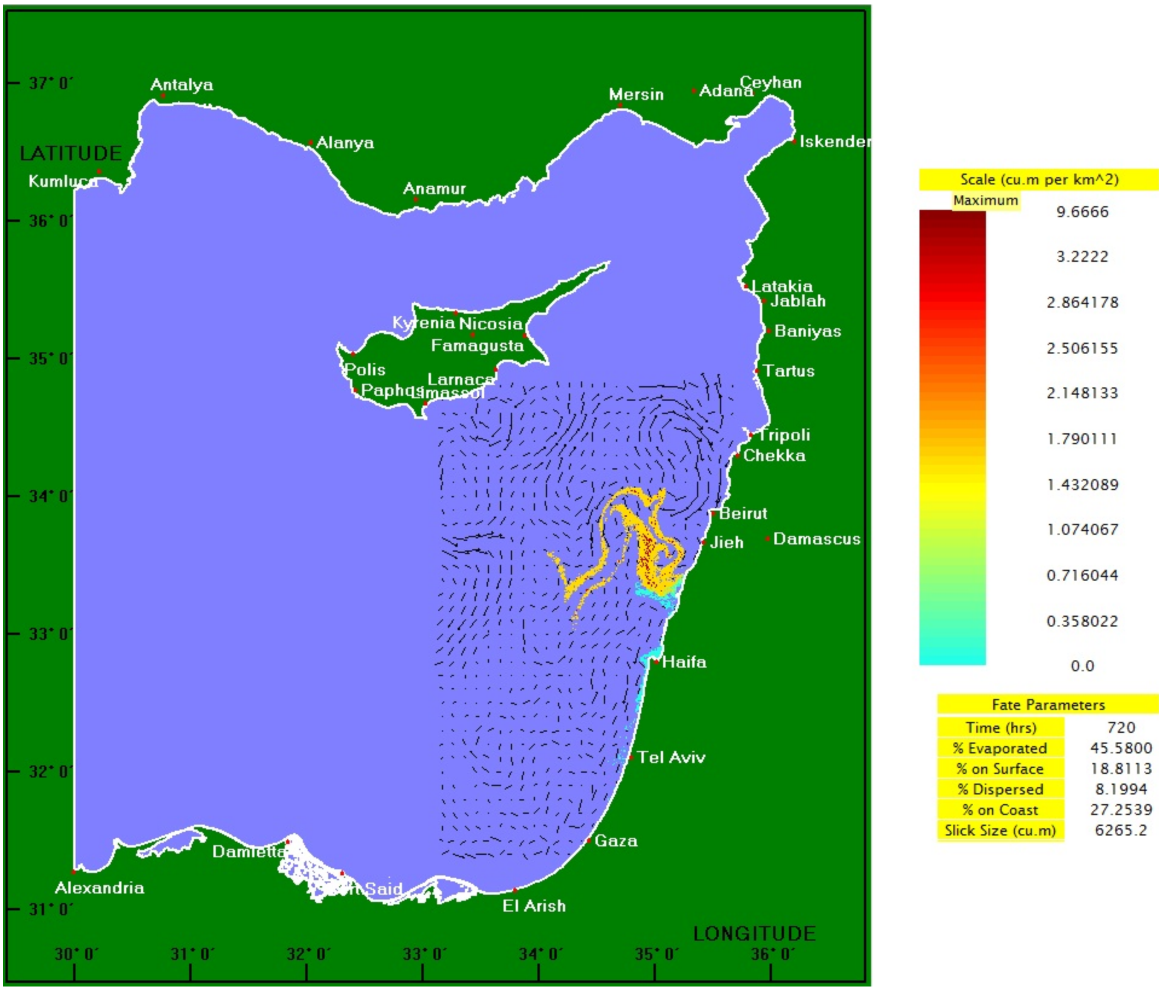

Figure A5: Diesel fuel remaining on the surface 30 days after
an instantaneous diesel fuel spill on 26 Jan 2008.

The total amount of diesel fuel accumulated on the coast after 30 days is shown on **Figure A6**. The section of coast from Ashkelon to Beirut is potentially affected by the coastal deposition, although in most areas the concentrations are less than 1 m^3/km. The two most adversely affected zones are near the border between Israel and Lebanon and south of Beirut where concentrations are typically 15-20 m^3/km, but with some limited, local hotspots where the concentration can exceed 50 m^3/km.

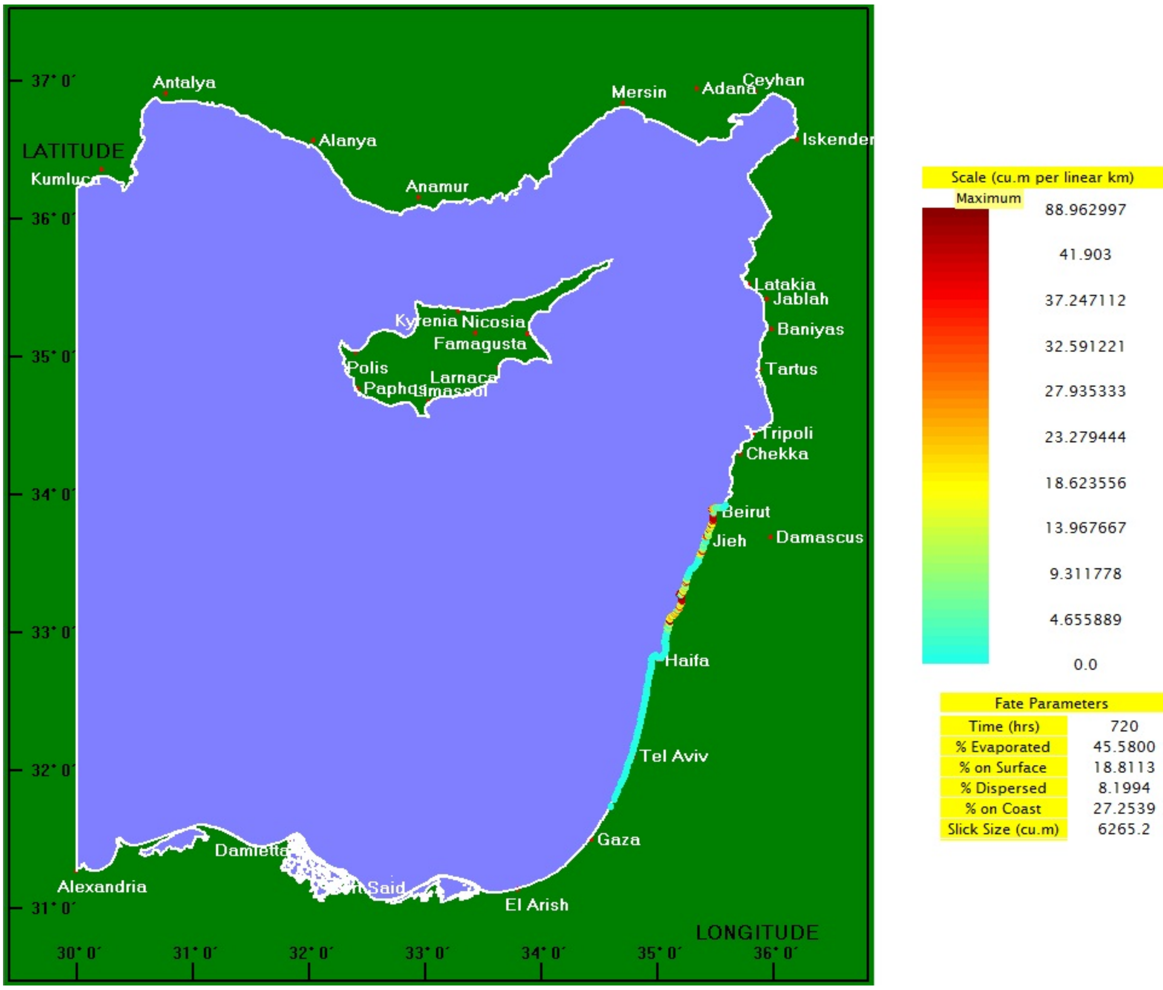

Figure A6: Total amount of diesel fuel deposited on the coast and the end of 30 days after an instantaneous diesel fuel spill on 26 Jan 2008.

17 Jul -16 Aug 2008

The oil fate parameters for the spill during the summer, on 17 Jul 2008, are shown in **Figure A7**. Here too evaporation occurs quickly with 45% of the diesel fuel evaporated within 54 hours. Significant coastal deposition begins on day 21 and continues rapidly for the next 5 days. The rapid coastal deposition is a result of the drift of the diesel fuel as a coherent slick (see Figure 20). The final balance is mainly between evaporation and coastal deposition with 45.6% and 44.6%, respectively. The remaining 9.8% is dispersed in the water column and no diesel fuel remains on the surface. The length of the impacted coast is 61 km (see discussion of Figure 21 for details).

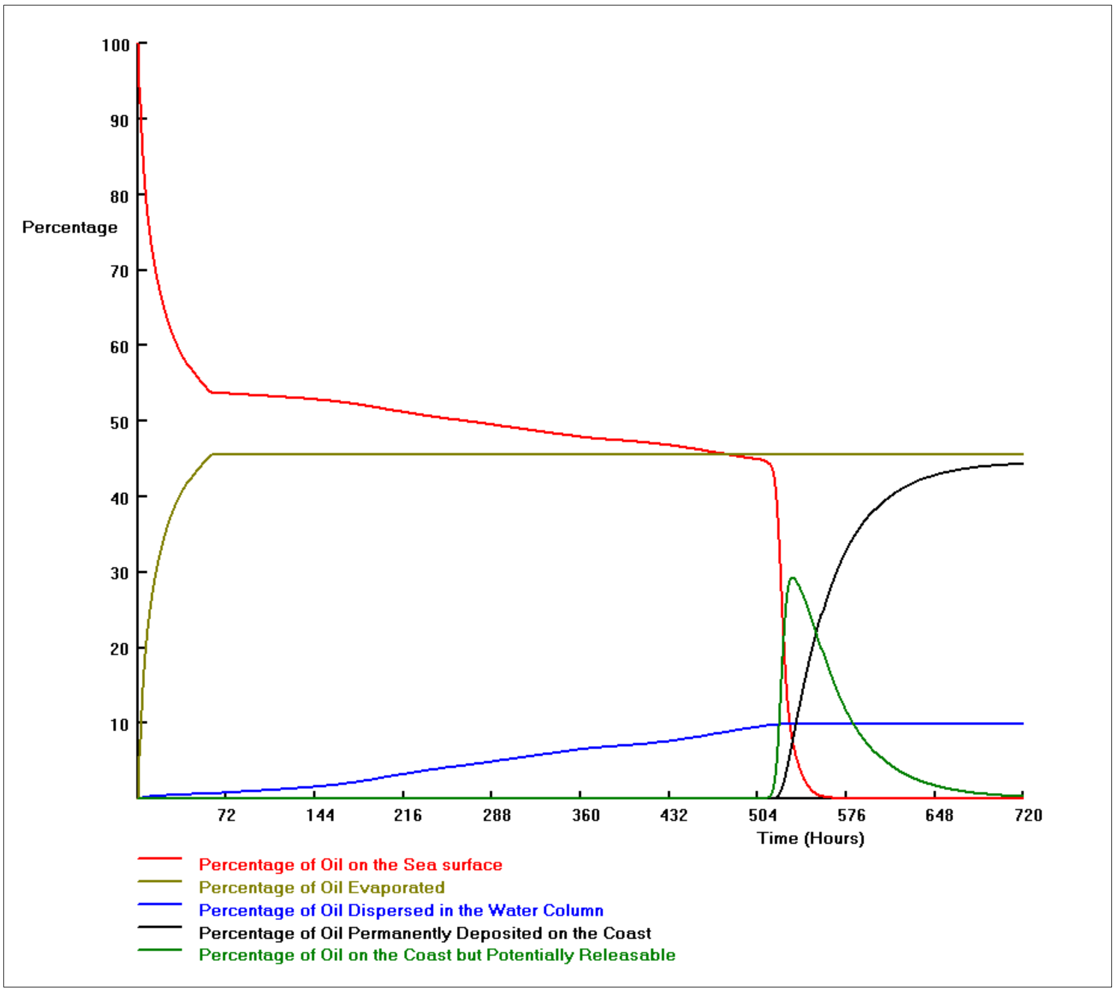

Figure A7: Oil fate parameters for the instantaneous diesel fuel spill on 17 Jul 2008

Figure A8 shows the diesel fuel remaining on the surface 20 days after the spill, just before coastal deposition begins. The diesel fuel drifts to the northeast as a coherent slick with minimal dispersion, due to the combined effects of the currents and winds. As noted above, significant coastal deposition begins on day 21 and continues until the end of the period at which point nearly 45% has been deposited on the coast.

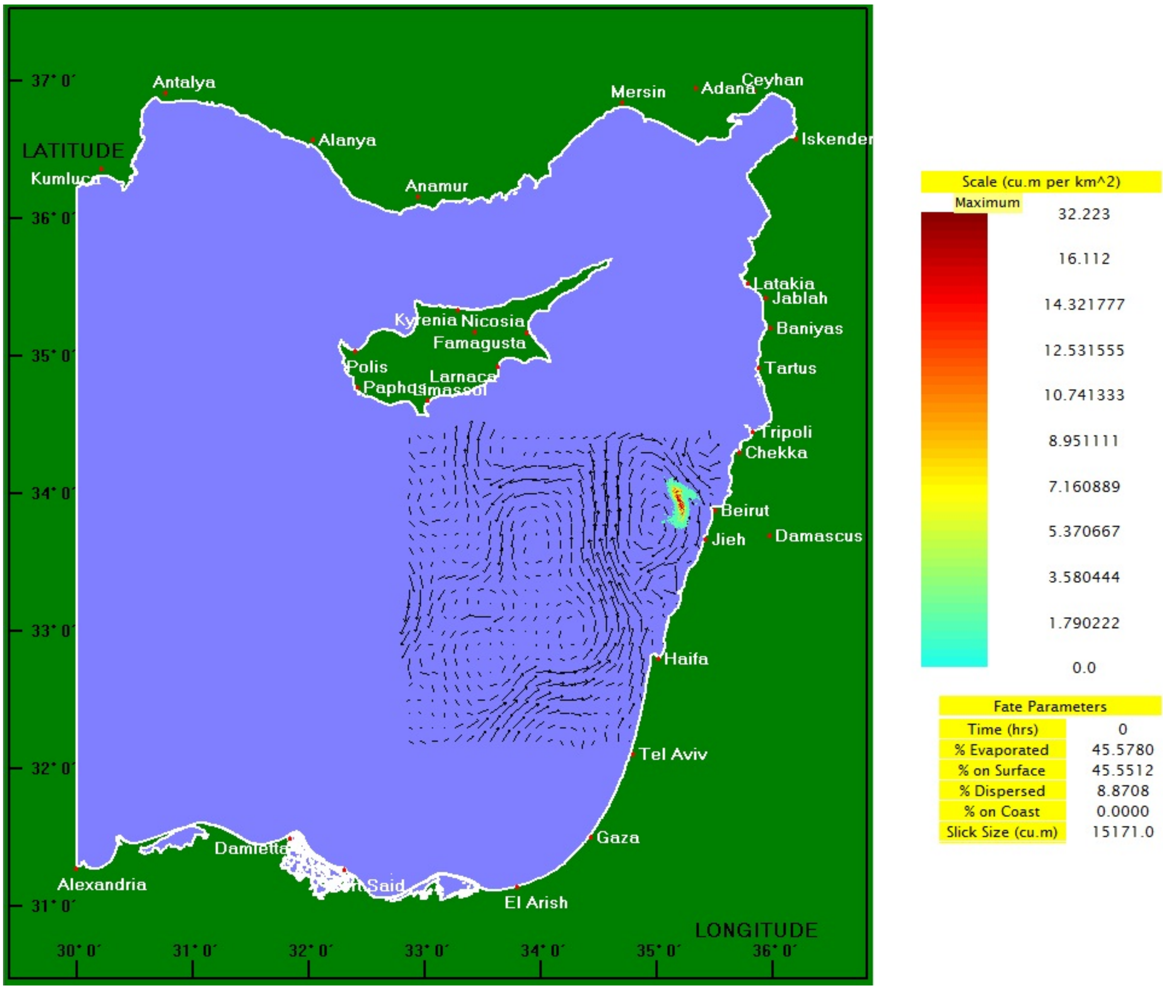

Figure A8: Diesel fuel remaining on the surface 20 days after an instantaneous diesel fuel spill on 17 Jul 2008.

Figure A9 shows the total amount of diesel fuel accumulated on the coast after 30 days. Most of the deposition occurs between days 21 and 26. The section of coast affected stretches over 61 km to the south of Beirut. Along most of this section of coast the concentrations are less than 1 m^3/km. The most adversely affected area is a 7 km zone north of Jieh where the concentrations may exceed 200 m^3/km.

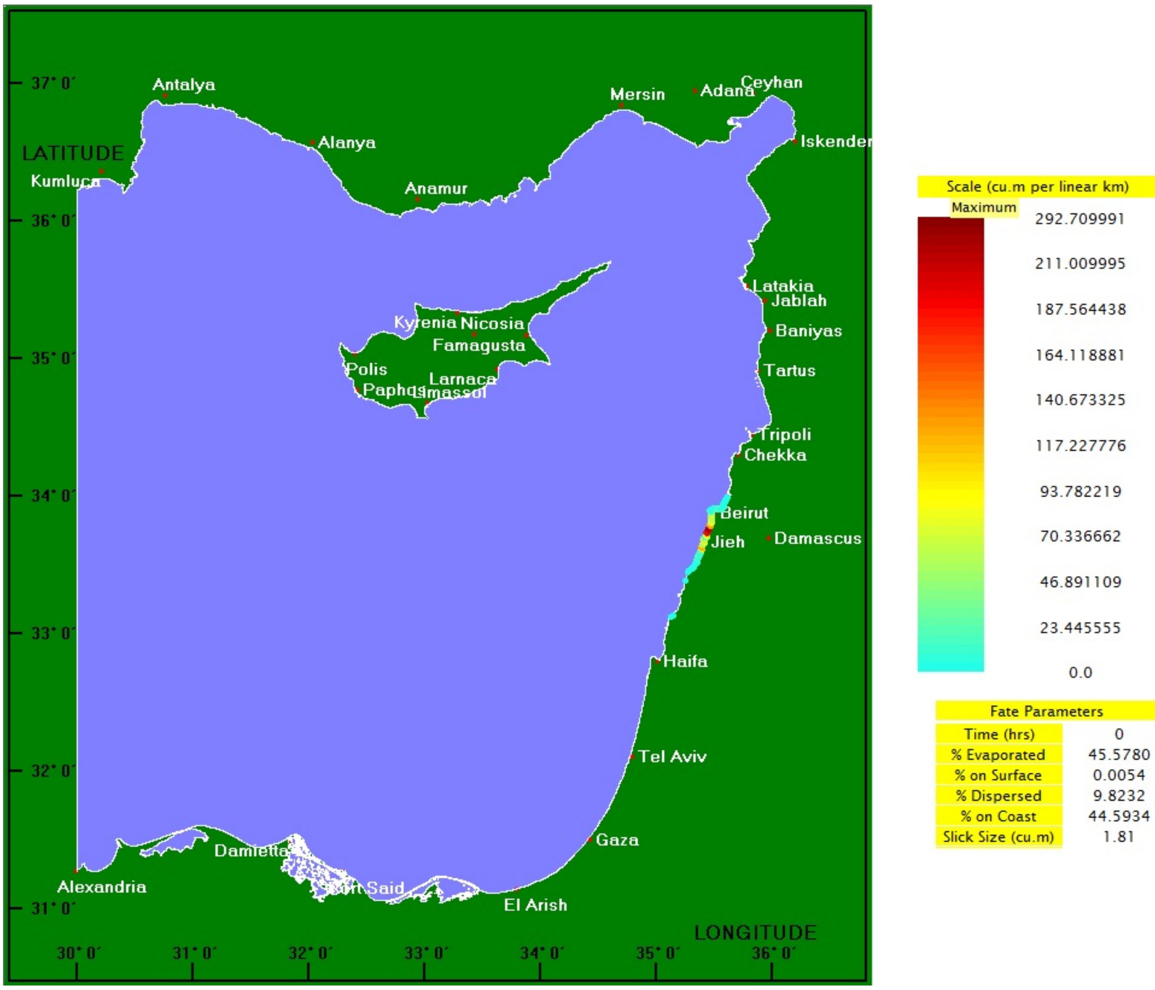

Figure A9: Total amount of diesel fuel deposited on the coast and the end of 30 days after an instantaneous diesel fuel spill on 17 Jul 2008.

25 Sep – 25 Oct 2007

The oil fate parameters for the instantaneous spill on 25 Sep 2007 are shown in **Figure A10**. As with all other scenarios, the evaporation is very rapid and within 55 hours more than 45% of the diesel fuel has evaporated. Coastal deposition begins on day 12 and continues to day 21 after which very little is added. The final balance is mainly between evaporation and coastal deposition with 45.6% and 51.8%, respectively. This is the highest amount of coastal deposition obtained in any of the scenarios considered. Roughly 2.5% is dispersed in the water column and only a negligible amount (0.02%) remains on the surface. A 110 km section of coast is affected (see Figure 24).

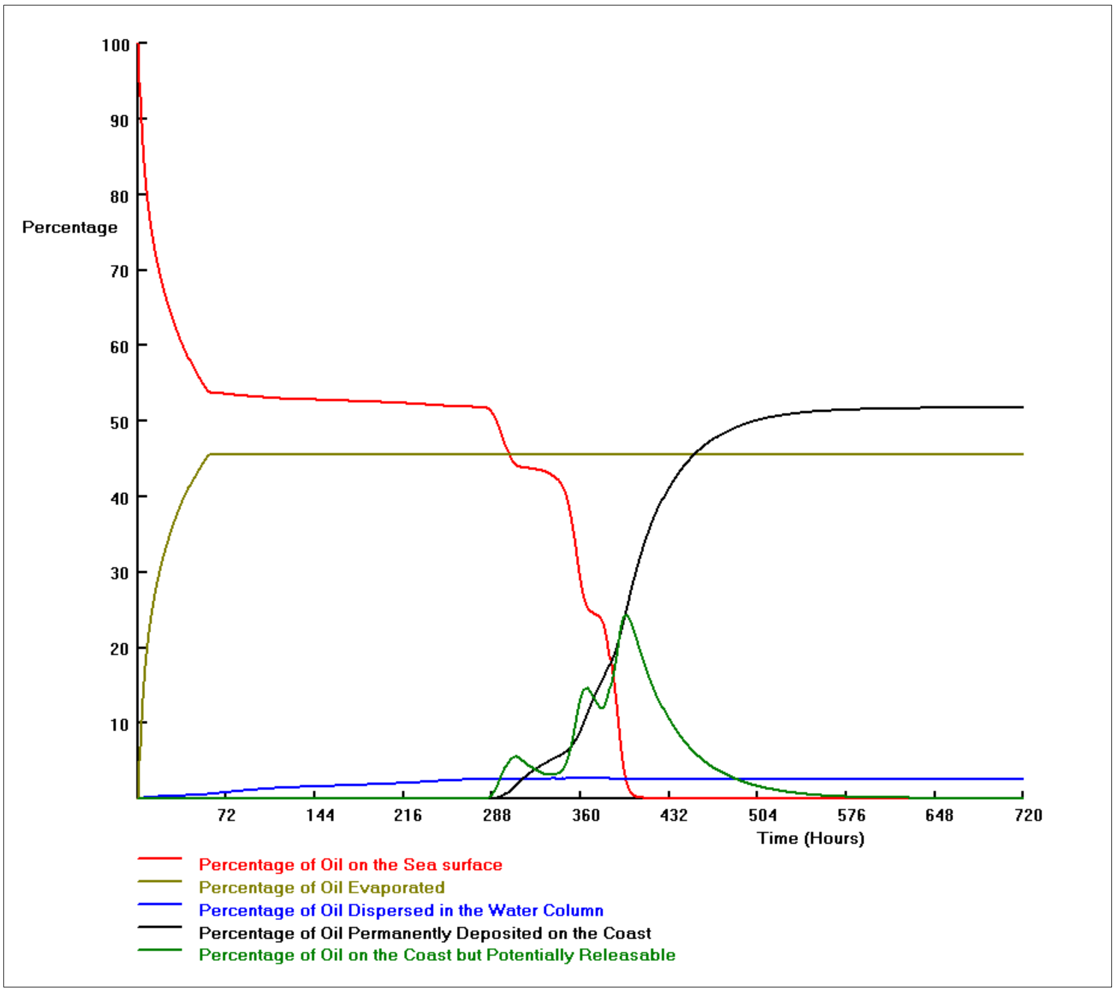

Figure A10: Oil fate parameters for the instantaneous diesel fuel spill on 25 Sep 2007

The diesel fuel on the surface on day 10, just before coastal deposition begins, is shown in **Figure A11**. As in the previous two scenarios, here too the diesel fuel spreads as a coherent slick. It is transported to the east by the combined effects of the currents and winds. Beginning on day 12, rapid coastal deposition occurs for the next 9 days.

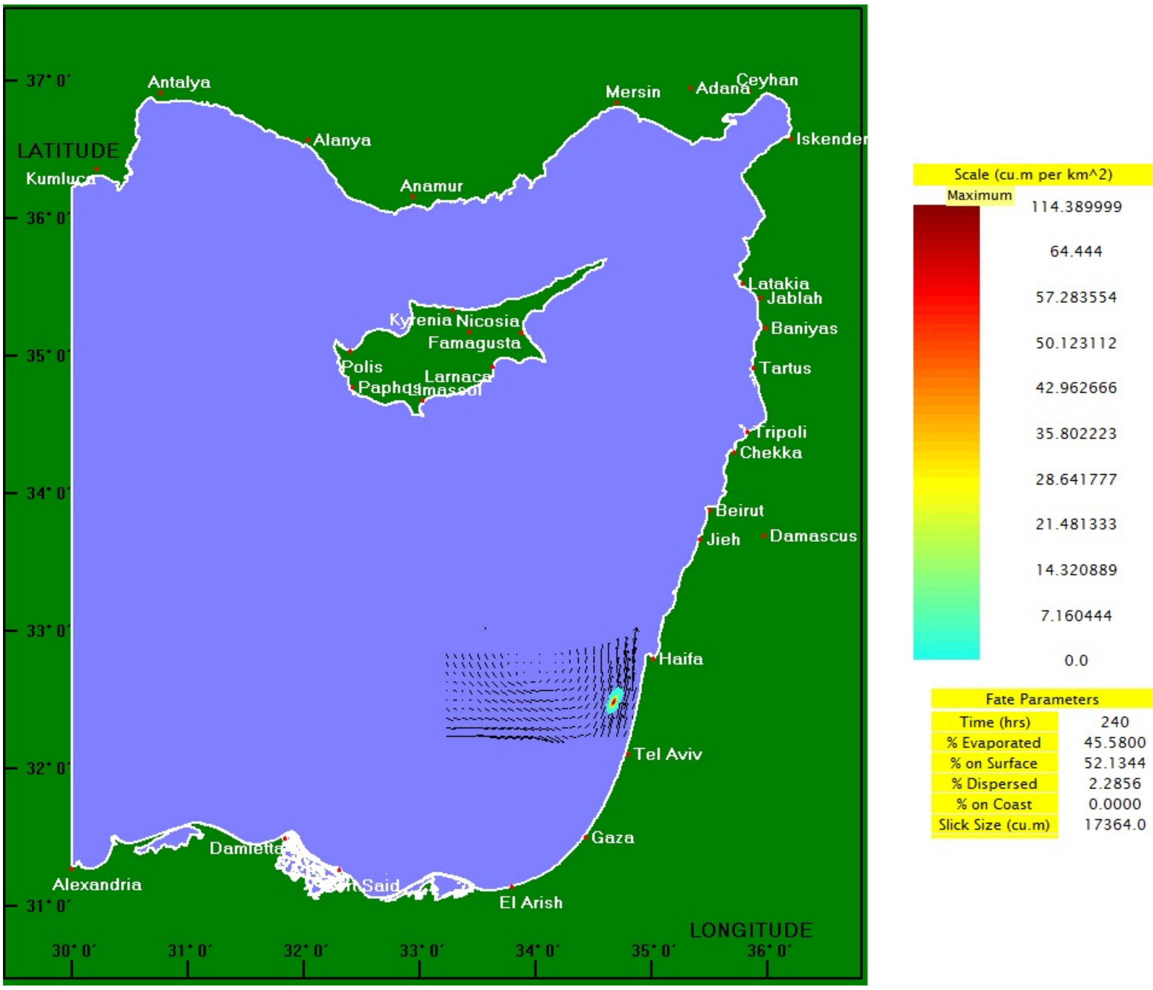

Figure A11: Diesel fuel remaining on the surface 10 days after
an instantaneous diesel fuel spill on 25 Sep 2007.

Figure A12 shows the total amount of diesel fuel accumulated on the coast at the end of 30 days. The section of coast that potentially may be affected extends from Netanya to the Israel-Lebanon border. A few localized spots as far north as Beirut may also be affected. Along most of this section of coast concentrations will be less than 2-3 m^3/km. The most adversely affected areas are projected to be Atlit, the southern coast of Haifa, parts of Haifa Bay and the coast of Akko. Concentrations will typically be 150 m^3/km with several localized hotspots where values may reach 500 m^3/km.

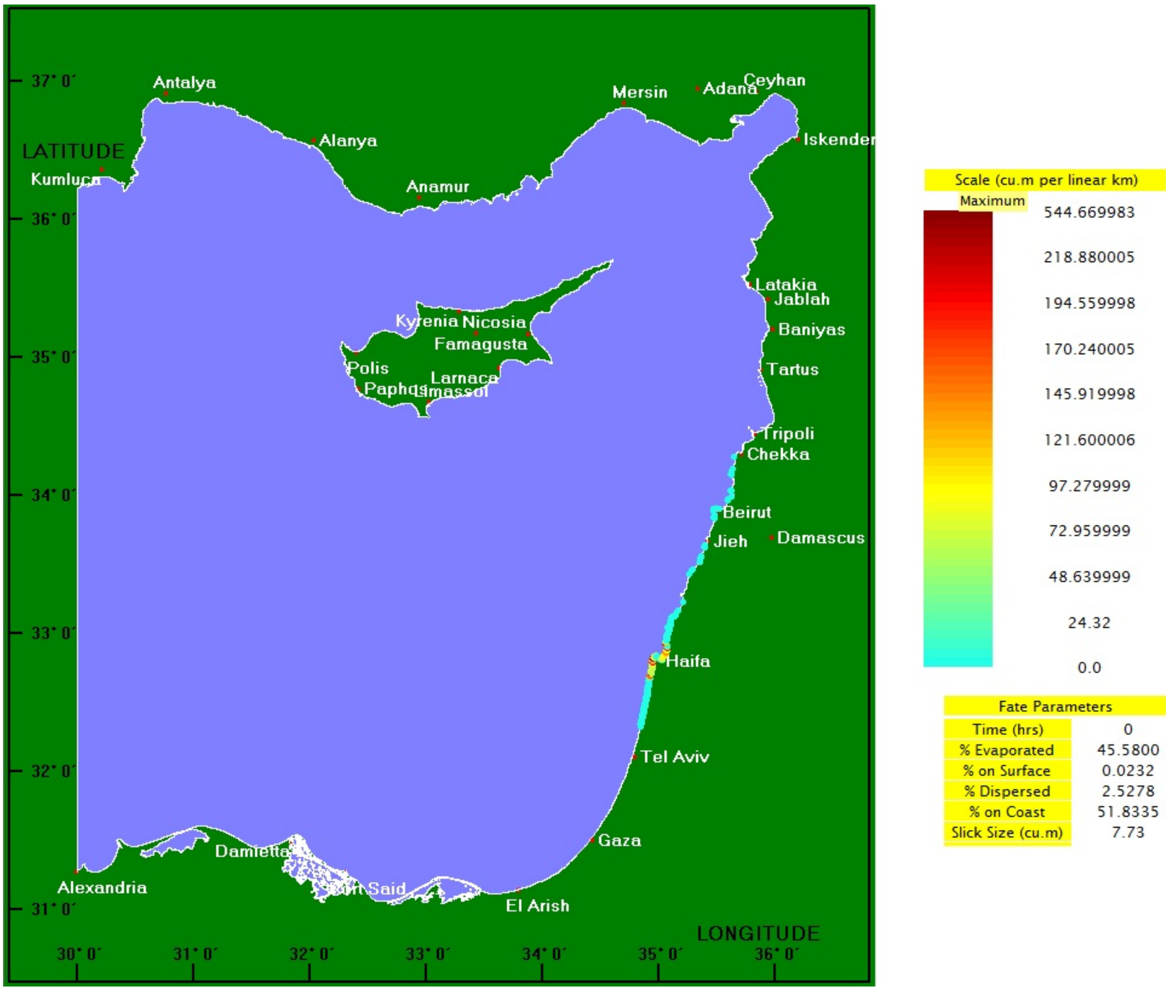

Figure A12: Total amount of diesel fuel deposited on the coast and the end of 30 days after an instantaneous diesel fuel spill on 25 Sep 2007.

Appendix N

Condensate Spill Model

Modeling the Dispersion of a Continuous Oil Spill from the Leviathan-6 Well Site

Steve Brenner

Report submitted to Noble Energy Mediterranean Ltd.

October 2015

Table of contents

Abstract

Within the framework of the environmental impact assessment of the offshore Leviathan 6 drilling platform, a series of model simulations were conducted to assess the potential dispersion of a continuous discharge of condensate from the well. The site is located approximately 122 km offshore from Haifa at water depth of ~1,625 m. The condensate is treated as an equivalent oil discharge from the well. The slick is assumed to be positively buoyant and rises instantaneously to the surface where it floats and is dispersed by the currents and the winds. It is also subjected to various physical and chemical weathering processes. The dispersion and fate of the oil slick are simulated with the MEDLSIK oil spill model. The slick is treated as a collection of small floating particles which are dispersed using a Lagrangian particle trajectory approach, based on current and wind effects, combined with random walk turbulent mixing and physiochemical weathering. The currents are computed by running the Princeton Ocean Model (POM) to produce a high resolution downscaling of the MOON/MyOcean reanalysis fields for the Mediterranean Sea while the winds are extracted from the ECMWF ERA-Interim 6 hourly reanalysis. Four simulations of a continuous discharge from a well blowout were run based on meteo-oceanographic conditions for different time periods that are expected to represent the worst case scenarios of an uncontrolled well blowout. These periods were determined in coordination with the Ministry of Environmental Protection.

In general the main concern is the amount and location of the oil that will potentially reach the coast. The well blowout was assumed to continue for a period of 30 days at a rate of 5,264 barrels of oil equivalent/day with an API of 34.2. The four time periods considered were: (1) 9 Dec 2010 – 8 Jan 2011 which included an extreme winter storm; (2) 26 Jan – 25 Feb 2008 which represents typical winter stormy conditions; (3) 17 Jul – 16 Aug 2008, typical summer conditions with persistent northwesterly winds and swell; and (4) 25 Sep - 25 Oct 2007, autumn conditions typical of the transition seasons and including at least one episode of stong easterly to northeaterly winds.

Since the well blowout continues over a 30 day period, each new addition to the slick will be subjected to widely varying current and wind conditions and therefore the

slick tends to spread over a relatively large area. For all four cases nearly 40% of the slick will evaporate within 24 hours while at the end of 30 days, 44% of the condensate has evaporated. Similarly since the well is located far offshore it will take more than one week the slick to begin reaching the coast although significant coastal deposition will take even longer.

Precise details of the location and amount of the slick remaining in the water versus the coastal deposition will depend on the combined advection due the wind and currents which occurs under the specific meteo-oceanographic conditions. For the extreme winter storm scenario most of the unevaporated material (~41.5% of the total spill) will remain on the surface, spreading over a relatively large area, while only a negligible amount (0.3%) reaches the coast. The main coastal areas affected are along the coast of Lebanon and the southern coast of Cyprus.

For the typical winter period ~25.8% of the condensate remains on the surface while 15.8% is deposited on the coasts of Israel and Lebanon with the highest concentrations occurring in northern Israel and southern Lebanon.

For the typical summer period nearly 40.2% of the oil from the continuous spill remains on the surface but only 1.8% reaches the coasts of northern Lebanon and Syria.

Finally in the transition season scenario (September) 30.6% of the oil from the continuous spill remains on the surface while only 13.4% reaches the coast extending from northern Sinai to southern Lebanon. The two most adversely affected areas are along the coasts of Gaza and Haifa.

In summary, the order of severity for the amount of oil deposited on the coast is projected to be 15.8, 13.4, 1.8, and 0.3% for the typical winter, transition season (fall), typical summer, and extreme winter scenarios, respectively.

1. General background

In fulfillment of the requirements of the guidelines to assess the potential environmental impacts of the Leviathan 6 (LEV-6) drilling platform, it was decided to conduct model simulations of potential condensate discharges from a 30 day continuous discharge of condensate (oil equivalent) from a well blowout, as was done for similar drilling sites in the vicinity. The condensate is treated as an oil slick which is positively buoyant. It is assumed to rise to the surface instantaneously where it floats. It is dispersed by the near surface currents and winds, and is subjected to various physical and chemical weathering processes. The modeling approach is to treat the spill as a collection of small floating particles which are dispersed using a Lagrangian particle trajectory approach, based on current and wind effects, combined with random walk turbulent mixing and physiochemical weathering.

Realistic current and wind fields are crucial for achieving reliable simulations of the dispersion. Direct current and wind measurements in the vicinity of the discharge or spill, if available, are often used to estimate the spreading and are especially useful for computing the initial dispersion. However currents and winds vary in both time and space and therefore as the slick drifts further from the source it will be affected the circulation patterns in other regions. In cases where no meteorological and/or oceanographic data are available, the necessary fields of currents and winds are typically derived from climatological data. Such data usually have relatively coarse resolution in both space (tens of kilometers or more) and time (monthly or longer term means). However, recent studies conducted with MEDSLIK oil spill model have demonstrated the clear advantages of using high spatial resolution currents and high temporal resolution winds (e.g. Coppini et al., 2011; De Dominicis et al., 2013). Thus the preferable way to provide spatially and temporally varying meteo-oceanographic conditions (especially for predictions) is from high resolution dynamical downscaling simulations or from forecast models and the associated reanalysis data sets. Following is a brief description of the models and data that are used in this study.

2. Hydrodynamic model

The currents used to drive the oil spill model were generated using an expanded domain version of the model developed by Brenner (2003) and Brenner et al. (2007) for the southeastern Levatine basin within the framework of the Mediterranean

Forecasting System (MFS) and today run operationally as part of the Mediterranean Operational Oceanoography Network, MOON/MyOcean (www.moon-oceanforecasting.eu). The model is based on the Princeton Ocean Model, POM (Blumberg and Mellor, 1987), which is a time dependent, free surface, three dimensional primitive equations ocean model with an embedded subgrid scale turbulence closure model. The dependent variables include the three spatial components of the current vector, temperature, salinity, the free surface height, the turbulent kinetic energy, and the turbulence length macroscale. The numerical scheme is based on second order accurate finite differencing schemes using an Arakawa-C grid (see Figure 1 for the placement of the variables), a terrain following coordinate in the vertical, and a split explicit, leap frog time scheme.

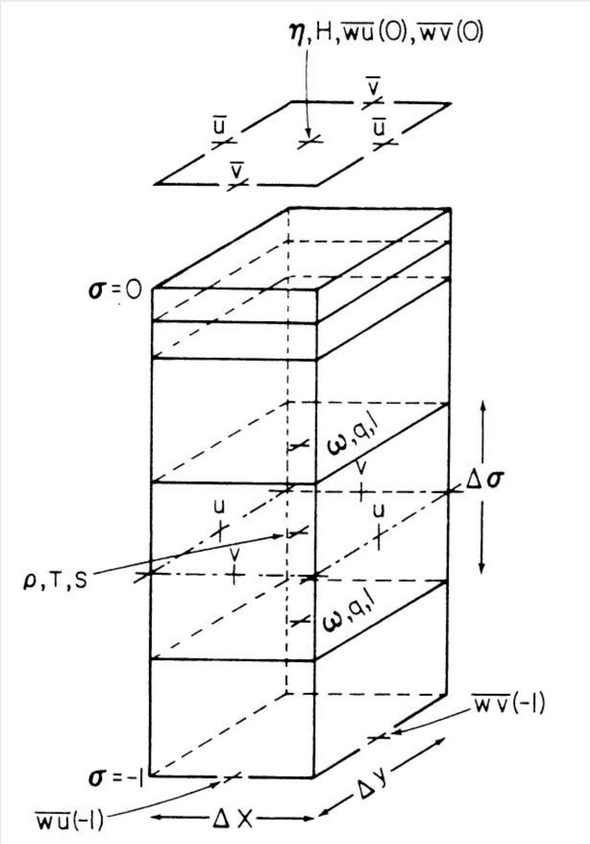

Figure 1: Placement of variables on the Arakawa-C grid

For the scenarios considered here, the model domain covers the entire Levantine basin east of 30°E. The horizontal resolution is 1' (~1.7 km) and the water column is divided into 30 unevenly spaced sigma layers which cover the entire water column. The bathymetry was extracted from the GEBCO global 1' data set (GEBCO, 2012). The model is one-way nested in the daily MOON/MyOcean reanalysis fields (1/16°,

~6.5 km horizontal resolution) for the relevant periods following the methodology of Brenner (2003) and Brenner et al (2007). These models and the nesting methodology have been extensively tested and validated for this region within the framework of MFS and MOON. The domain and the bathymetry for the model are shown in Figure 2. The location of the LEV-6 drilling site is indicated by the red dot.

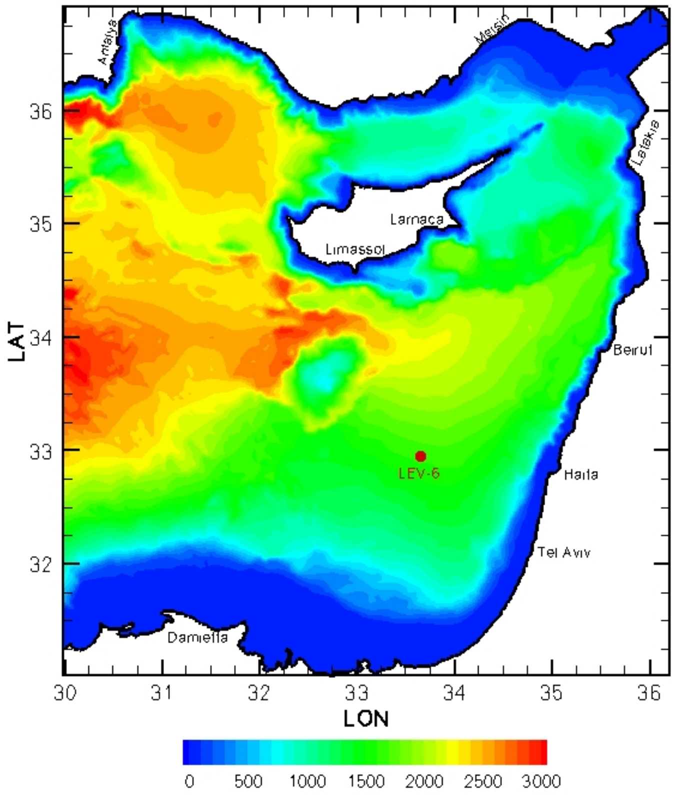

Figure 2: Domain and bathymetry (m) for the circulation model. The red dot indicates the location of the LEV-6 drilling site.

Further details concerning the MOON/MyOcean reanalysis and the results of the downscaling with the high reoslution ocean model are given in Chapter 5.

3. Oil spill model and discharge characteristics

The model used for the assessment of the condensate dispersion is MEDSLIK Version 5.3.6. MEDSLIK is a software package designed to predict the fate and dispersal of an oil spill. It has been developed over a period of more than ten years at the Cyprus Oceanographic Center. The version used here is described by Lardner (2011). The surface oil slick is advected and dispersed by both the near surface currents and direct wind forcing. Advection of the oil is simulated as a Lagrangian displacement by the currents and winds plus a horizontal turbulent diffusion based on the random walk hypothesis. Details can be found in recent studies such as Coppini et al. (2011) and Zodiatis et al. (2012). The model also accounts for weathering of the oil through physiochemical processes such as evaporation, emulsification, and small scale turbulent mixing in the water as well as adhesion to the coast as described by Lardner and Zodiatis (1998).

MEDSLIK has been incorporated as part of the Mediterranean Forecasting System (Pinardi et al., 2003) which provides daily forecasts of the circulation on various scales within the framework of the Mediterranean Operational Oceanography Network (MOON/MyOcean).

During the past few years, MEDSLIK has been used in various oil spill exercises in the eastern Mediterranean. The most recent and extensively studied application of MEDSLIK was the oil spill from the Jieh power station near Beirut in July 2006 (e.g., Zodiatis et al., 2007; Coppini et al., 2011; Neves et al., 2015). Scientists from INGV in Italy have also used MEDSLIK in a preliminary study of the Deepwater Horizon oil spill in the Gulf of Mexico.

The various parameters that determine the weathering processes have been carefully chosen and tuned by the model developers so there is no need to adjust these values. In addition there are two tuning parameters related to the wind fields, one related to the choice of current fields, and one related to the eddy diffusion which is used for the random walk component of the advective displacement. Here it is proposed to use the values that were determined as suitable for this region of the eastern Mediterranean based on the experience of the model's developers in general, and specifically based on the forecasts and hindcasts that were conducted as part of the study of the Lebanon accident in 2006 (e.g., Zodiatis et al., 2007; Coppini et al., 2011; Neves, 2015) using a similarly configured oceanographic model, as well as for other oil spills in the eastern Levantine basin (Zodiatis et al, 2012; Di Dominicis et al., 2013). A short model simulation run for the Lebanon spill with our model, currents, and winds for the relevant period gave similar results as to the other studies mentioned. The relevant values are summarized in Table 1.

Table 1. Calibration parameters for MEDSLIK

Parameter	Value
Wind drift factor	0.03
Wind drift angle	0
Current depth	30 m
Horizontal diffusivity	2 $m^2 s^{-1}$

As will be described in the next section, four time periods representative of various meteo-oceanographic conditions over the eastern Mediterranean were considered. For each period simulations were conducted for a continuous 30 day discharge of condensate (i.e., a well blowout) at a rate of 5,264 barrels of oil equivalent (boe)/day with API 34.2 (details provided by Noble Energy).

4. Meteorological data

For surface forcing, the 10 m winds were extracted from the ECMWF ERA-Interim reanalysis data (Dee et al., 2011). These data are available with a frequency of 6 hours. Surface heat and fresh water fluxes were approximated by relaxing the model's surface temperature and salinity to the MOON/MyOcean reanalysis fields with a relaxation time scale of 2 days. All data were spatially and temporally interpolated to the hydrodynamic model grid and time steps as necessary. Four specific periods were chosen which represent meteo-oceanographic conditions that could potentially lead to worst case scenarios. They were chosen in accordance with the guidelines issued by the Ministry of Environmental Protection.

9 Dec 2010 – 8 Jan 2011

The 30-day average of the mean sea level pressure is shown in Figure 3. This period was chosen due to the extreme winter storm that occurred between 10-12 Dec 2010.

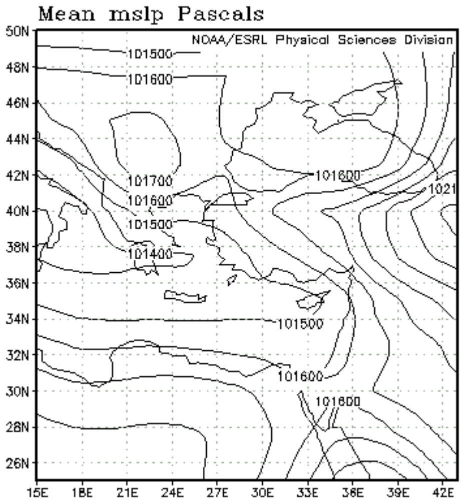

Figure 3: 30-day average of the mean sea level pressure for 9 Dec 2010- 8 Jan 2011.

The extreme storm of interest is represented by the sea level pressure field on 12 Dec 2010 as shown in Figure 4. During this storm, the central pressure dropped to below 996 hPa and sustained westerly to southwesterly winds with speeds of nearly 15 m s^{-1} or more blew across the southeastern corner of the Levantine basin.

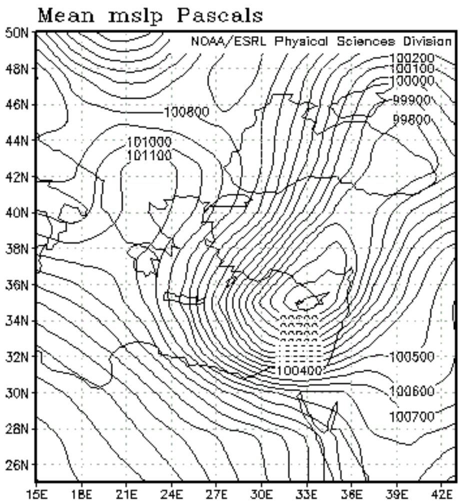

Figure 4: Mean sea level press for 12 Dec 2010.

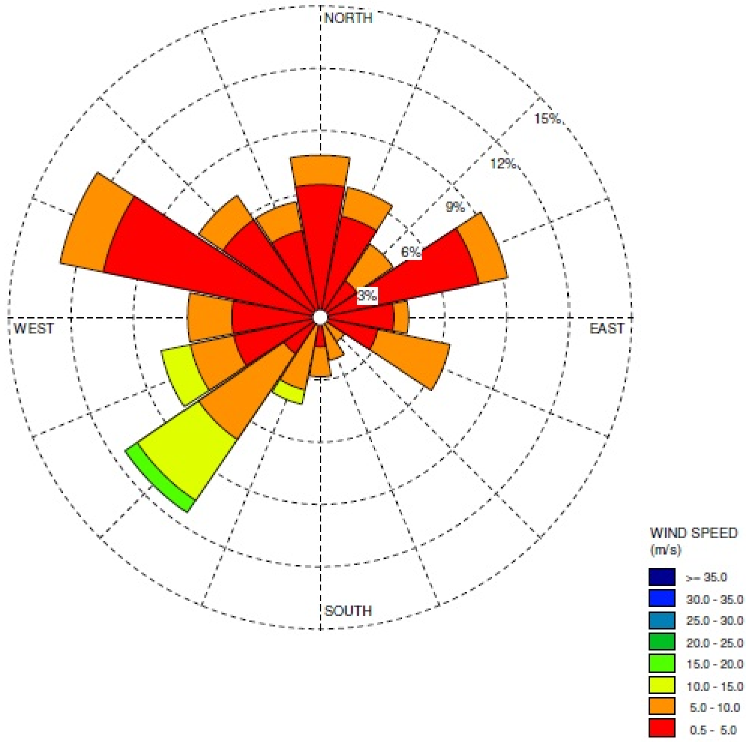

Figure 5: Wind rose at the drilling site for the period 9 Dec 2010 – 8 Jan 2011.

The wind rose at the location of the drilling site for this period is shown in Figure 5. The winds fall mostly in the northwesterly to southwesterly quadrant with the two most frequest directions being SW and WNW. The extreme storm appears as the strongest winds (green sector) from the southwest.

<u>26 Jan – 25 Feb 2008</u>

This period was chosen to represent typical winter stormy conditions including at least one typical storm, The 30-day average of the mean sea level pressure for this period is shown in Figure 6. The zone of low pressure over the eastern part of the Levantine basin is indicative of the combined effects of Cypus lows and the Red Sea trough.

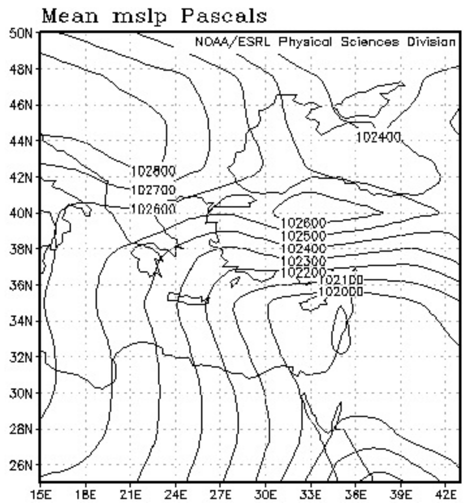

Figure 6: 30-day average of the mean sea level pressure for 26 Jan – 25 Feb 2008

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The wind rose at the location of the drilling site for this period is shown in Figure 7. The winds fall mostly in the northeasterly to westerly quadrant and the speeds are less than or equal to 5 ms^{-1} 53% of the time and less than or equal to 10 ms^{-1} 91% of the time. The strongest winds (indicated by the yellow zones) always have a predominant westerly component and range in direction from SW to NNW.

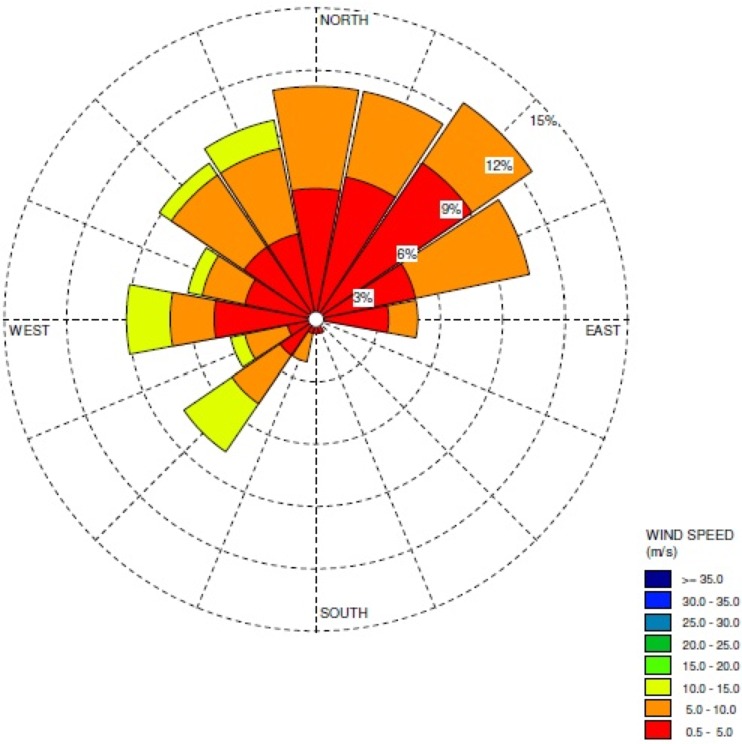

Figure 7: Wind rose at the drilling site for the period 26 Jan – 25 Feb 2008.

17 Jul – 16 Aug 2008

This period is representative of typical summer conditions with persistent northwesterly to westerly winds and swell. The Levantine basin is under the influence of a pronounced Persian trough as shown by the mean sea level pressure field in Figure 8.

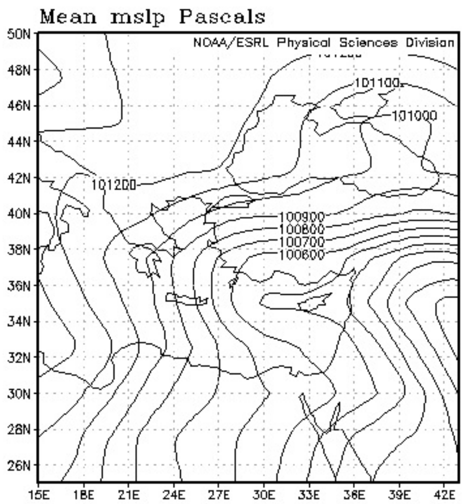

Figure 8: 30-day average of the mean sea level pressure for 17 Jul – 16 Aug 2008.

The wind rose in the vicinity of the drilling site for this period is shown in Figure 9. The very persistent westerly winds are apparent with a secondary direction of WNW. Wind speeds are 5 ms^{-1} or less 63% of the time and never exceed 10 ms^{-1}.

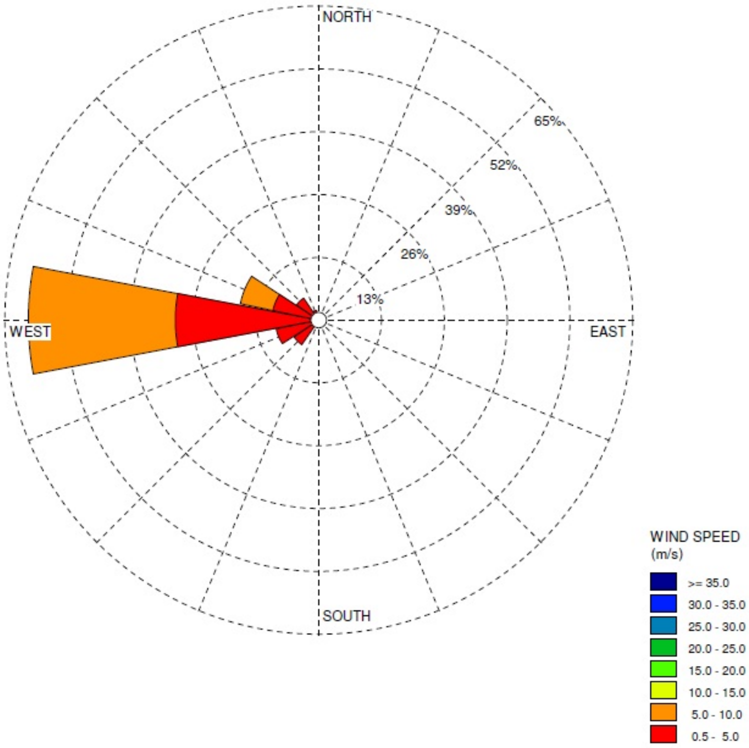

Figure 9: Wind rose at the drilling site for the period 17 Jul – 16 Aug 2008.

<u>25 Sep - 25 Oct 2007</u>

This period represents autumn conditions which are typical of the transition seasons. The transitions seasons are often affected by sharav cyclones which result in dry, northerly to easterly winds over the southeastern Levantine basin. A persistent Rd Sea trough also contributes to these northeasterly winds. The mean sea level pressure field averaged over the 30-day period is shown in Figure 10.

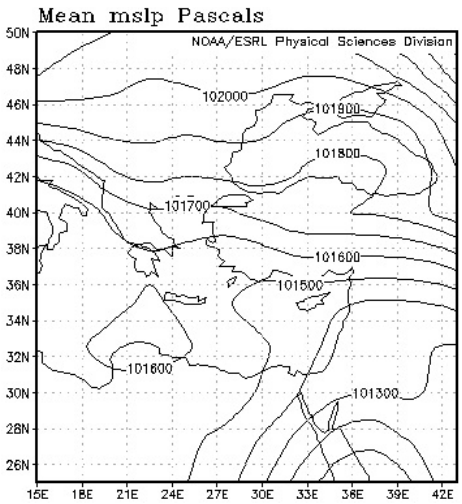

Figure 10: 30-day average of the mean sea level pressure for 25 Sep – 25 Oct 2007.

The corresponding wind rose in the vicinity of the drilling site is shown in Figure 11. The wind are mostly in the north to west quadrant with a maximum frequency of 22% in the WNW direction. Northeasterly to NNE winds occur 16% of the time. Wind speeds are 5 ms^{-1} or less 73% of the time and do not exceed 10 ms^{-1}.

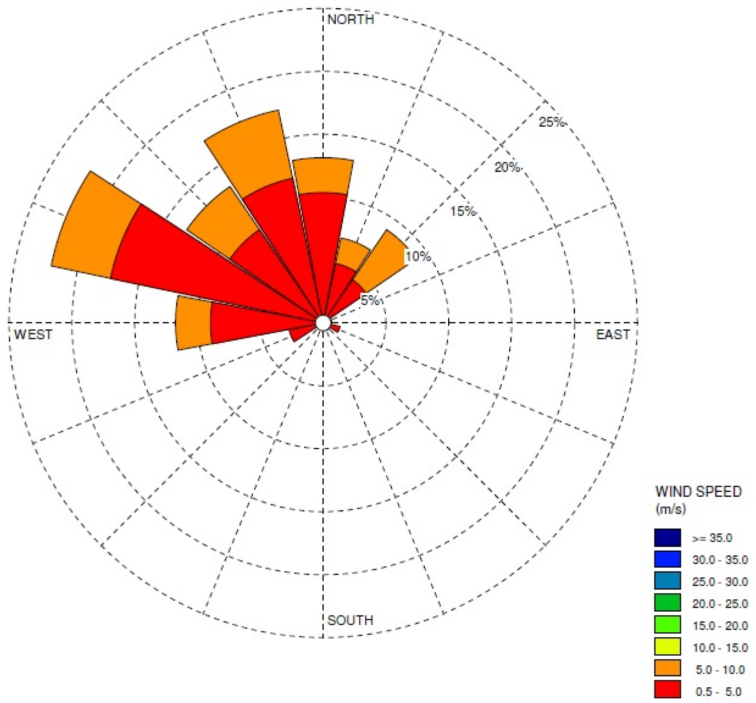

Figure 11: Wind rose at the drilling site for the period 25 Sep – 25 Oct 2007.

5. Oceanographic conditions

In addition to the winds described in the previous section, the oil spill model also needs currents as an input for computing the trajectiories of the oil spills and sea surface temperature (SST) for the computations of the physio-chemical weathering. Recent studies have shown that high resolution current fields improve the accuracy of the oil spill model. Thus the currents and SST were computed by downscaling of coarser resolution reanalysis fields with the hydrodynamic model (POM). The hydrodynamic model requires initial conditions as well as time dependent lateral boundary conditions at the open (western) boundary and surface forcing. The initial and lateral boundary conditions were extracted from the reanalysis fields produced within the framework of the operational MOON/MyOcean forecast system. Daily averaged three dimensional fields of temperature, salinity, currents, and sea level are available beginning from 1999 with a spatial resolution of 1/16° (~6.5 km) horizontally and 72 fixed depth levels in the vertical. The high resolution fields were produced from a continuous 34 day downscaling run of the model. In order to eliminate the initial shock or mismatch between the original reanalysis fields and the interpolated values, each simulation was started three days before the desired date to allow for model spin up and adjustment.

9 Dec 2010 - 8 Jan 2011

The 30-day average currents at 30 m depth for this period are shown in Figure 12. The general basinwide cyclonic circulation can be seen beginning with the eastward flowing jet entering the domain at 32°N (Robinson and Golnaraghi, 1994). It forms the northern flank of an intense anticyclonic eddy and near 33-34°E where it splits into two northward flowing branches. The right branch, which is weaker, flows along the continental shelf and break of Israel and Lebanon. The left branch turns to the northwest where it forms the western

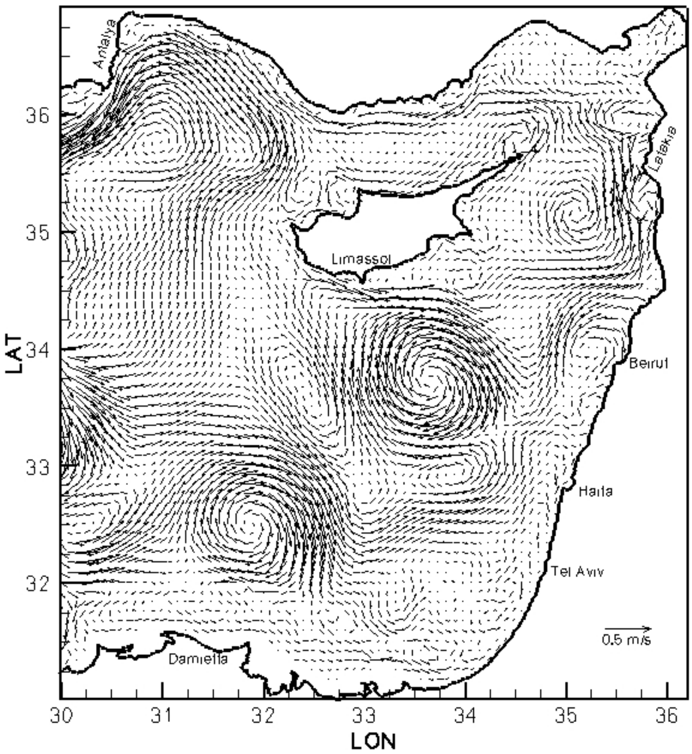

Figure 12: 30-day average currents at 30 m for 9 Dec 2010 – 8 Jan 2011.

flank of another an intense anticyclonic eddy locate south of Cyprus, which can be indentified as the Shikmona Gyre (Robinson and Golnaraghi, 1994). In then loops around the west side of Cyprus and continues to the coast of Turkey where it turns westward and leaves the domain near 36°N. Four very prominent, large mesoscale eddies can be seen – the two intense anticyclonic eddies already mentioned, and two cyclonic eddies – one in the northeast corner off the coast of Syria and one near the northwest corner of the domain.

<u>26 Jan – 25 Feb 2008</u>

The 30-day average currents at 30 m depth for this period are shown in Figure 13. The meandering Mid-Mediterranean Jet (Robinson and Golnaraghi, 1994) enters the domain near the center of the western boundary, forming a series of mesoscale eddies as is flows eastward to the south of Cyprus. The jet turns northward between Cypus and Syria and then westward along the coast of Turkey where is forms a well defined, meandering Asia Minor Jet. In contrast to the Dec 2010 case with four large eddies, here the circulation is composed of a relatively large number of small to medium sized anticyclonic and cyclonic eddies in the open sea as well as along the northeastern and northern coastal areas.

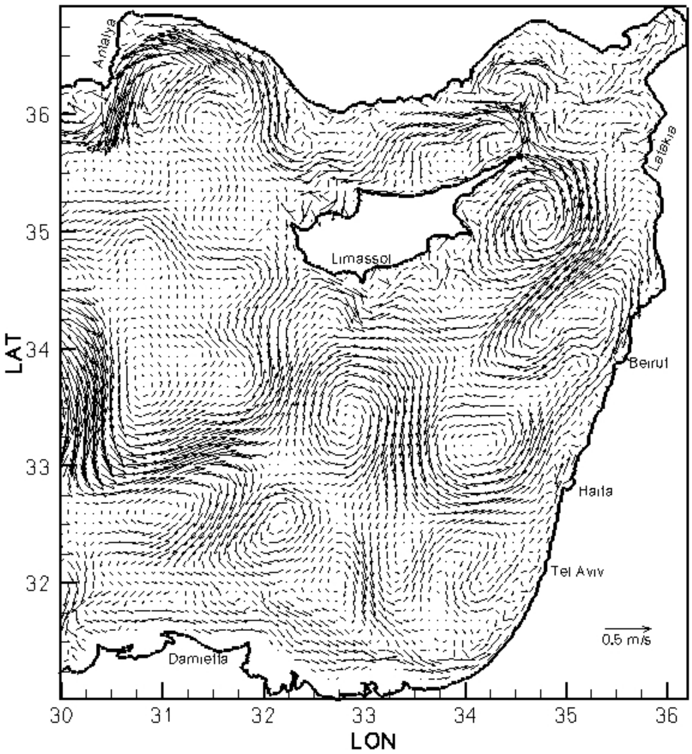

Figure 13: 30-day average currents at 30 m for 26 Jan – 25 Feb 2008.

<u>17 Jul – 16 Aug 2008</u>

Figure 14 shows the 30-day average current at 30 m for this period. Here a very prominent coastal jet enters the domain in the southwestern corner and continues to follow the coasts of Egypt and Israel. This jet bifurcates near 33.5°E and the western branch forms an anticyclonic eddy off the coast of Israel. The other branch forms a persistent, intense shelf current off the coast of Israel, which is consistent with the summer maximum northward current speed observed by Rosentraub and Brenner (2007). This current separates from the coast near Haifa and meanders as it continues flowing northward and forming a series of small, coherent eddies.

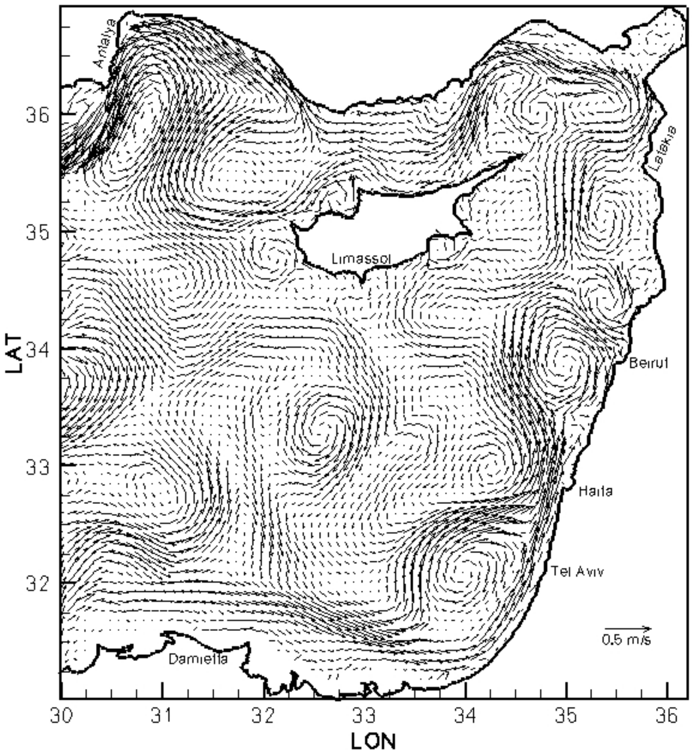

Figure 14: 30-day average currents at 30 m for 17 Jul – 16 Aug 2008.

<u>25 Sep – 25 Oct 2007</u>

The 30-day average currents for this period are shown in Figure 15. Here the coastal jet enters in the southwestern corner of the domain but it quickly turns northward and merges with the Mid-Mediterranean Jet. This jet meanders through the center of the basin, bifurcating several times and forming several anticyclonic eddies. This jet continues flowing eastward, forming the northern flank of a well defined anticyclonic eddy of the coast of Gaza, and then turning north forming a strong shelf current along the coast of Israel. This current continues to flow northward, intensifying between Cyprus and Syria, and then turning westward to form a strong, coherent Asia Minor Jet. A series of small to medium anticyclonic and cyclonic eddies can be seen throughout the domain.

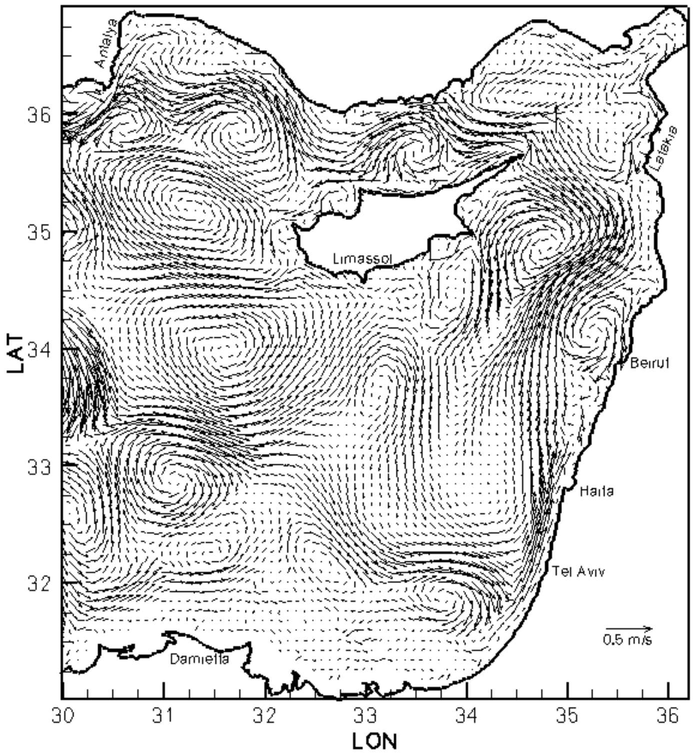

Figure 15: 30-day average currents at 30 m for 25 Sep – 25 Oct 2007.

6. Results of the 30-day continuous oil spill simulations

The set of simulations presented in this section includes four scenarios of a 30-day continuous condensate spill which might occur in the event of a well blowout. The discharge rate is 5,264 boe/day with API 34.2.

6.1 Extreme winter storm: 9 Dec 2010 – 8 Jan 2011

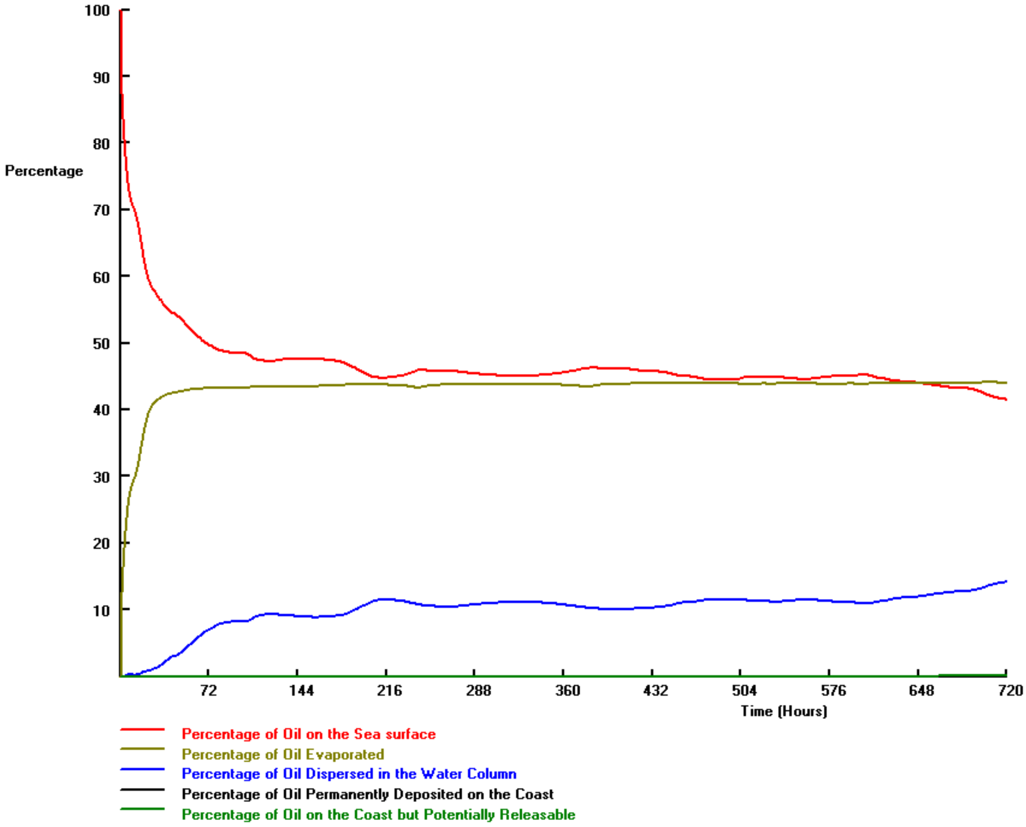

Figure 16: Oil fate parameters for the 30 day continuous discharge beginning 9 Dec 2010

The oil fate parameters for this scenario are shown in Figure 16. The fate parameters include oil remaining on the sea surface, oil evaporated, oil permanently deposited on the coast, and oil deposited on the coast but which may wash back into the sea depending upon its physio-chemical condition. The oil is relatively light (API 34.2), and therefore a significant amount evaporates rather quickly. Within 24 hours, 40% of the oil has evaporated. The final balance of the slick at the end of 30 days is mainly between evaporation and oil remaining on the surface with 44.1% and 41.5%, respectively. Roughly 14.2% of the oil is dispersed (i.e., vertically mixed) in the water column and only 0.28% is deposited on the coast during the final 4-5 days of the simulation. The length of impacted coastline is only 54.2 km and is located along the southern and western coasts of Cyprus (see discussion of Figure 18 for details).

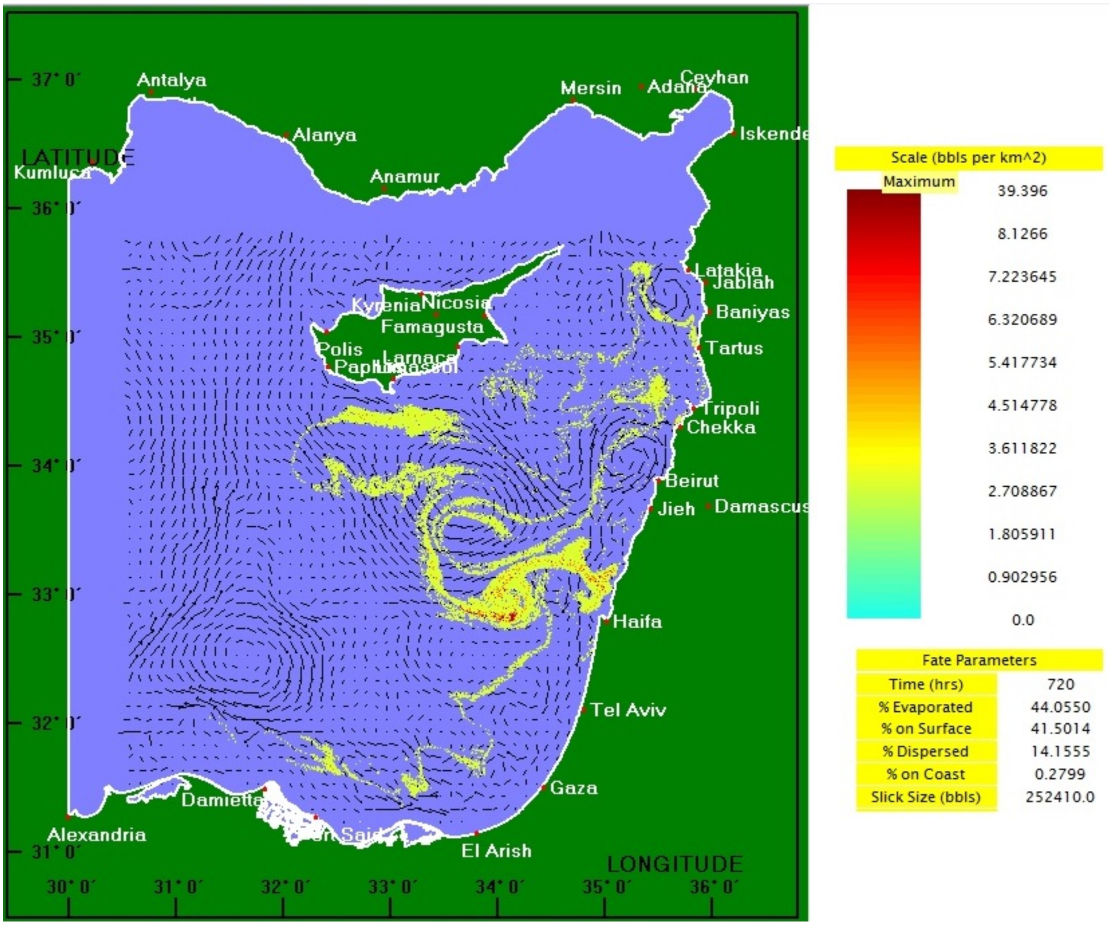

Figure 17: Oil remaining on the surface at the end of 30 days of continuous discharge beginning on 9 Dec 2010 and ending on 8 Jan 2011.

Figure 17 shows the oil remaining on the surface at the end of 30 days of the simulation. The part of the oil not evaporated is spread by combined effects of the winds, currents, horizontal eddy diffusion, and vertical mixing. In this case the relatively strong and variable currents play a central role in dispersing the oil on the surface. Throughout the period, the winds have a very strong westerly component which would be expected in general to drive the oil towards the coasts of Israel and Lebanon. However a large portion of the oil remains at sea within 150-200 km of the drilling site. The highly energetic mesoscale circulation field advects most of the oil to the north and to the northwest, although there are also some filaments that spread to the south and to the northeast. Only a very small amount of oil reaches the coasts of northern Lebanon and southwestern Cyprus (see Fig. 18). Part of the oil remaining on the surface is trapped by the jet that marks the flank of a well defined large, anticyclonic (clockwise) eddy (Shikmona gyre) centered neat 34°N, 34°E. Some of the oil spirals around this eddy and some spins off to the northwest but the largest concentration accumulates along the southern boundary of this eddy. As noted above, a very small amount of oil is deposited on the coast (less than 0.3%) beginning at day 26. The deposition occurs mainly along the northern coast of Lebanon and the southwestern coast of Cyprus as shown in Figure 18. The maximum concentration of 169.1 bbl/km occurs near Madfoun, Lebanon (between Beirut and Tripoli), but drops off to less than 40 bbl/km within 3-4 km. In other affected coastal areas (e.g., Cyprus and south of Beirut)), the distribution is patchy with values of less than 10 bbl/km, although there are some localized patches of up to 35-40 bbl/km north of Beirut.

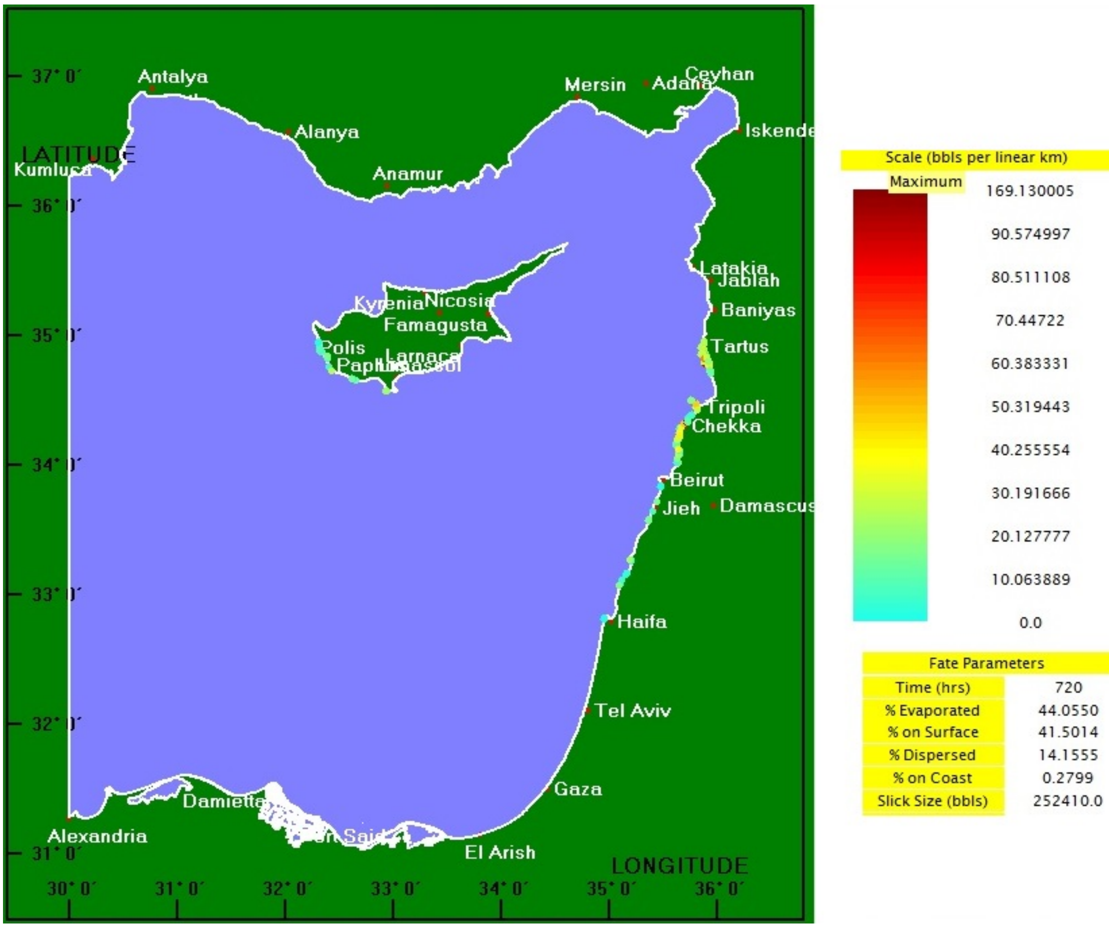

Figure 18: Total oil deposited on the coast at the end of 30 days of continuous discharge beginning on 9 Dec 2010 and ending on 8 Jan 2011.

6.2 Typical winter conditions: 26 Jan – 25 Feb 2008

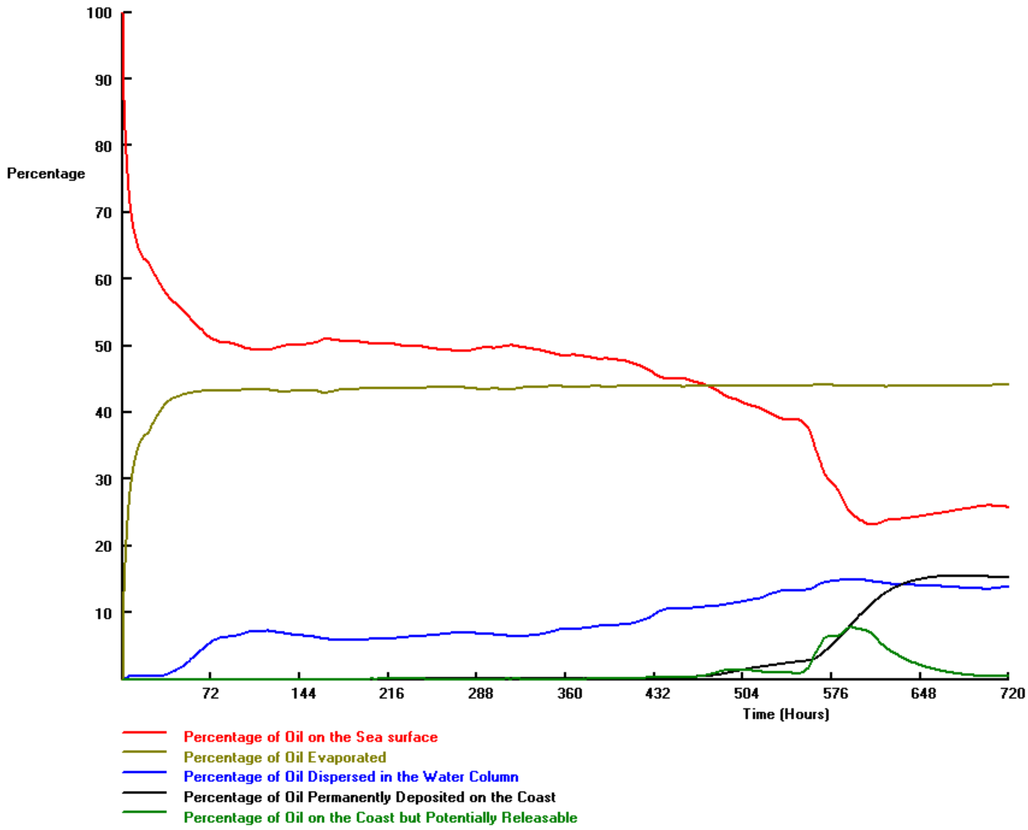

Figure 19: Oil fate parameters for the 30 day continuous discharge beginning 26 Jan 2008

The oil fate parameters for the typical winter scenario are shown in Figure 19. As in the previous scenario a significant amount evaporates rather quickly. After 24 hours 37.5% of the oil has evaporated. In this scenario coastal deposition begins on day 8 with significant accumulation beginning on day 22 and continuing for the next 3 days, after which it levels off. At the end of 30 days the main terms in the balance are evaporation and oil remaining on the surface with 44% and 25.8%, respectively. 15.8% is deposited on the coast and 13.8% of the oil is dispersed water column. The length of impacted coastline is 388 km along the coasts of Israel, Lebanon, and southern Syria (see discussion of Figure 21 for details).

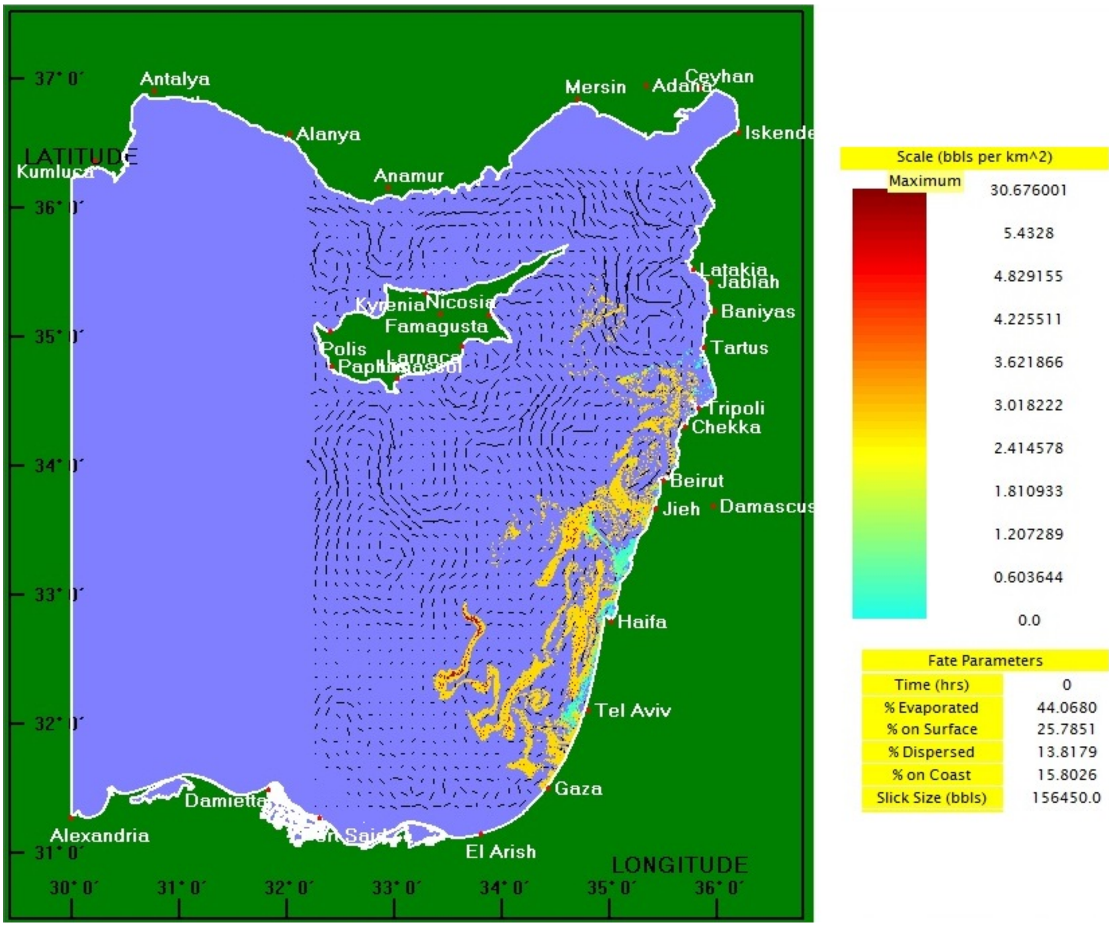

Figure 20: Oil remaining on the surface at the end of 30 days of continuous discharge beginning on 26 Jan 2008 and ending on 25 Feb 2008.

From Figure 20, which shows the oil remaining on the surface at the end of the simulation, it is clear that combined effects of winds and currents are comparable. On the one hand the dominant westerly component of the wind drives the slick towards the east, but the currents over the continental shelf and slope, which flow mainly parallel to the coast cause spreading to the north and south in thin filaments over a relatively large region, although not as large as in the previous case.

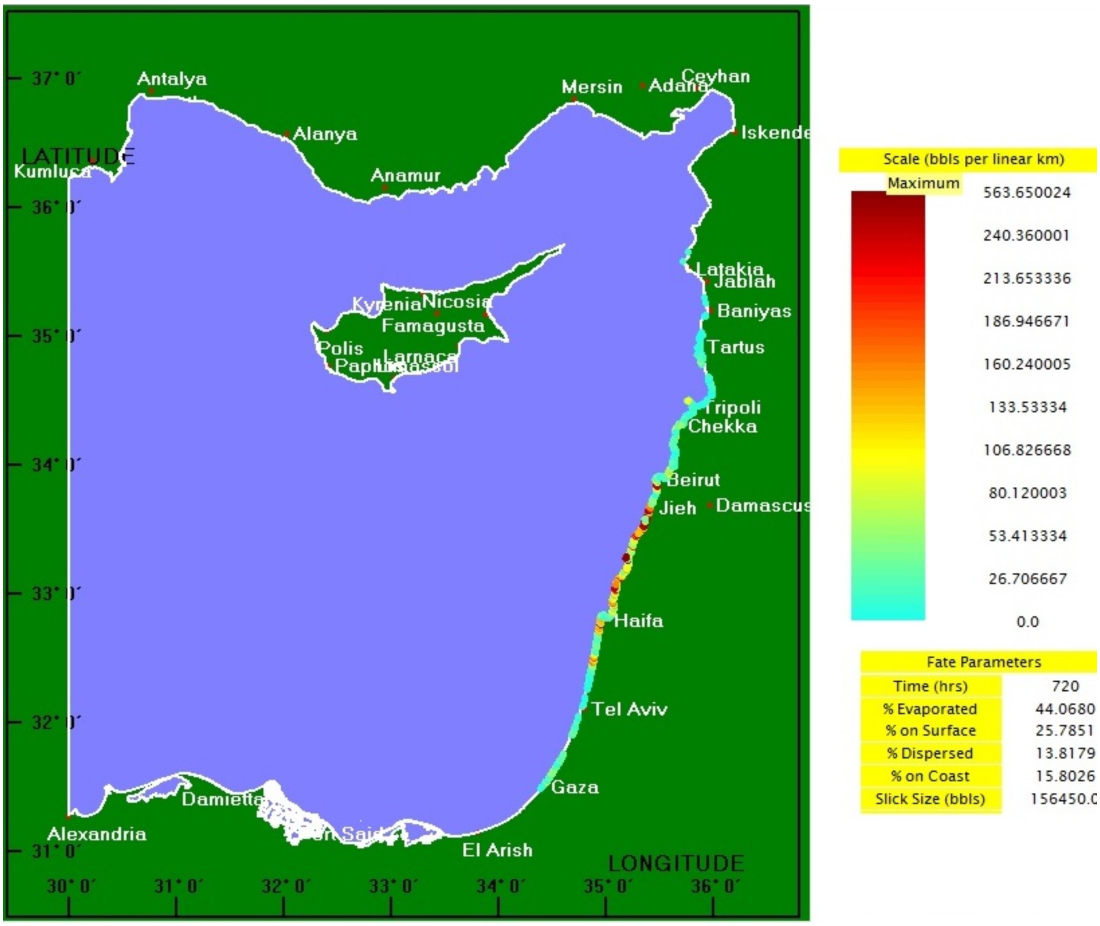

Figure 21: Total oil deposited on the coast at the end of 30 days of continuous discharge beginning on 26 Jan 2008 and ending on 25 Feb 2008.

The total oil deposited along the coast throughout the simulation is shown in Figure 21. A 388 km long section of coast (longest of all four cases), extending from Gaza and as far north as southern Syria, could potentially be affected. Along a large part of this section the concentrations are projected to have values less than 10 bbl/km. The most adversely affected region is the coast from Haifa to Jieh, but mainly south of Jieh, where values are projected to be over 100 bbl/km along the entire section. Several local hot spots appear with concentrations over 250 bbl/km. The highest concentrations will occur along a 10 km section of coast around Sidon, Lebanon.

6.3 Typical summer conditions: 17 Jul – 16 Aug 2008

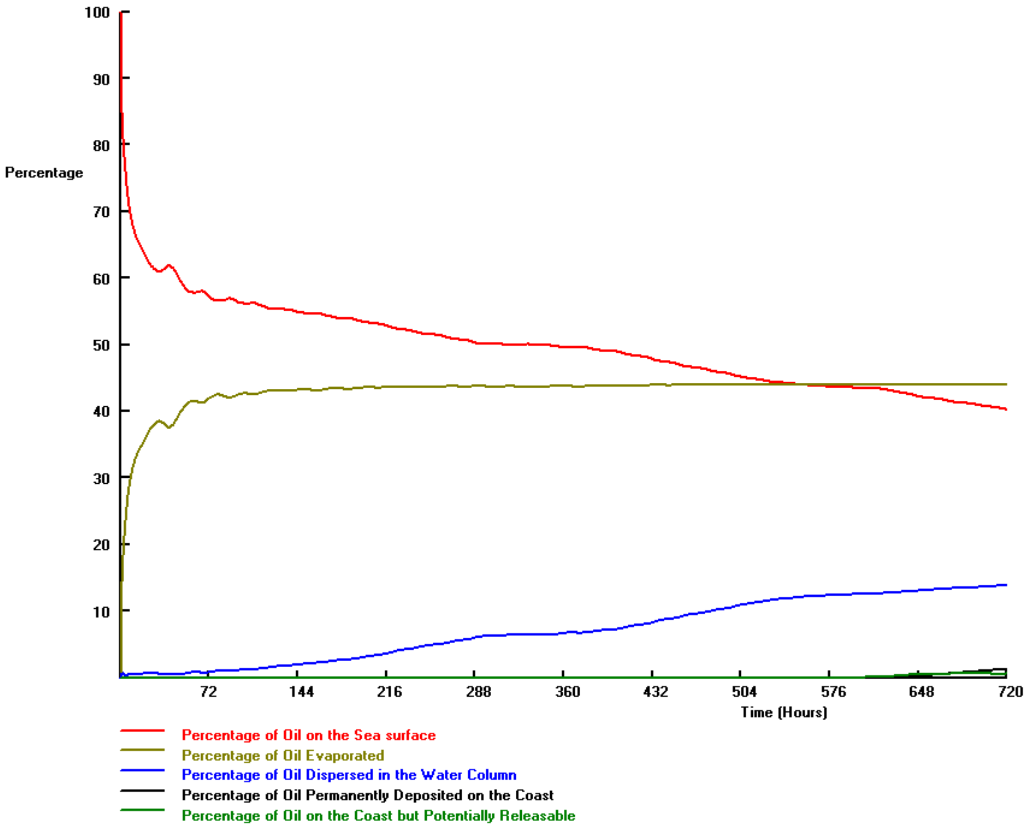

Figure 22: Oil fate parameters for the 30 day continuous discharge beginning 17 Jul 2008

The oil fate parameters for this scenario are shown in Figure 22. As with the other scenarios, here too the evaporation occurs rather quickly. Within 24 hours 36.8% of the oil evaporates whereas the 44% level is reached within one week. Coastal deposition begins on day 25 and increases slowly until the end of the period. The final balance at the end of 30 days is mainly between evaporation and oil remaining on the surface with 44% and 40.2%, respectively. Slightly less than 14% of the oil is dispersed water column and only 1.8% is deposited mainly along the coast of northern Lebanon and Syria. The length of impacted coastline is 103.8 km (see discussion of Figure 24 for details).

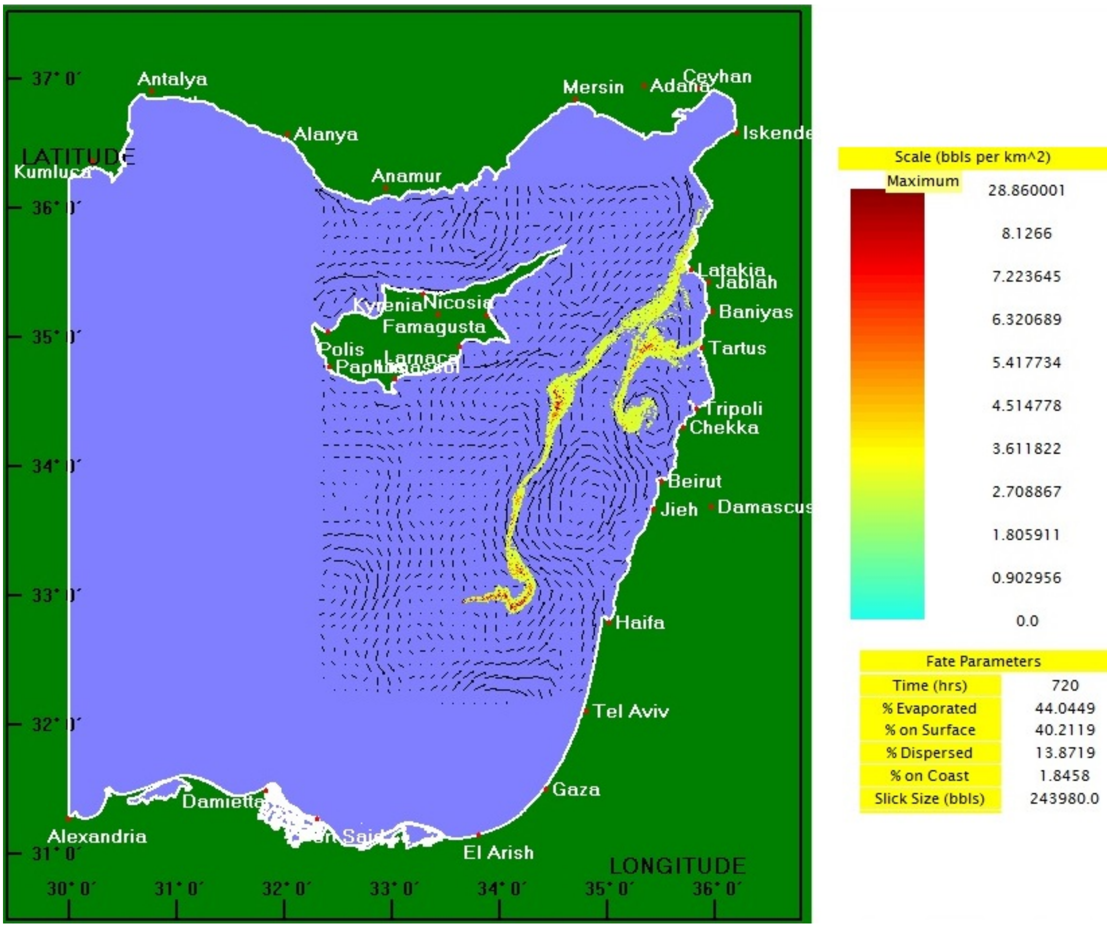

Figure 23: Oil remaining on the surface at the end of 30 days of continuous discharge beginning on 17 Jul 2008 and ending on 16 Aug 2008.

Figure 23 shows the oil remaining on the surface at the end of this 30 day simulation. The pattern here reflects an interesting interaction between the winds, the northward shore-parallel jet and several mesoscale eddies located off the coast of Lebanon. Initially the westerly to northwesterly winds spread the slick towards the coast. By day 12 the oil enters the zone of the northward flowing jet which transports the slick to the north. The winds continue pushing the slick eastward towards the coast and by day 17 the leading edge of the slick leaves the zone of influence of the jet and part of it begins to move the coast. Some of the oil becomes trapped in the eddy located off the coast of Tripoli. The rest of the oil continues to move to the northeast and some of it eventually reaches the coast of northern Lebanon and Syria. In contrast to the two winter cases, here the slick remains rather coherent and spreads laterally over a much smaller area.

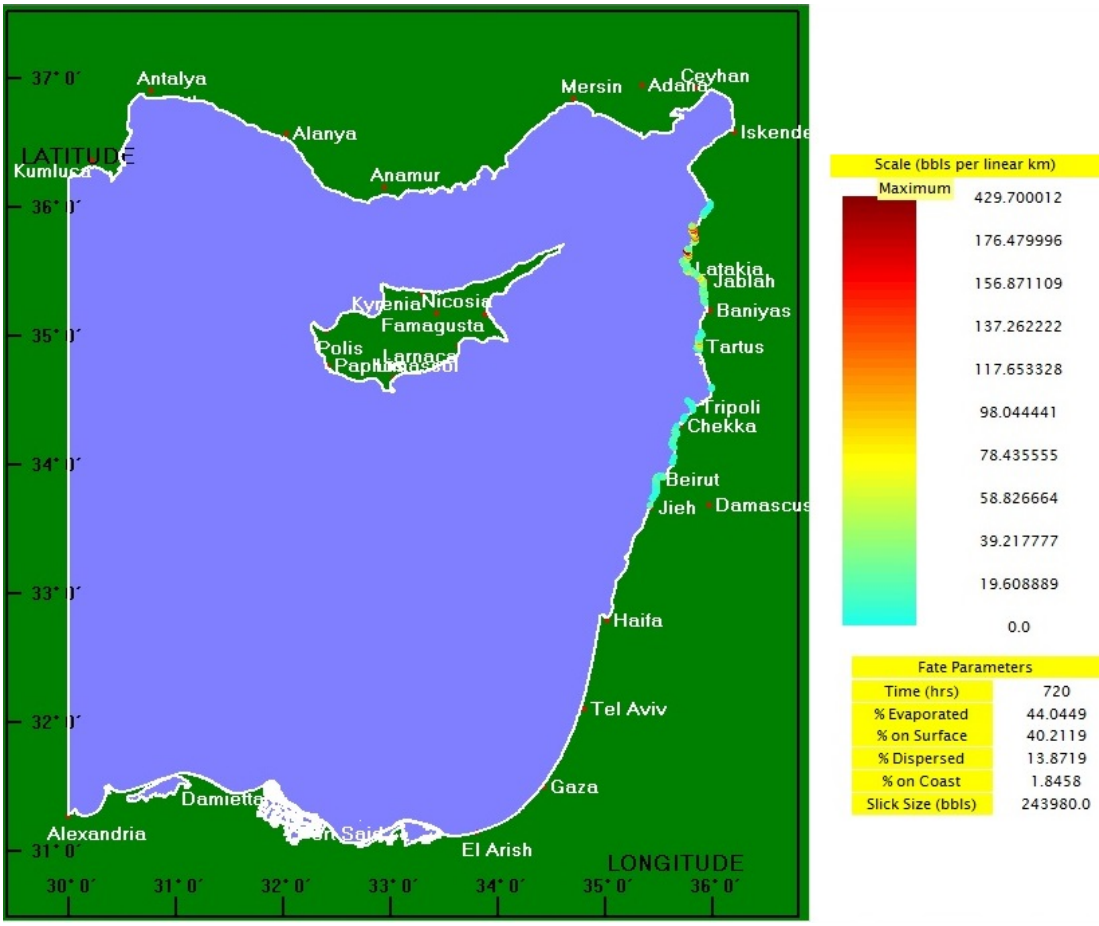

Figure 24: Total oil deposited on the coast at the end of 30 days of continuous discharge beginning on 17 Jul 2008 and ending on 16 Aug 2008.

The total oil deposited on the coast after 30 days is shown in Figure 24. The combined effects of the winds and the currents described above limit the impacted coastal section to 103.8 km extending along the northern coast of Lebanon extending from Jieh and northward into Syria. The concentrations in most of this zone are less than 15-20 bbl/km. The most adversely affected region is located north of Latakiya with two 5-10 km stretches of coast with concentrations over 100 bbl/km. The maximum values is 429.7 bb/km. Nevertheless, the coastal deposition is less than 2% of the total discharged oil.

6.4 Transition season with easterly winds: 25 Sep – 25 Oct 2007

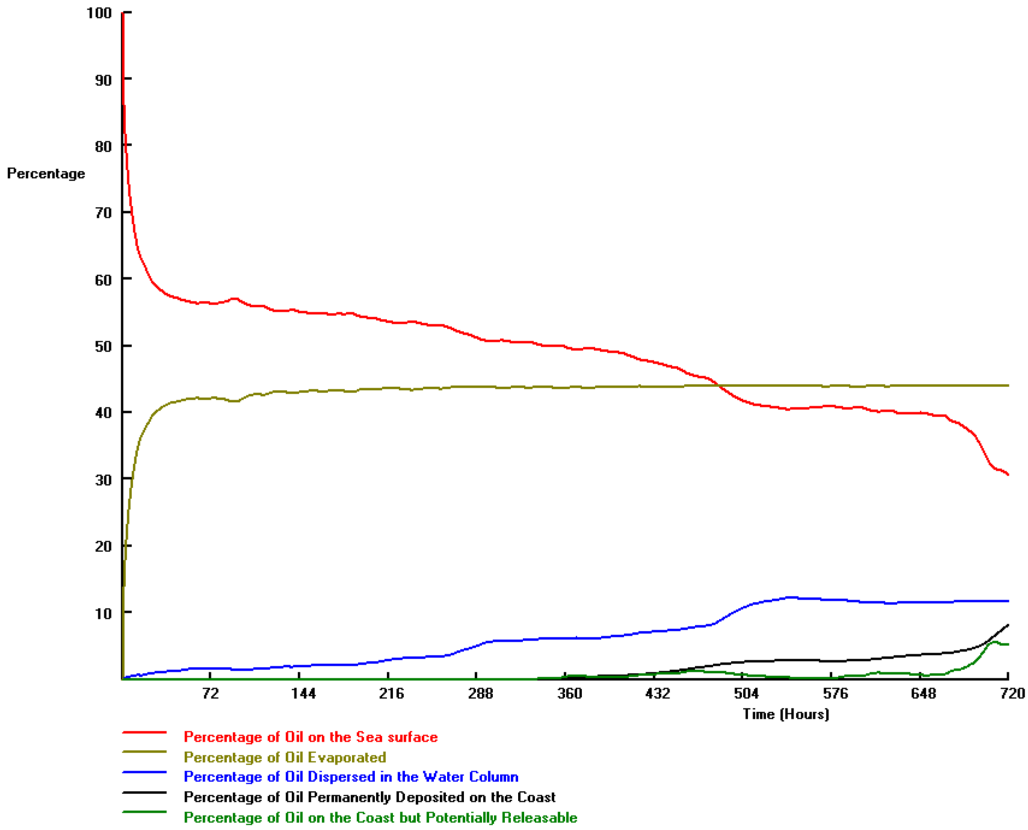

Figure 25: Oil fate parameters for the 30 day continuous discharge beginning 25 Sep 2007

The oil fate parameters for this scenario are shown in Figure 25. As with the other scenarios the evaporation occurs rather quickly. Within 24 hours nearly 39% of the oil evaporates. Significant coastal deposition begins on day 14, continuing gradually until the end of the period. The final balance at the end of 30 days is mainly between evaporation and oil remaining on the surface with 44% and 30.6%, respectively. 11.6% of the oil is dispersed water column and 13.4% is deposited on the coast. The length of impacted coastline is 321 km but the concentrations are relatively low along most of this section (see discussion of Figure 27 for details).

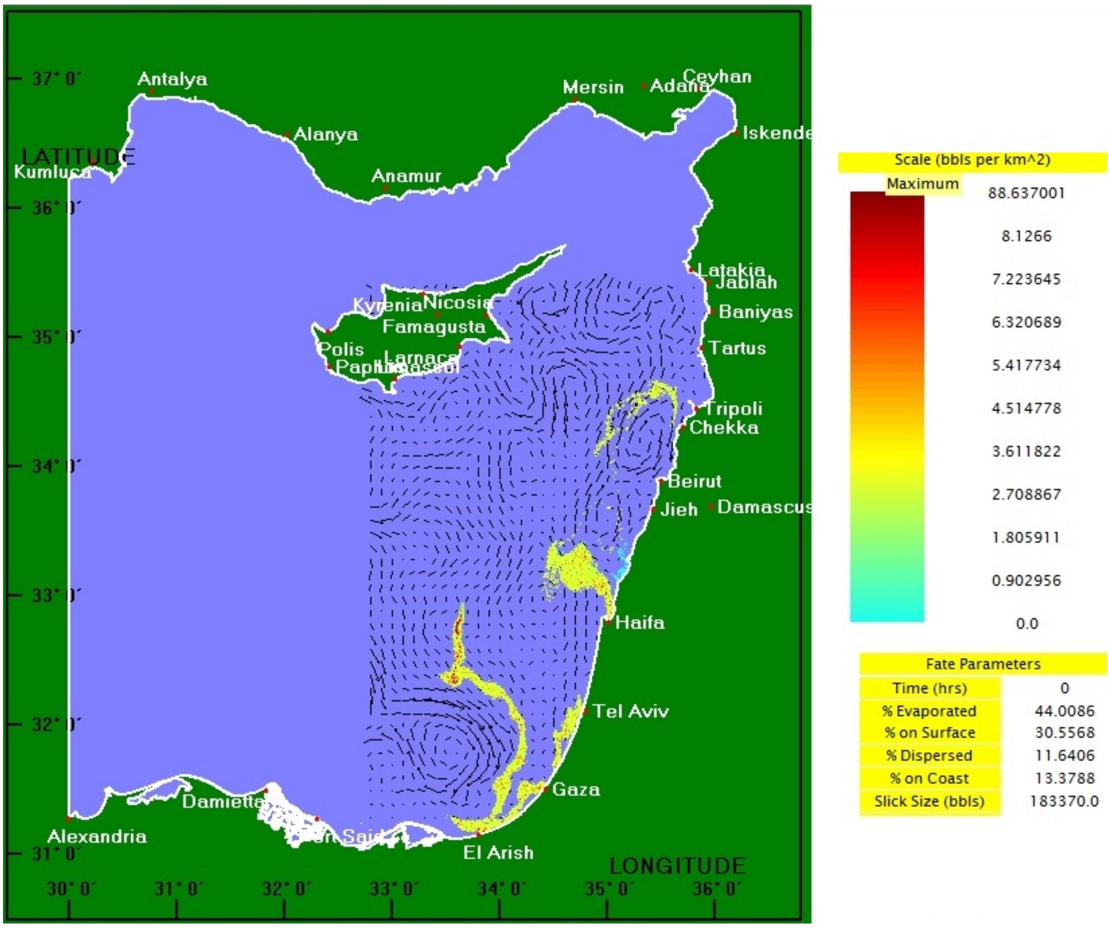

Figure 26: Oil remaining on the surface at the end of 30 days of continuous discharge beginning on 25 Sep 2007 and ending on 25 Oct 2007.

The oil remaining on the surface at the end of 30 days for this scenario is shown in Figure 26. During the transition season both the winds and the currents tend to be highly variable (speed and direction). As a result the oil on the surface spreads to the north and the south in thin filaments in the jets that flow parallel to the coast, although there is some offshore accumulation off the coast of Haifa. Some of the oil is also trapped in and transported by small mesoscale eddies. The winds have a strong northerly component throughout most of this period, which contributes to the significant southward spreading of this slick in this scenario.

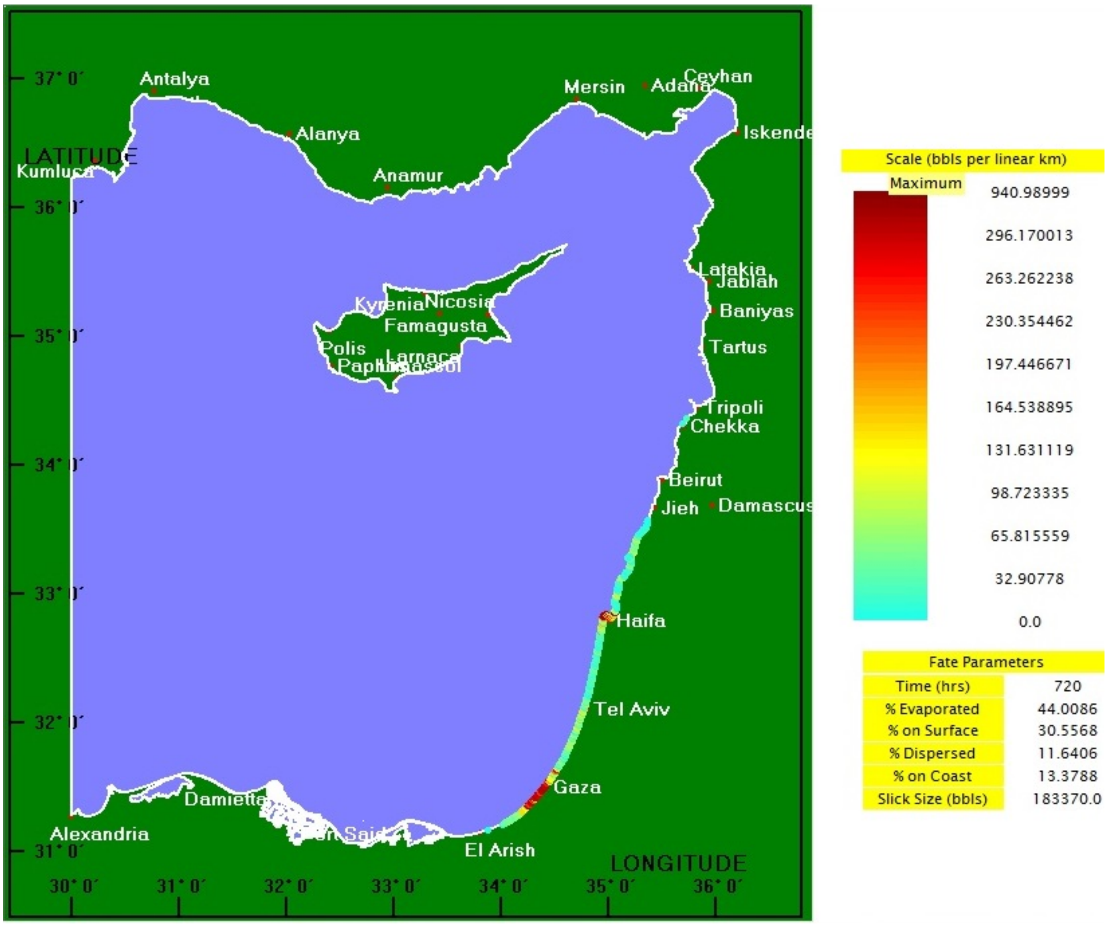

Figure 27: Total oil deposited on the coast at the end of 30 days of continuous discharge beginning on 25 Sep 2007 and ending on 25 Oct 2007.

The coastal deposition of oil at the end of the 30 days is shown in Figure 27. Approximately 13.4% of the oil is projected to reach the coast beginning on day 13 and steadily accumulating between until the end of the simulation on day 30. The affected coast, 320.8 km, is the second longest of all four simulations, and stretches from El-Arish, Egypt in the south to Jieh, Lebanon in the north. The concentrations along most of the most of this continuous zone are projected to be less than 15-20 bbl/km. The most adversely affected sections of coast are projected to be along the southern coast of Gaza and the southern coast of Haifa Bay. In these two regions the concentrations are typically expected to exceed 250 bbl/km, with localized hot spots and a maximum of several hundred bbl/km. The maximum point concentration is 941 bbl/km located in Haifa Bay.

6.5 Summary of the continuous oil spill simulations

In all four scenarios, more than 40% of the oil evaporates within a few days and levels out at around 44%. The rest of the oil is divided between oil remaining on the surface, dispersion in the water column, and coastal deposition with the division depending upon the spreading of the slick due to the winds and currents, although the surface oil accounts for most of the remaining mass (ranging from 25.8% in the July case to 41.5 in the extreme winter storm case). Table 2 summarizes the coastal deposition for all four cases. In all cases, as noted above, roughly one quarter to one half of the oil remains on the surface while between 0.3 and 15.8% is deposited on the coast for the extreme winter and typical winter cases, respectively. Since the well is located in deep water far offshore, it takes more than one week for coastal deposition to begin, although in most cases it takes even longer for any significant coastal accumulation to occur.

Table 2: Summary of initial and maximum coastal deposition of oil

Simulation period	Time of first oil on coast (hours)	Location of first oil on coast	Total oil on coast (% of spill)	Length of coast affected (km)	Maximum oil on coast at end of period (bbls/km)	Location of maximum oil on coast at end of period	Most affected region
9 Dec 2010-8 Jan 2011	618	34.6653 N 32.6203 E	0.3	54.2	169.1	34.2142 N 35.6465 E	Madfoun, Lebanon
26 Jan – 25 Feb 2008	180	33.6480 N 35.3984 E	15.8	388.5	563.7	33.5920 N 35.3849 E	Sidon, Lebanon
17 Jul – 16 Aug 2008	552	33.9036N 35.4933E	1.8	103.8	429.7	35.6692N 35.7681E	Latakiya, Syria
25 Sep – 25 Oct 2008	318	32.8316 N 34.9687 E	13.4	320.8	941.0	32.8262 N 34.9566 E	Haifa Bay

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