Environmental Impact Assessment
Tamar Field Development Project
Offshore Israel

September 2012

Prepared for:

Noble Energy Mediterranean, Ltd.
100 Glenborough Drive
Houston, Texas 77067-3610

Prepared by:

CSA International, Inc.
8502 SW Kansas Avenue
Stuart, Florida 34997
Telephone: (772) 219-3000

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Table of Contents

Table of Contents
(Continued)

Page

Table of Contents
(Continued)

Page

List of Tables

Table **Page**

List of Tables
(Continued)

List of Figures

List of Figures
(Continued)

Figure **Page**

List of Figures
(Continued)

Figure **Page**

List of Figures
(Continued)

Figure **Page**

List of Acronyms and Abbreviations

3D	three-dimensional
3LPP	three-layer polypropylene
AHTSV	anchor handling tow and supply vessel
AISC	American Institute of Steel Construction
AOT	Ashdod Onshore Terminal
API RP	American Petroleum Institute Recommended Practice
ASD	allowable stress design
AVHRR	advanced very high resolution radiometer
BCE	Before Common Era
BCFPD	billion cubic feet per day
BOD	biochemical oxygen demand
CH_4	methane
CIESM	Mediterranean Science Commission
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO	carbon monoxide
CO_2	carbon dioxide
CR	Critically Endangered
CYCOFOS	Cyprus Coastal Ocean Forecasting and Observation System
DD	Data Deficient
DP	dynamically positioned
DSL	digital subscriber line
DST	Dead Sea Transform
EBS	Environmental Baseline Survey
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EMP	Emergency Management Plan
EMS	Emergency Management System
EN	Endangered
EPU	electric power unit
ERL	effects range low
ERM	effects range median
FAO	Food and Agriculture Organization
GFCM	General Fisheries Commission for the Mediterranean
GMC	Greenwich Mean Time
GMS	Global Management System
HNO_3	nitric acid
IAA	Israel Antiquities Authority
IFREMER	Institut Francais de Recherche pour l'Exploitation de la Mer (French Research Institute for Exploitation of the Sea)
IMMRAC	Israel Marine Mammal Research and Assistance Center
INGL	Israel Natural Gas Line
INNPA	Israel National Nature and Parks Authority
IPF	impact producing factor
IOLR	Israel Oceanographic & Limnological Research
ITCZ	Intertropical Convergence Zone
IUCN	International Union for Conservation of Nature
IUTA	intermediate umbilical termination assembly
LDW	Levantine Deep Water
LFA	low-frequency active
LIW	Levantine Intermediate Water
LR/CD	Lower Risk/Conservation Dependent
LR/LC	Lower Risk/Least Concern
LR/NT	Lower Risk/Near Threatened
MARPOL	Marine Pollution convention (International Convention on Prevention of Pollution from Ships)
MCS	master control station
MEG	monoethylene glycol
MERIS	medium resolution imaging spectrometer
MEWR	Ministry of Energy and Water Resources
MMJ	Mid-Mediterranean Jet
MMscfd	million standard cubic feet per day
MODIS	moderate resolution imaging spectroradiometer
MPA	Marine Protected Area
MVSS	mean vertical sound speed
NATO SACLANT	North Atlantic Treaty Organisation Supreme Allied Commander Atlantic
NMFS	National Marine Fisheries Service
NO_3	nitrate
NOAA	National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Noble Energy	Noble Energy Mediterranean, Ltd.
NO_x	oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
O_3	ozone
OCS	Outer Continental Shelf
Offshore Protocol	Protection of the Mediterranean
OHGP	open hole gravel pack
OSHMS	Occupational Safety and Health Management Systems
OSRP	Oil Spill Response Plan
PAH	polycyclic aromatic hydrocarbon
PAN	peroxyacetal nitrate
PCB	polychlorinated biphenyl
PCS	Production Control System
PM	particulate matter
PO_4	phosphate

psig	pounds per square inch gauge
PTS	permanent threshold shift
ROV	remotely operated vehicle
SCM	subsea control module
SDA	subsea distribution assembly
SEM	subsea electronic module
Si $(OH)_4$	silicic acid
Si	silicon
SO_2	sulfur dioxide
SO_4	sulfate
SO_x	oxides of sulfur
SPA	Specially Protected Area(s)
SSIV	subsea isolation valve
TBT	tributyltin
TEG	triethylene glycol
TEU	20-ft equivalent unit
TNT	trinitrotoluene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TSS	total suspended solids
UNEP MAP RAC/SPA	United Nations Environment Programme, Mediterranean Action Plan, Regional Activity Centre for Specially Protected Areas
UNEP	United Nations Environmental Programme
UPS	uninterruptible power supply
USCG	U.S. Coast Guard
USDOI, BOEM	U.S. Department of the Interior, Bureau of Ocean Energy Management
USDOI, MMS	U.S. Department of the Interior, Minerals Management Service
USEPA	U.S. Environmental Protection Agency
UTA	umbilical termination assembly
VHF	very high frequency
VOC	volatile organic compound
VU	Vulnerable

1.0 Introduction

1.1 PROJECT OVERVIEW

Noble Energy Mediterranean, Ltd. (Noble Energy), as Operator, has prepared this Environmental Impact Assessment (EIA) for the development of a subsea gas production and transportation system connecting the deepwater Tamar Gas Field to a new offshore receiving and processing platform – the Tamar Platform – to be located in proximity to the existing Mari-B Platform. The project has been termed the Tamar Field Development Project (**Figure 1**).

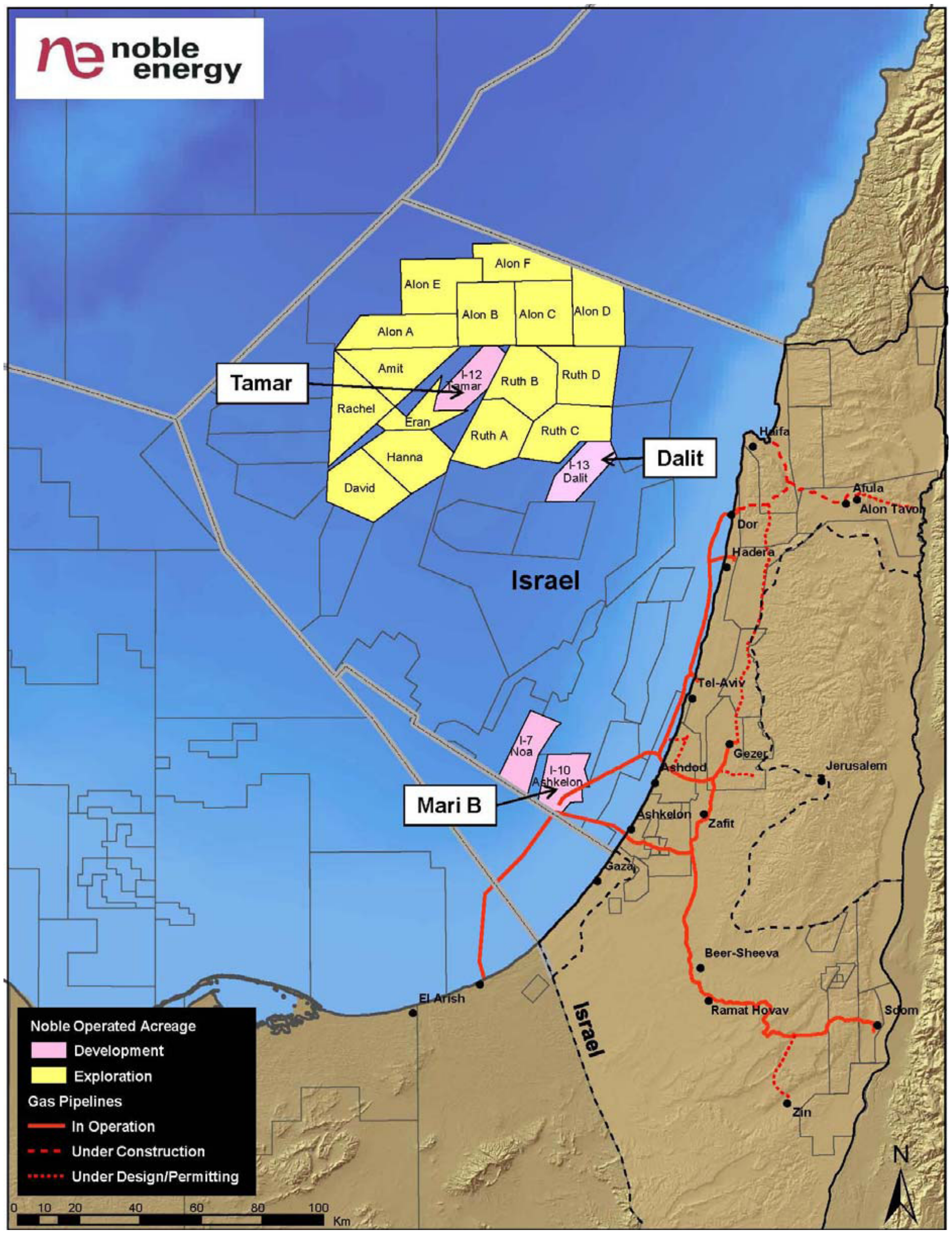


Figure 1. Regional location map showing location of the Tamar Field and Mari-B Platform.

The EIA sets out to 1) identify the various components of the Tamar Field Development Project, 2) characterize the environmental and socioeconomic resources of the project area, 3) assess the environmental and socioeconomic impacts of installation and operation of the Tamar Field Development Project, and 4) identify relevant mitigation measures available to reduce or eliminate potentially significant impacts. Summary characterizations of Tamar Field Development Project components were based on Noble Energy's Development Plan Document (Document No. TAM-PM-NEM-PRM-POD-0006 Rev 6).

1.2 EIA ORGANIZATION

The main sections of the report are as follows:

- **1.0 Introduction** – An overview of the project and information about the scope and organization of the EIA is provided.
- **2.0 Project Description** – The project description considers various project characteristics, including location and schedule, effluent discharges, air pollutant emissions, support operations, decommissioning plans, and alternatives. The following project activities are described:
  - installation of the Tamar Field gathering system (flowlines, umbilicals);
  - installation and commissioning of pipelines and flowlines between the Tamar Field and the Tamar Platform;
  - Installation of the Tamar Platform; and
  - Installation of pipelines to shore and to the Mari-B Platform.
- **3.0 Description of the Environment** – Environmental and socioeconomic conditions within and near the project area that could be affected by various phases of the installation and commissioning of new facilities are summarized.
- **4.0 Social and Environmental Impacts** – Impact producing factors are identified and the rationale for impact determination is provided (e.g., identification of impact levels; assessment and determination of significance; analysis of the positive and negative impacts of the project, including those from routine operations and potential accidents). Cumulative impacts and transboundary effects are identified. Feasible mitigation measures and resulting residual impacts are also determined.
- **5.0 Mitigation and Residual Impacts** – Available mitigation measures are identified to reduce or eliminate potential impacts and the residual impacts (i.e., impacts after mitigation measures have been applied) are determined.
- **6.0 Environmental, Health, and Safety Management** – Noble Energy corporate policies pertinent to environmental, health, and safety management policies are outlined.
- **7.0 Conclusions** –Impact determinations, available mitigation measures, and residual impacts associated with the proposed Tamar Field Development Project are summarized.
- **8.0 References** – A comprehensive listing of data sources used in compiling the EIA is provided.
- **Appendices** – Appendices provide technical data to support descriptions of the project components, baseline resources, and/or impact assessment and mitigation.

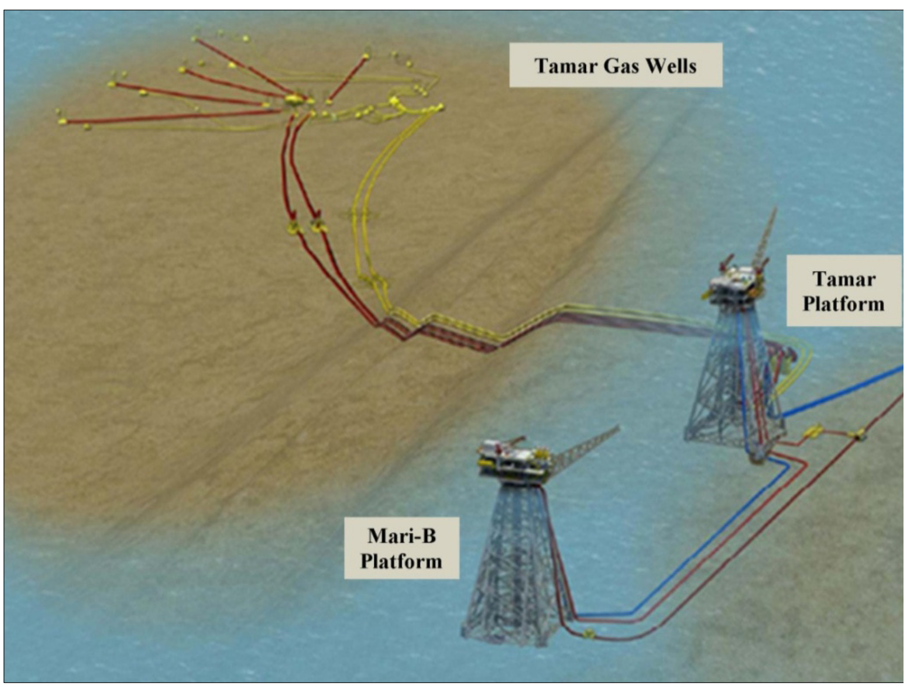
2.0 Project Description

Noble Energy is pursuing the Tamar Field Development Project, a venture between Noble Energy and its partners – Isramco Negev 2 Limited Partnership, Delek Drilling Limited Partnership, Avner Oil Exploration Ltd, and Dor Gas Exploration – to commercially develop the Tamar Field located in the Eastern Mediterranean, off the coast of Israel. Noble Energy proposes installation of a subsea gas production and transportation system connecting the deepwater Tamar Gas Field to a new offshore receiving and processing platform – termed the Tamar Offshore Receiving and Processing Platform, or Tamar Platform – and linking to the existing Mari-B Platform.

2.1 OVERVIEW

Noble Energy proposes development of a subsea gas production and transportation system connecting the deepwater Tamar Gas Field to the Tamar Offshore Receiving and Processing Platform (Tamar Platform). The Tamar Field is located in License 309, Matan Block, approximately 90 km west of Haifa, within the Levantine Basin.

The Tamar Gas Field will be developed as a subsea tieback to the Tamar Platform, which will be located within 2 km of the existing Mari-B Platform. The Mari-B Platform is located approximately 25 km off the coast of Israel at a water depth of 234 m. The Tamar Field Development Project will have a production capacity of 1,200 million standard cubic feet per day (MMscfd). A subsea view of the Tamar Field Development Project is shown in **Figure 2**.



Legend:
Red lines: 4-in. MEG/hydrate inhibitor/corrosion inhibitor lines and hydro-electrical umbilical lines (Tamar Platform to Tamar Field)
Yellow lines: 10-in. infield flowlines; subsea manifold; dual 16-in. gas pipelines (Tamar Field to Tamar Platform)
Blue line: Tamar gas line to AOT; gas line to Mari-B for injection

Figure 2. Subsea view of the Tamar Field Development Project.

Gas production from the Tamar Reservoir will occur through five or six high flow rate subsea wells into the subsea gathering system, which consists of a 10-in. infield flowline from each well to a subsea manifold. From the subsea manifold within the Tamar Field, dual 16-in. subsea pipelines will transport Tamar production approximately 149 km to the Tamar Platform where the gas will be processed.

The Tamar Field will be controlled from the Tamar Platform via electro-hydraulic umbilicals. The umbilicals will terminate at a Subsea Distribution Assembly (SDA) located close to the subsea manifold. Electric power, communication, and chemicals will be distributed from the SDA to the wells via individual infield umbilicals.

Corrosion inhibitor will be mixed with monoethylene glycol (MEG), a hydrate inhibitor, and will be delivered from the Tamar Platform to the SDA via dual 4-in. supply pipelines and distributed to the wells through infield umbilicals.

The processed gas will be delivered to the existing Ashdod Onshore Terminal (AOT) via hot tap into the existing 30-in. pipeline for gas sales into the Israel Natural Gas Line (INGL) system. When required, the processed gas may also be delivered to the existing Mari-B Platform through an interconnect pipeline and injected into the Mari-B Reservoir for gas storage.

Tamar condensate will be injected into a dedicated condensate pipeline running between the Tamar Platform and AOT receiving facility. The condensate line is one of three new utility pipelines for production services to be installed from the Tamar Platform to AOT. Because condensate handling is a key element of efficient gas production, Tamar condensate may be reinjected into the Mari-B reservoir if utility pipelines are not immediately available at start-up. Modifications will also be made to the existing AOT (including debottlenecking) to manage the increased produced gas flow.

The Tamar Platform is designed to be self-sustaining and independent from the existing Mari-B Platform. The Tamar Platform will be designed for a maximum gas flow capacity of 1,200 MMscfd. A process design diagram for the various components of the Tamar Field Development Project is provided in **Figure 3**.

2.2 LOCATION AND SCHEDULE

Drilling and completion of the subsea wells, installation of the subsea pipeline and control system, and installation of the Tamar Platform are targeted for 2013. Actual dates for completion of each of these phases depends on the availability of contractors to complete the associated tasks.

The Mari-B Platform.

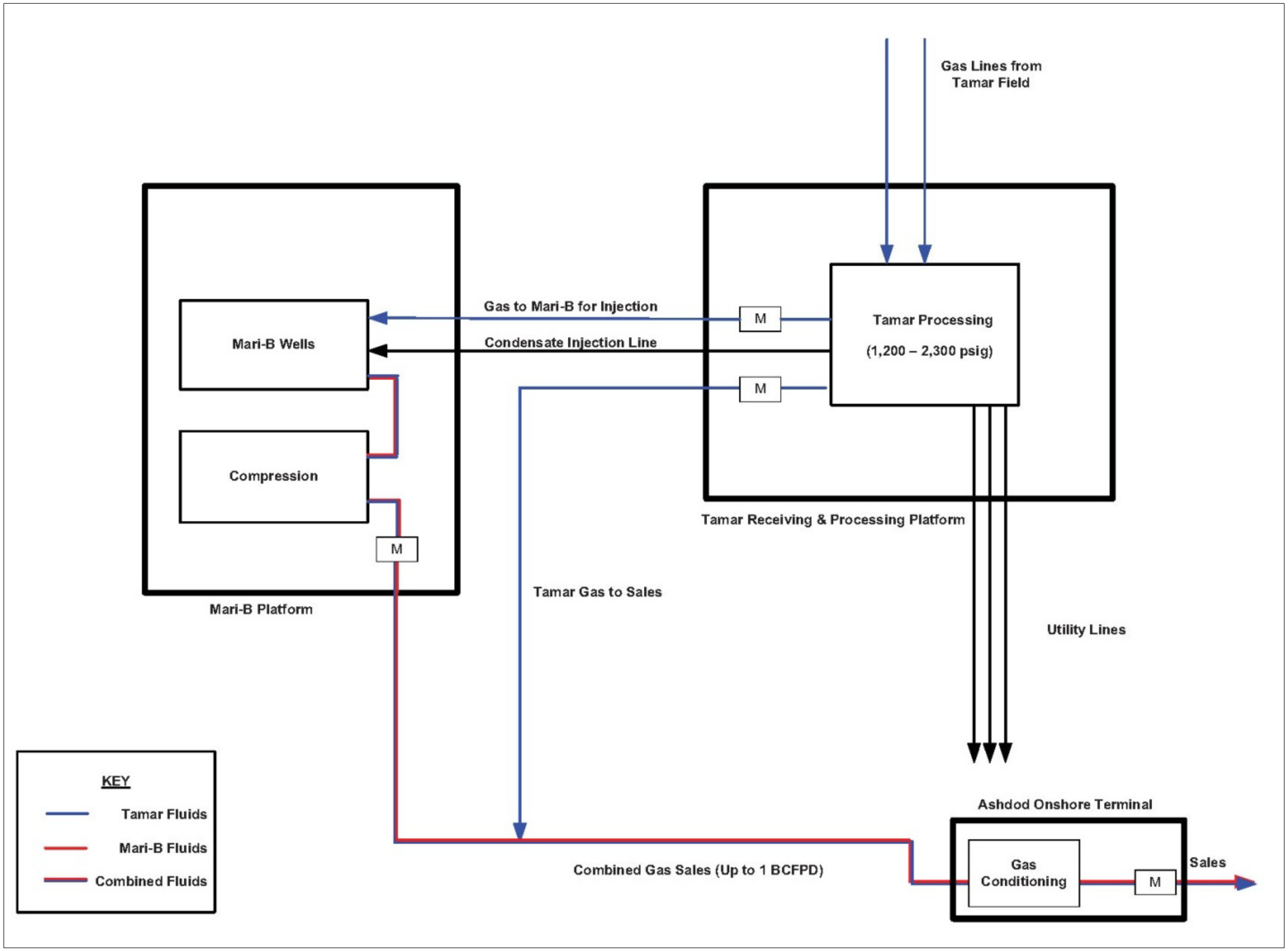


Figure 3. Process flow diagram for the Tamar Field Development Project. BCFPD = billion cubic feet per day; psig = pounds per square inch gauge.

2.2.1 Mari-B Modification

The Mari-B Platform is located approximately 25 km off the coast of southern Israel at a water depth of 234 m. Geographic coordinates for the Mari-B Platform are 622,624 easting; 3,511,745 northing (Well No. 3) (**Figure 4**).

Modifications to the Mari-B were initiated in early 2011 and are slated for completion in 2012.

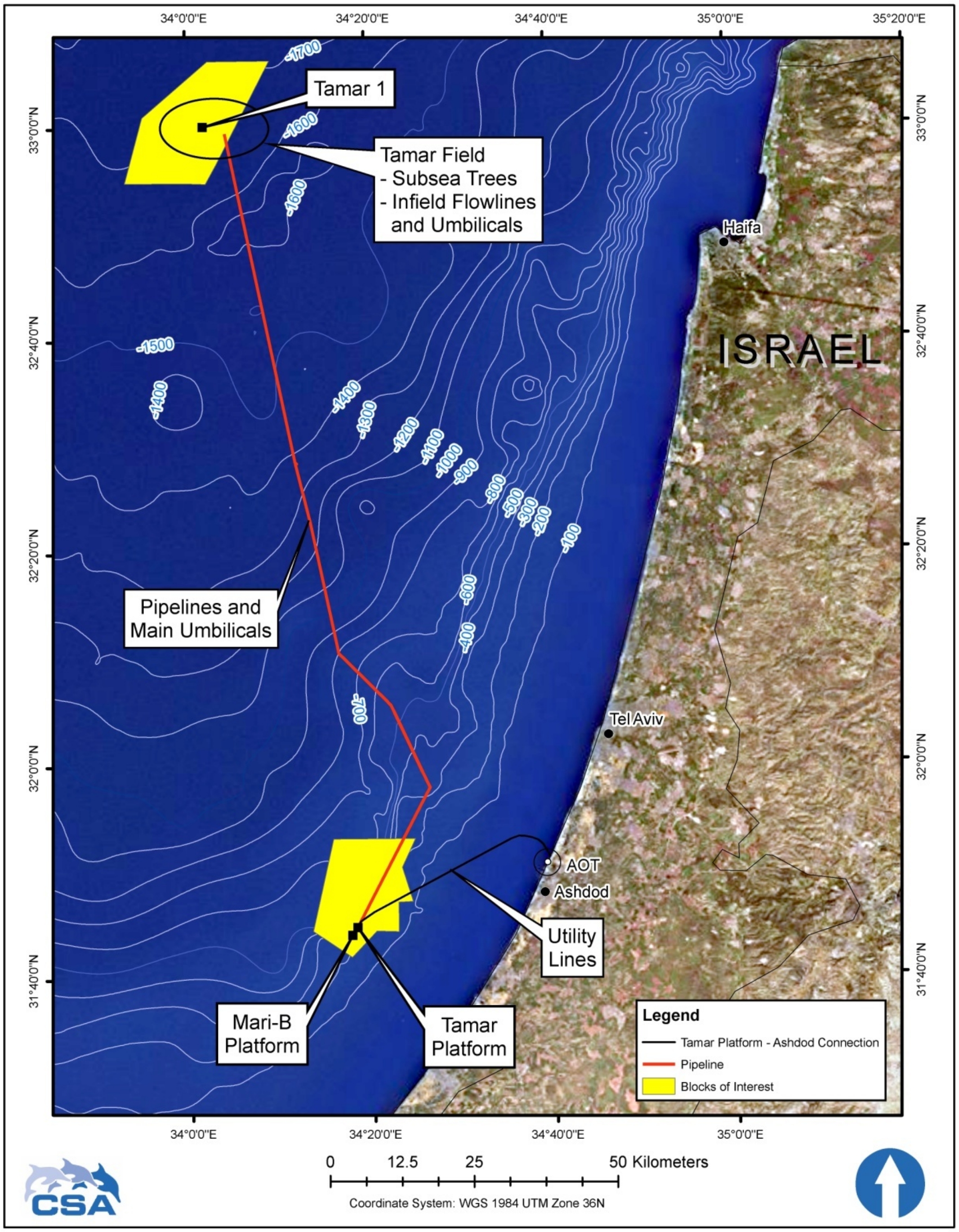


Figure 4. Tamar Field Development Project components. (Water depths are in meters.)

2.2.2 New Tamar Platform Installation

The proposed Tamar Platform will be located at 623,628.63 easting; 3,513,181.93 northing, approximately 2 km from Mari-B Platform (**Figure 4**). Installation of the Tamar Platform is expected to take place in 2013.

2.2.3 Pipelines, MEG Lines, Utility Lines, and Control Lines

The Tamar Field is located approximately 90 km off the coast of northern Israel in the Mediterranean Sea at a water depth of 1,678 m. The stylized layout of pipelines, MEG lines, and control lines within the Tamar Field is shown in **Figure 2**. The route to be followed by pipelines, MEG lines, and control lines between the Tamar Field and the Tamar Platform is shown in **Figure 4**, as well as the routing of the threeutility lines between the Tamar Platform and AOT. Installation of pipelines, MEG lines, control lines, and the utility lines between Tamar Platform and AOT is scheduled to occur in the 2011-2012 timeframe.

2.2.4 Tamar Wells and Field Infrastructure

The Tamar Field will be developed in multiple phases. Phase 1 encompasses an early production system comprising five producing wells–Tamar-2 through Tamar-6. Total production from the Tamar Field will range from 200 to 1,200 MMscfd. The Tamar-6 well will be a re-drill of Tamar-1. A contingent seventh location (Tamar-7) has been identified for risk mitigation. The surface locations of the Tamar wells are outlined in **Table 1**.

Table 1. Tamar well surface locations. Five source wells for Tamar gas are shaded.

Well	Geographic Coordinates				Mud Line Depth (m)	Seabed Gradient	Notes
	Easting (m)	Northing (m)	Latitude (N)	Longitude (E)			
Tamar-1	596,477	3,652,061	33°00'09.76"	34°01'58.01"	-1,678	--	Will not be completed; see Tamar-6
Tamar-2	600 ,749	3,655,499	33°01'59.98"	34°04'43.97"	-1,684	--	As-drilled (T-P1-NC-A1)
Tamar-3	594,501	3,649,469	32°58'46.25"	34°00'40.90"	-1,672	0.3	Old Name: T-P1-S-C1
Tamar-4	597,455	3,654,459	33°01'28.25"	34°02'36.59"	-1,689	0.3	Revised location as per document TAM-PM-NEM-PRC-MOC-0004
Tamar-5	596,255	3,654,046	33°01'14.27"	34°01'50.21"	-1,705	1.4	Old Name: T-P1-C-B1
Tamar-6	596,449	3,652,069	33°00'10.03"	34°01'56.93"	-1,678	<1.0	Tamar-1 twin. Required for an open hole gravel pack completion
Tamar-7	596,057	3,651,746	32°59'59.66"	34°01'41.70"	-1,674	1.5	Contingent well location (T-P2-C-A1)

The purpose of Phase 1 is to establish reservoir and field performance relative to deliverability and vertical and lateral reservoir connectivity, in addition to meeting gas market needs. There will be at least one completion in each producing sand horizon. One fault block will have completions in two different sands to establish vertical connectivity, and one sand horizon will be completed in two adjoining fault blocks to establish lateral connectivity.

Noble Energy has designed the Tamar Field Development Project to ensure reliable production. With the exception of Tamar-2 and Tamar-6, each new development well will be logged and a bypass drilled for completion. Single zone completions are planned and each well will be monitored for production performance.

2.2.4.1 Subsea Trees

Subsea trees for the Tamar Field Development Project will be Cameron G3 Spooltrees, a horizontal style tree with a nominal 5-in. bore and nominal 2-in. annulus. The trees will be rated for 10,000 psig (689 barg) working pressure and configured for a 7-in. tubing completion. Each tree will be designed for a nominal flow rate of 250 MMscfd of gas at the full range of working pressures. The trees will be controlled from the Tamar Platform via a multiplexed electro-hydraulic control system and will utilize a single subsea control module (SCM) per tree. The trees will be designed for guideline-less installation.

Each tree will have an insert retrievable style choke valve rated for 10,000 psig (689 barg). The choke will be used to regulate flow from the well and to absorb excess well pressure so that well(s) can be commingled downstream. The tree will include a standard remotely operated vehicle (ROV) panel to allow override of all the pressure and flow controlling valves. All tree actuated valve overrides and manual valves will be operable by ROV.

The trees are approximately 3 to 6 km from the manifold. Infield flowlines are used to connect the wells to the manifold. Dual-hub flowline end terminations are installed at each end of the infield flowlines. Primary hydrate inhibition is accomplished by continuous injection of MEG at the trees. The MEG is delivered to the field through two 4-in. pipelines bundled with the 16-in. lines for installation.

2.2.4.2 Production Control System

The subsea Production Control System (PCS) for the Tamar Field Development Project will be an electro-hydraulic multiplexed system capable of monitoring and controlling the operations of up to 12 subsea wells, 1 manifold, 2 SDAs, and associated gathering system for the Tamar Field.

The subsea production control system will require the use of fiber optic cable communication due to the offset distance, required scan rate (for adequate update of displayed data and well security), data rate, and quantity of data. The system is identified as being a separate communications and power system. The main umbilical will contain sufficient fiber optic cores to transmit the signals required to control the subsea facilities. Fiber optic repeaters will be installed at the intermediate umbilical termination assembly (UTA) of the second segment of each main umbilical. Spare optical fibers are required for contingency purposes.

Power and communication, chemicals, and hydraulic control fluid are delivered to the field through dual umbilicals that terminate at an SDA near the manifold. From the SDA, these services are routed to the individual wells and manifold through infield umbilicals and flying leads. The SDA will include provisions for tying in a separate umbilical and MEG pipeline from an onshore facility in the future.

The platform-mounted control equipment will consist of a master control station (MCS), production hydraulic power unit, electric power unit (EPU), uninterruptible power supply (UPS), and topsides umbilical termination assembly. Because of the long offset distance, the EPU will use direct current power to provide increased cable efficiency. The UPS will be capable of powering the MCS and EPU for a minimum of 60 minutes following a platform power loss.

The subsea control system equipment consists of UTAs; SDAs; hydraulic, electrical, and optical flying leads; SCMs; sand detectors; wet gas flow meters; and pressure/temperature transducers. The SCMs will be based on previously built Cameron SCMs that used integrated high-pressure and low-pressure accumulators. Because the SCMs will be built with integrated high-pressure and low-pressure accumulators, therefore, separate subsea accumulator modules will not be necessary.

The SCMs feature redundant electrical and electronic configuration provided by two subsea electronic modules (SEM). Separate power and communication will be provided to the redundant SEMs within each SCM to minimize the possibility of a common mode failure.

The SCMs will be installed on each tree and SDA. Two SCMs will be installed on the manifold because of the high function count requirement brought on by the use of double-acting valves. Two SCMs will also be installed on the SDA to provide the functionality required to operate the Tamar Field from the platform or an onshore host. The SCMs will be designed for replacement by an ROV and dedicated running tool.

Each tree-mounted SCM will control and monitor the valves and transducers associated with that tree. The SDA-mounted SCMs will control and monitor the SDA valves, transducers, and chemical injection metering valves. The manifold-mounted SCMs will control and monitor the manifold valves and transducers.

The hydraulic, electrical, and optical flying leads will be installed by an ROV. They will connect the intermediate UTAs, main UTA to the SDA, SDA to manifold, SDA and infield UTAs, and the infield UTAs to the trees. The control fluid used will be water-based and will be vented to the environment upon valve closure. The MEG line valves are controlled by the SCM on the SDA.

2.2.4.3 Main Umbilical

The main umbilical will be manufactured in two parallel segments of three sections each because of the long offset distance in combination with the size. Intermediate umbilical termination assemblies (IUTA) will be used to provide connection points to deliver electrical, fiber, hydraulic, and chemical services onward to the Tamar production field.

The main electro-hydraulic umbilical utilizes super duplex steel tubes, electrical cables, and fiber optic cables (**Figure 5**). Each parallel umbilical segment provides the following functionality:

- High-pressure hydraulic supply;
- Low-pressure hydraulic supply;
- Methanol supply;
- Silicate inhibitor;
- Spare;
- Three 25-mm^2 electric quads to supply electric power; two in service plus a spare; and
- Two 16-channel fiber optic bundles.

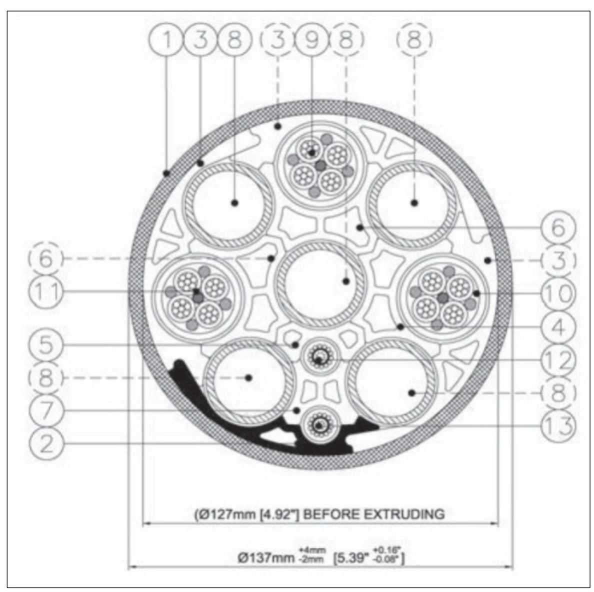


Figure 5. Cross section of main umbilical.

The various UTAs employ hydraulic configuration plates (logic caps) to reconfigure hydraulic and/or chemical services in the event of a tube failure. All quads are terminated in ROV-type electrical bulkhead connectors on the various UTAs. The spare and any unused connectors are protected by long-term protection caps. The fiber optic bundles transmit bi-directional communication signals between the subsea facilities and the topsides control station.

The fiber optic bundles contain spares for contingency and design redundancy. Backup communications will not be provided through electrical cables. All bundles/cores are terminated in ROV-type fiber bulkhead connectors on the various UTAs. The spare connectors are protected by long-term protection caps. The main umbilicals are designed to be pulled through individual J-tubes at the platform.

2.2.4.4 Infield Umbilicals

The infield electro-hydraulic umbilical utilizes super duplex steel tubes and electrical cables. The infield umbilicals are configured to support two wells on each infield leg. To meet the functionality required, the infield umbilical cross section (**Figure 6**) includes

- two high-pressure hydraulic supply lines;
- two low-pressure hydraulic supply lines;
- three methanol supply lines;
- two auxiliary lines (service, annulus vent/monitoring);
- two silicate injection lines;
- two spares; and
- six 10-mm^2 electrical quads to supply electrical power.

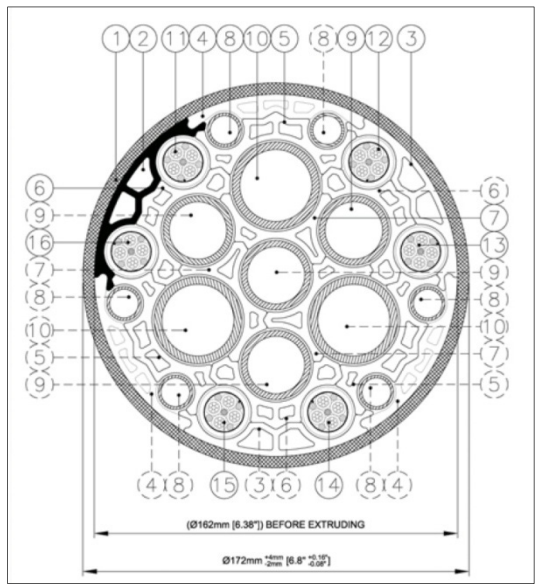


Figure 6. Cross section of an infield umbilical.

Fiber communication is not used in the infield umbilicals. The infield umbilicals will be manufactured in one length of approximately 35 km and cut into six sections of 4- to 7-km lengths, depending on final field layout. The infield umbilical ends will be terminated with an infield UTA on each end and connected to the SDA and trees with electrical and hydraulic steel flying leads. The near tree IUTA will employ hydraulic configuration plates (logic caps) to reconfigure hydraulic and/or chemical services in the event of a tube failure. The configuration plates are designed to accommodate subsea intensifiers as a back-up contingency plan in the event of high numbers of tube failures either in the main or infield umbilicals.

The infield umbilical contains six electrical quad conductors to supply electrical power and digital subscriber line (DSL) communication signals to the trees' SCMs. As a contingency plan, two of the six electrical quads are designated as spare electrical quads. All quads are terminated in ROV-type bulkhead connectors in the various IUTAs. The spares and any unused connectors will be protected by long-term protection caps.

2.3 SPECIFICATIONS AND INSTALLATION OR MODIFICATION ACTIVITIES

2.3.1 Mari-B Platform

Eight major modifications to Mari-B Platform are considered in this analysis. Planned modifications to Mari-B Platform include

- addition of a new 16-in. gas riser for the pipeline from the Tamar Field;
- addition of gas filtering equipment, piping, and valves for gas injection into the Mari-B wells;
- addition of condensate separation/filtering equipment, piping, and valves for condensate injection into a Mari-B well;
- addition of a new deck extension to provide space for the new equipment;
- relocation of the existing fast rescue boat to the new deck extension;
- Master Control Center building modifications to incorporate new starters and variable frequency drives for the new equipment;
- pipe, valves, fittings, and instruments to tie-in the new equipment to the existing process; and
- instrumentation and electrical modifications to incorporate the new equipment.

New equipment on Mari-B Platform will include

- gas pipeline pig receiver;
- slug catcher;
- gas filter skid;
- condensate filter skid;
- condensate pump skid;
- condensate cooler skid;
- condensate flash gas compressor skids;
- valves, piping, fittings, and instruments to interconnect components;
- three Solar Titan 130 turbine compressors; and
- one natural gas compressor (replacement).

Modifications and installation of new equipment on Mari-B Platform will require the use of support vessels to effect the transport of skids, compressors, and other equipment and supplies. Noble Energy and contractor personnel will install and test new equipment onboard the Mari-B.

2.3.2 New Tamar Platform

The new Tamar Platform will be a self-sustaining and independent facility, separate from the Mari-B Platform. Process capabilities will be designed for full flow from Tamar up to the maximum design pressure of the incoming production flowlines. System design shall include the ability to direct full flow to the departing pipeline(s) or split flow to the dedicated injection wells via an injection header on the Mari-B Platform. Flow splitting will be accomplished through a combination of in-line flow control and pressure control devices. The Tamar Platform design characteristics are outlined in **Table 2**. A view of the proposed Tamar Platform is provided in **Figure 7**.

Figure 7. Elevation view of the Tamar Platform.

Table 2. Tamar Platform design characteristics.

Component or Characteristic	Details
Water depth	234 m
Orientation	Platform north 56.5° west of true north
Design field life	30 years
Design code	API RP 2A, 21st Edition AISC Manual of Steel Construction (ASD), 9th Edition
Number of legs	6-leg; 80’ x 80’ (length); 60’ (width)
Leg spacing EL (+)	34’-0-in. W.P.: 6-leg; 80’ x 80’ (length); 60’ (width); transition to 4-leg
Leg batter	North-South 1:8, East-West 1:16
Leg diameter	72-in. to 96-in., as required
Bracing type	X-bracing
K-factors	In accordance with API RP 2A 21st Ed.
Key Elevations	
Top of jacket cut-off	EL (+)38’-0-in. (with ± 2’-6-in. allowance for leveling)
1st level	EL (+)31’-0-in.
Mudline	EL (-)766’-0-in. (mudmats at (-)773’-0-in.) sloped with seafloor
Launch truss spacing	110’-0-in. (to match Barge H851 skidways)
Pile to Jacket Connection	
Skirt piles	Plated sleeve-to-leg connection and grouted
Skirt sleeve annulus	2.5-in. nominal

AISC = American Institute of Steel Construction; API RP = American Petroleum Institute Recommended Practice; ASD = Allowable Stress Design.

Both the platform structure and process facility have the capability for expansion to meet future field optimization requirements. For the Tamar development, the offshore platform design includes

- two 16-in. high-pressure pipeline risers;
- two 4-in. MEG pipeline risers;
- one 10-in. utility pipeline riser for AOT;
- one 6-in. utility pipeline risers with ID coating for AOT;
- one 6-in. utility pipeline risers without ID coating for AOT;
- two 20-in. J-tubes for main umbilicals;
- one 30-in. pipeline riser for Mari-B 30-in. pipeline crossover (hot tap);
- one 16-in. pipeline riser for gas injection;
- one 8-in. pipeline riser for condensate injection; and
- one 14-in. I-tube for subsea isolation valve (SSIV) umbilical.

For the future expansion or future development(s), additional risers and tubes include

- two 16-in. high-pressure pipeline risers;
- two 4-in. MEG pipeline risers;
- one 10-in. utility pipeline riser;
- one 6-in. utility pipeline risers with ID coating;
- one 6-in. utility pipeline risers without ID coating;
- one 30-in. pipeline riser;
- two 20-in. I-tubes; and
- one 14-in. I-tube.

The Tamar Platform will have four 300-MMscfd production trains. These will feed two 600-MMscfd export gas-metering trains and one 600-MMscfd injection gas filtering and metering train. Each train will be independent of the others so that one train can be totally shut in without affecting the others. Each 300-MMscfd production train will consist of two inlet line heaters, two pressure reduction chokes, a production separator/slug catcher and a triethylene glycol (TEG) contactor. Production train design capacities (i.e., 400 MMscfd production; 1,200 MMscfd sales metering), when compared to anticipated usage, indicate that considerable redundancy exists in the Tamar gas production and metering system.

Liquid slugs captured in the slug catchers will be fed at a steady rate to a free water knockout that will be used for bulk condensate/rich MEG separation. The rich MEG will flow to the MEG regenerator.

The new platform production trains will need to operate up to 2,100 psig (145 barg) to be able to continue to inject gas into the Mari-B reservoir as it becomes repressurized. Furthermore, the production trains will need to operate at a minimum of 1,300 psig (90 barg) after the subsea field pressures have declined. Equipment and piping will be sized for all stated operating pressures.

The jacket and topsides of the Tamar Platform are being constructed onshore and transported via barges to the field location. The jacket legs will be flooded and positioned over the Tamar Platform location using assist vessels. The platform topsides will be lifted and set onto the jacket by a heavy lift crane vessel. Noble proposes the use of the *Thialf*, a 165-m long, dynamically positioned (DP) crane vessel for the lifting operations. Specifications for the *Thialf* are provided in **Appendix A**.

The new Tamar Platform will be equipped with all ancillary systems, including living quarters, power generation, emergency power generation, safety systems, heating and heat medium processes, potable water, sewage, and produced water equipment processing to make the new platform entirely self-sufficient. Water, instrumentation, utility air, diesel, and electricity will be connected to the existing Mari-B Platform (via subsea cables, conduits, or lines) to allow sharing of these utilities as necessary.

2.3.3 Pipelines, MEG Lines, and Control Lines – Installation/Modification and Pre-Commissioning

2.3.3.1 Background

Flow assurance played a significant role in both the design and ensuring the operability of the gas production system proposed for the Tamar Field Development Project. The long-distance tieback (~149 km), coupled with the deepwater location of the wells (~1,700 m water depth) posed a significant challenge. Noble Energy has noted the following attributes for Tamar Field production:

- Transportation of the raw reservoir fluids, including gas, liquids, and water represents a multiphase flow system; various phases travel at different speeds in the pipeline, leading to liquid accumulation along the pipeline route. The rate of liquid accumulation is determined by various factors, including operating pressure, pipeline diameter, liquid yield, and flow rate demands. In general, lower flow rates lead to higher accumulated liquid volumes in the pipeline, an attribute that increasingly slows gas production.
- The Tamar Field development is unique, as gas requirements are based on hourly nominations (i.e., gas demand is based on electrical power loadings). During the daytime or hours of high demand, the flow rate from the Tamar subsea wells will be high to meet the corresponding demand. During nighttime, weekends, or holidays, the demand will be low. The demand fluctuates between these high and low values on a daily basis; thus, a tight control over the flow rate and deliverability of gas from the wells must be maintained. This will be accomplished through a combination of allowing the pipeline to pressurize during periods of low demand and storing gas in the pipeline,

followed by allowing the pipeline to de-pressure during periods of high demand. Alternately, this can also be achieved through storing gas within the existing Mari-B reservoir, using Mari-B as both a storage location, as well as a peak demand-loading source to meet high spot-market demands due to the proximity of the Mari-B facility to shore.

- A flow assurance evaluation program that has been undertaken by Noble Energy to understand the multiphase flow characteristics of Tamar Field production, as well to better assess the system operability to ensure safe and reliable deliverability of gas.

The following production chemicals are envisioned for Tamar Field development, as noted in Noble Energy's Development Plan Document (Document No. TAM-PM-NEM-PRM-POD-0006 Rev 5):

- Hydrate Control: Continuous MEG injection at each wellhead and each manifold (if required):
  - ~0.5 to 1.0 bbl pure MEG/bbl H_2O
  - Batch injection of methanol available for shutdowns and start-ups
- Corrosion Control: Continuous injection at each wellhead
  - 50 to 100 ppm concentration
  - Slip-stream with MEG at platform
- Scale Control: Continuous injection at each wellhead or downhole:
  - 25 to 50 ppm
  - Either direct injection or slip-stream with MEG at platform
- Paraffin Control: None required
- Asphaltene Control: None required

The MEG will be injected through two 4-in. nominal MEG supply lines. The 2 x 4-in. MEG lines terminate at the deepwater end SDA, whereby the MEG will be distributed via infield umbilicals to each of the individual subsea trees. Continuous MEG is required to prevent any water in the system from forming gas hydrates. The production fluids will cool to ambient temperatures (~14°C) between the wellhead and the onshore terminal, which is well below the hydrate formation temperature at the operating conditions of the system (>22°C). **Section 2.4.1** provides additional information regarding project-associated chemicals.

2.3.3.2 Installation

Pipelines and flowlines will be integral components of the Tamar Gas Field development and production systems. Within the Tamar Gas Field, a subsea gathering system will be installed comprised of an infield flowline from each well, one three-header manifold, and dual 16-in tieback pipelines. In addition, the subsea control system will comprise an infield umbilical to each well, subsea distribution assembly, and dual main umbilicals. Each well in the Tamar Gas Field will have dual 4-in. nominal pipelines to deliver hydrate inhibitor (i.e., MEG) to each well.

The Tamar pipelines will consists of identical dual 16-in. export pipelines and identical dual 4.5-in. MEG lines from the Tamar Platform to the Tamar deepwater field manifold. Single 10-in. flowlines will be used to connect the manifold to each individual well. The material grade chosen for the export pipelines, the MEG lines, and infield flowlines is DNV OS F-101 grade 450 (API X65). The export pipelines will be manufactured as seamless pipe as will MEG lines and infield flowlines. The infield flowlines, export pipelines, and MEG lines will be coated using a three-layer polypropylene (3LPP) corrosion coating.

The Tamar project offshore installation scope of work encompasses the following components:

- West export pipeline/MEG line bundle (Tamar manifold to the Tamar Platform);
- East export pipeline/MEG line bundle (Tamar manifold to the Tamar Platform);
- Infield flowlines (Tamar manifold to each well);
- SSIV structure (base of platform risers);
- Three utility pipelines for production services (Tamar Platform to AOT);
- Installation of the manifold and SDA;
- Installation of associated pipeline jumpers; and
- Installation of electrical, hydraulic and optical flying leads.

Pipelines can be installed by several different methods, including S-lay, J-lay, reel barge, and tow-in-lay methods (Cranswick, 2001; Guo et al., 2005). Noble Energy anticipates the use of 1) the *Audacia*, a 225-m long, dynamically-positioned (DP) pipelay vessel that employs a 106-m long stinger; and 2) the *Solitaire*, a 300-m long DP pipelay vessel equipped with a 97-m long stinger. Both vessels deploy pipeline from a horizontal position. Vessel details for the *Audacia* and *Solitaire* are provided in **Appendix A**.

The pipelines will be assembled, welded, tested, and coated on site in the sheltered "firing line" area of the vessel, which extends from the stern to the bow, then off the stinger. Usually, the *Audacia* or *Solitaire* will receive a regular supply of pipes from other vessels during pipelaying, however, each vessel has onboard storage capacity (e.g., *Audacia*: 16,000 tons pipeline storage capacity; *Solitaire*: 22,000 tons pipeline storage capacity). Normally, pipelaying can proceed at a rate of 5 to 7 km per day. Installation of a 149-km long pipeline will require 21 to 30 days. Maximum number of persons onboard the *Audacia* and *Solitaire* is 270 and 420, respectively.

Pipeline installation activities in deepwater areas can be difficult both in terms of route selection and construction. Depending on the location, the seafloor surface can be extremely irregular. Engineering challenges include high hydrostatic pressure, cold temperatures, darkness, and variable subsurface current velocities and directions. Accurate, high-resolution geophysical surveying becomes increasingly important in areas with irregular seafloor. Operators may be expected to analyze high-resolution data to minimize pipeline length and avoid areas of unstable seafloor geologic structures and obstructions that might cause excessive pipe spanning, and potentially adverse effects on sensitive benthic communities. Review of the geohazards report for the pipeline route indicates the absence of significant seafloor irregularities.

2.3.3.3 Tamar Platform to Ashdod Onshore Terminal

Noble Energy proposes installation of three utility lines connecting the Tamar Platform to the AOT. The 42-km long utility pipelines will include dual 6-in. lines for MEG and MEG/water, and a single 10-in. line for condensate. The line pipe material for each offshore utility line will comply with the requirements of API 5L and DNV-OS-F101. Each line will be equipped with indium-activated cathodic protection and 3LPP external coating; design life of the lines will be 30 years. Each line will be hydrotested using filtered and inhibited freshwater; the hydrotesting of each line should require less than 4 hours. The utility lines will be buried to a depth of 1 m from the shore crossing to a water depth offshore of 60 m (IntecSea, 2011).

The proposed Tamar-AOT utility lines will parallel existing pipelines from the Mari-B Platform to AOT. Permitting of the Tamar-AOT utility line right of way is expected to fall under requirements established under TAMA 37. According to Permit No. 3/11, granted to Noble Energy in November 2011, a total of 700,000 m^3 of clean sand excavated from the pipeline route may be disposed of at an approved disposal area.

2.3.3.4 Pre-Commissioning

The subsea pipeline system has been designed to provide for efficient pre-commissioning of the system components to ensure integrity and mitigation of hydrate risk before handover of operations for introduction of hydrocarbons. In general, pre-commissioning will include flooding, cleaning, gauging, hydrostatic testing, dewatering, drying, and nitrogen purging. As applicable, pre-fabricated components will be hydrostatic tested prior to installation and the component will be corrosion inhibited, hydrate inhibited, and inert before introducing hydrocarbons.

The pipeline system design, as much as practical, allows for flexibility to conduct pre-commissioning operations independent of installation sequences. Pipeline systems have been designed as piggable. Testing and additional pre-commissioning operations will be carried out in compliance with pertinent design standards and industry practice. The subsea control system – umbilicals and subsea distribution equipment – will be subject to various pre- and post-installation hydrostatic, electrical, and hydraulic tests to ensure integrity of core component and communications throughout the system.

Following commissioning of the pipeline, initial start-up of the Tamar Field will be carried out in a controlled manner, dictated primarily by initial drawdown limits imposed by subsurface/reservoir constraints. Initially, a single well will be ramped up (flow rate/drawdown limits to be determined by Noble Energy and its Sub-Surface Group) to a fixed production rate.

Methanol injection at the tree will serve to limit any Joule-Thomson cooling issues across the wellhead choke. This is envisioned to require 30 to 60 min. In addition, MEG injection at the tree will also commence upon initial well start-up for hydrate inhibition.

Following start-up of a single well, additional wells will be brought on-line in series. It is desirable to increase the pipeline rate to 200+ MMscfd in order to achieve sufficient velocities to limit liquid accumulation in the pipeline. This will also serve to expedite MEG returns onshore, as the pipeline will accumulate MEG initially until the liquid loading reaches an equilibrium level in the pipeline.

2.4 SUMMARY OF CHEMICAL USAGE AND DISPOSITION AND HYDROCARBON PRODUCTION CHARACTERISTICS

The scope of this environmental impact analysis includes various components of the Tamar Field Development Project, including 1) installation and testing of various Project components (i.e., subsea wells, pipelines and flowlines, Tamar Platform, utility lines to shore at AOT); and 2) initial operation of the producing wells, pipelines and flowlines (from the Tamar Field to the Tamar Platform), platform processing and handling equipment, and natural gas and condensate disposition systems (e.g., gas and condensate to AOT) – termed pre-commissioning.

2.4.1 Project-Associated Chemicals

A variety of chemicals are employed to facilitate gas transport from the Tamar wells to the Tamar Platform, and during gas processing. These chemicals include TEG (used to dehumidify natural gas) and MEG (used to inhibit hydrate formation), as identified in **Table 3**.

Table 3. Summary of chemical storage, disposition, and discharge – Tamar Field Development Project.

Chemical	Storage	Disposition	Discharge
Monoethylene glycol (MEG)	Tamar Platform	Chemical line (within umbilical) to Tamar wells as lean MEG; returned with gas production to the Tamar Platform as rich MEG; removed from gas stream and reused via regeneration system	Yes, in minimal amounts at Tamar Platform, following processing through skimmer
Triethylene glycol (TEG)	Tamar Platform	Used aboard Tamar Platform to dehydrate Tamar gas prior to pumping to Ashdod Onshore Terminal (commercial sales) or Mari-B (re-injection); regenerated when possible	Yes, in minimal amounts at Tamar Platform, following processing through skimmer
Methanol	Tamar Platform	Batch injection of methanol, as required, during shutdowns and start-ups	Yes, in minimal amounts at Tamar Platform, following processing through skimmer
Corrosion control chemical(s)	Tamar Platform	Slip-stream with MEG at Tamar Platform, as needed	Yes, in minimal amounts at Tamar Platform, following processing through skimmer
Scale control chemical(s)	Tamar Platform	Continuous injection at wellheads or downhole; either direct injection or slip-stream with MEG at platform	Yes, in minimal amounts at Tamar Platform, following processing through skimmer

Chemical use will fluctuate, depending upon conditions (e.g., fluctuations in gas demand). **Table 4** identifies storage quantities for project-associated chemicals.

Table 4. Chemical storage characteristics – Tamar Field Development Project.

Chemical	Storage Quantity
MEG (lean)	1,265 bbl
MEG (rich)	700 bbl
TEG make-up	1,100 gal
TEG circulation (lean)	N/A
TEG circulation (rich)	N/A
Potassium hydroxide	100 bbl
Methanol	780 bbl
Corrosion inhibitor	550 gal
Scale inhibitor	550 gal
Defoamer	550 gal
Demulsifier	550 gal
Xylene	N/A (temp only)

Note: 1 bbl = 42 gallons.
MEG = methylene glycol; N/A = not applicable; TEG = triethylene glycol.

2.4.2 Hydrocarbon Production Characteristics

Table 5 summarizes the volumes of natural gas, condensate, and condensed water expected from the Tamar Field Development Project. No produced water is expected during initial gas production from the Tamar wells. Disposition and characteristics of each production component are also identified.

Table 5. Summary of hydrocarbons, condensate, and condensed water produced from the Tamar Field Development Project.

Production Component	Estimated Production	Disposition	Characteristics
Natural gas	Maximum: 1,200 MMscfd	Dehydrate; ready for commercial sale (pipeline to Ashdod Onshore Terminal (AOT); AOT processing) or potential re-injection (at Mari-B)	Methane: 99% CO_2 Content: 0.10-0.17% H_2S Content: 0% Design Flow Rate: 250 MMscfd per well (maximum)
Condensate	Anticipated: 1.0-2.0 bbl/MMscf Design: 4.5 bbl/MMscf	Options: 1) Export to AOT through a dedicated pipeline for sales; or 2) Transport to Mari-B through a dedicated pipeline, and dispose via injection into the Mari-B Reservoir	API Gravity: 34-36 Wax Appearance Temp.: <0°C Asphaltene Content: 0 wt%
Condensed water	Condensed Water: ~0.35 bbl/MMscf	Route to oil-water separator/skimmer, monitor for hydrocarbon content, and discharge at Tamar Platform	Compliance with 29 mg/L monthly average; and 42 mg/L daily maximum effluent limits (U.S. Environmental Protection Agency National Pollutant Discharge Elimination System permit limits)

2.4.3 Water Produced During Processing

Primary disposal of water from the flowlines (i.e., condensed water) will be by venting from the MEG and TEG regeneration systems. Some condensed water from the vents off these systems may be treated in the water skimmer and disposed of overboard. This water will be contained in the stream as described in **Section 2.5.2.2** (Deck Drainage, New Tamar Platform). Treating requirements for water being discharged overboard, including condensed water, are based on oil and grease limits established by the U.S. Environmental Protection Agency (USEPA) for the U.S. Gulf of Mexico. Limitations on this discharge include:

- Oil and Grease (USEPA National Pollutant Discharge Elimination System [NPDES] discharge permit limits, U.S. Gulf of Mexico); and
  - Maximum, daily rate: 42 mg/L
  - Maximum, monthly average: 29 mg/L
- Salt Content: Negligible.

2.4.4 Ramifications of Daily Fluctuations in Gas Demand and Production

Gas demand is expected to fluctuate over the course of the day, with higher usage during daytime/business hours and lower usage during nights, weekends, and holidays. Unlike the current operation within Noble Energy's Mari-B development (platform wells), where the well can be cycled quickly to meet demand, the subsea development is much more "elastic" due to the volume of stored gas within the pipeline, the fact that multiphase flow is occurring in the pipeline, and the residence time of gas flow from the wellhead to shore (Document No. TAM-PM-NEM-PRM-POD-0006 Rev 5).

In addition, by cycling the flow rate up and down on a daily basis, the liquid holdup in the pipeline will also fluctuate. Daily fluctuations are characterized as follows:

- Nighttime Operation (Low Demand): Turndown of flow rate results in an increase in liquid holdup within the pipeline. Injected MEG will build up, requiring supplemental MEG storage.
- Daytime Operation (High Demand): Ramp-up of flow rate results in liquid swept from pipeline arriving as a liquid surge and potential excess MEG volumes that must then be re-introduced into the closed-loop MEG circulation system.

Severity of the liquid slug received onshore is a function of multiple factors, including turndown rate, turndown duration, and ramp-up rate.

2.4.5 Gas Transport to Shore

Gas from the Tamar Field will arrive at the Tamar Platform, where it will be dehydrated and either re-injected into the Mari-B reservoir or exported through a gas pipeline connected via hot tap to the existing 30-in. pipeline from the existing Mari-B Platform to the AOT. MEG will be separated with the water, regenerated, and re-injected at the Tamar subsea wells. Any hydrocarbon/condensate produced from Tamar wells will be separated and transported to the AOT in a dedicated pipeline for sales or, if required, injected into the Mari-B reservoir.

2.5 EFFLUENT DISCHARGES

Effluent discharges will occur during all phases of operation – installation and testing, and operation (i.e., pre-commissioning). The nature of the discharges will vary, however, depending upon the activity being conducted. Effluent discharges (as categorized by USEPA under their NPDES permit program) will include sanitary and domestic wastes, well maintenance chemicals, deck drainage, hydrotest water, miscellaneous discharges, and food wastes. **Table 6** identifies discharge effluents expected during the Tamar Field Development Project and their source(s). Effluent generation rates have been derived from environmental analyses associated with offshore oil and gas exploration, development, and production facilities (e.g., U.S. Department of the Interior, Minerals Management Service [USDOI, MMS], 2007), or from Noble Energy sources. Discharge rates are based on manufacturer's equipment specifications or were provided by Noble Energy personnel.

Table 6. Summary of projected effluent discharges and sources.

Effluent Discharge	Activity	
	Installation and Testing	Operation (Pre-Commissioning)
Sanitary and domestic wastes	Pipelay vessel Mari-B & Tamar Platform Support vessels Transport barge(s) and crane vessel	Tamar Platform Mari-B Platform Support vessels
Well maintenance chemicals	Tamar Platform	Tamar Platform
Deck drainage	Pipelay vessel Support vessels Transport barge(s) and crane vessel	Tamar Platform Mari-B Platform Support vessels
Hydrotest water	Tamar Platform Mari-B Platform	N/A
Miscellaneous discharges	Pipelay vessel Support vessels Transport barge(s) and crane vessel	Tamar Platform Mari-B Platform Support vessels
Food wastes	Mari-B & Tamar Platform Pipelay vessel Crane vessel Support vessels	Tamar Platform Mari-B Platform Support vessels

N/A – not applicable; effluent in question will not be discharged during this activity.

2.5.1 Sanitary and Domestic Wastes

Sanitary waste (i.e., also known as black water or sewage) consists of human body wastes from toilets and urinals. Domestic waste (i.e., also known as gray water) consists of the water generated from showers, sinks, laundries, and galleys, safety showers, and eye wash stations.

2.5.1.1 Mari-B with Modifications

No additional operations personnel are expected to be required following installation of the new equipment aboard the Mari-B Platform (see **Section 2.3.1**). However, during construction, there will be a brief increase in the number of onboard personnel, with temporary quarters provided for the construction crew. As a consequence, there will be a temporary increase in the volumes of sanitary and domestic wastes generated aboard the Mari-B Platform during construction.

The Mari-B Platform is currently equipped with a Red Fox system to process sanitary waste, capable of accommodating up to 28 people, the normal compliment of platform personnel. The treatment capacity in flow conditions is 750 gal/d. The method of treatment is extended aeration, clarification and settling, and chlorination. For sanitary waste discharges, effluent quality standards for biochemical oxygen demand (BOD), and total suspended solids (TSS) are normally established; the draft discharge permit for Mari-B does not currently contain BOD and TSS effluent limits.

2.5.1.2 New Tamar Platform

It is expected that the Tamar Platform will house up to 50 personnel. Treated sanitary and domestic waste effluent volumes are expected to be greater than those being discharged from the Mari-B Platform, or approximately 4,250 to 6,750 gal/d. Volumes are based on estimates of 35 gal/person/d for treated sanitary waste and 50 to 100 gal/person/d for domestic waste. Sanitary waste effluents will be treated prior to discharge via extended aeration, clarification and settling, and chlorination; domestic wastes will be screened to remove any floating solids, then discharged.

2.5.1.3 Pipelines, MEG Lines, Utility Lines, and Control Lines

No sewage or domestic waste discharges will occur in association with operation of the pipelines, MEG lines, and control lines. Vessels operating during installation of pipelines, MEG lines, utility lines, and control lines (e.g., DP pipelay vessel *Audacia* and *Solitaire*) will be equipped with approved marine sanitation devices. Sanitary and domestic wastes will be collected and treated prior to discharge (e.g., chlorination for sewage; removal of floating solids for domestic wastes) according to the requirements of the International Convention on Prevention of Pollution from Ships (MARPOL Convention). All discharges will be in accordance with the requirements of MARPOL Annex V and the Mediterranean Action Plan (MAP) Barcelona Convention Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil, regulations implemented by the U.S. Department of the Interior, Bureau of Ocean Energy Management (USDOI, BOEM), U.S. Coast Guard (USCG), and the USEPA. Discharge volumes of sanitary and domestic wastes are expected to be 35 gal/person/d and 50 to 100 gal/person/d, respectively. Maximum number of persons aboard the *Audacia* and *Solitaire* is 270 and 420, respectively; assuming a maximum number of personnel aboard, daily discharges of treated black and gray water from the DP pipelay vessel would be: *Audacia*: 9,450 gal and 13,500 to 27,000 gal, respectively; *Solitaire*: 14,700 gal and 6,000 to 21,000 to 42,000 gal, respectively.

2.5.2 Deck Drainage

Deck drainage includes rainfall and wash water that comes in contact with platform equipment (i.e., runoff). In NPDES permit language, the USEPA (2007) defines deck drainage as including all (liquid) waste resulting from platform washings, deck washings, and runoff from curbs, gutters, and drains including drip pans and wash areas. Deck drainage may be comprised of various substances, including freshwater, seawater, residual hydrocarbons from equipment surfaces (e.g., oil, grease, hydraulic fluid), and soap/detergent.

2.5.2.1 Mari-B with Modifications

The few skids being added as part of this scope will be provided with skid pans to capture any rainwater or leakage from the equipment. The additional water-treating requirement will be fairly minimal, and should have no impact on the treating capability of the open drain system.

2.5.2.2 New Tamar Platform

Skid pans will be used to capture rainwater or equipment leakage, and processed through an oil-water separator prior to ocean discharge.

Expected volumes of deck drainage will range from 0 to ~75 bbl/d, depending on rainfall and exposed deck and equipment surface area. Treated/processed deck drainage will be released at a maximum discharge rate of 500 L/hr. All deck drainage will be processed through an oil-water separator prior to discharge. Threshold maxima for the discharge will be 29 mg/L (monthly average) or 42 mg/L (daily maximum) of hydrocarbons, both of which are consistent with oil and grease limits established for Gulf of Mexico NPDES permits issued for offshore hydrocarbon extraction facilities.

2.5.2.3 Pipelines, MEG Lines, Utility Lines, and Control Lines

Deck drainage is not applicable to project pipelines, MEG lines, utility lines, or control lines. However, vessels operating during installation activities that occur during periods of rainfall will produce deck drainage. Vessels are equipped with catchments (drip pans) in machinery areas. Deck drainage is routinely routed to oil-water separators for treatment prior to discharge. Threshold maxima for the discharge will be 15 ppm of hydrocarbons.

2.5.3 Hydrotest Water and Miscellaneous Discharges

Hydrotest water, also known as hydrostatic test water, is used following installation and prior to commencement of operations to test the integrity of a pipeline, flowline, or chemical transport line. Miscellaneous discharges generated during offshore oil and gas operations potentially encompass a variety of materials and include (as defined by USEPA, 2007) desalinization unit discharge, diatomaceous earth filter media, blowout preventer control fluid, uncontaminated ballast and bilge water, uncontaminated freshwater and seawater (e.g., from fire control, fire system testing, and utility lift pumps), boiler blowdown, subsea wellhead preservation fluids, subsea production control fluid, hydrate control fluid, umbilical steel tube storage fluid, leak tracer fluid, and riser tensioner fluids.

2.5.3.1 Mari-B with Modifications

No hydrotest water or miscellaneous discharges are expected in association with the proposed modifications to the Mari-B Platform. No new loads to cooling water are planned because the design will take advantage of existing cooling water capacity.

2.5.3.2 New Tamar Platform

No hydrotest water or miscellaneous discharges are expected to be discharged from Tamar Platform equipment.

2.5.3.3 Pipelines, MEG Lines, Utility Lines, and Control Lines

Hydrotesting of pipelines, chemical lines, and utility lines will be conducted prior to start-up. Control lines will not be tested. Seawater, freshwater, or chemically-treated seawater or freshwater can be used for hydrotesting. Noble Energy considered several available options regarding hydrotest water disposal. In the event treated water is used, hydrotest water could be sent via pipeline to shore for treatment and disposal, or it could be discharged offshore following environmental risk analysis and careful selection of treatment chemicals. However, Noble Energy has determined that fresh seawater will be used for hydrotesting (i.e., with no treatment chemicals); hydrotest water will be discharged back to the ocean upon completion of testing.

Additional miscellaneous discharges typically occur from numerous sources on vessels. Examples include uncontaminated freshwater and seawater used for cooling water, ballast, and/or fire test water, desalination unit discharges, and boiler blowdown discharges (USEPA, 1993). These discharges must meet MARPOL and Barcelona Convention requirements.

2.5.4 Food Wastes

Food wastes are generated from galley and food service operations. Food waste, a type of domestic waste, will be ground prior to discharge (i.e., comminuted), in accordance with MARPOL requirements (i.e., for vessels 400 gross tonnage and above). Food waste is typically ground to <25-mm 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). Fixed platforms are also allowed to discharge ground food waste when located >12 nmi from shore, which is the case with the Mari-B Platform.

2.5.5 Summary of Effluent Discharges

Table 7 outlines expected volumes for discharges from the Tamar Field Development Project. Effluent discharges will include sanitary and domestic wastes, well maintenance chemicals, deck drainage, hydrotest water, miscellaneous discharges, and food wastes.

Table 7. Summary of effluent discharges, Tamar Field Development Project.

Effluent	Expected Volumes; Treatment or Processing	Source	Activity Phase
Sanitary and domestic wastes	Total volumes depend on number of personnel. Sanitary wastes: 35 gal/person/d – chlorinate, discharge. Domestic wastes: 50-100 gal/person/d – remove floating solids, discharge. Sanitary and domestic wastes will be collected and treated prior to discharge in compliance with MARPOL 73/78, Annex IV (vessels only).	Pipelay vessel Mari-B Platform Tamar Platform Transport barge(s) and crane vessel Support vessels	• Installation and Testing • Operations (Pre-Commissioning)
Deck drainage	Total volume depends on rainfall; discharge rate: 500 L/hr maximum separator discharge. Remove oil and grease and discharge (not to exceed 29 mg/L monthly average, or 42 mg/L daily maximum) for hydrocarbons. All discharges will be in compliance with MARPOL 73/78, Annex I.	Pipelay vessel Mari-B Platform Tamar Platform Transport barge(s) and crane vessel Support vessels	• Installation and Testing • Operations (Pre-Commissioning)
Hydrotest water	Noble Energy will use untreated seawater; discharge offshore. Estimated volume: several thousand bbl.	Tamar Platform Mari-B Platform	• Installation and Testing
Bilge water	Variable volumes, depending upon vessels used. Estimated volumes: 3 m^3/d. Discharged in compliance with MARPOL 73/78, Annex I (vessels only).	Pipelay vessel Transport barge(s) and crane vessel Support vessels	• Installation and Testing
Ballast water	Variable; compliance with vessel operator's ballast water management system requirements (e.g., pipelay vessel); ballast water exchange at sufficient distance offshore/out of area to effectively eliminate the potential for introducing alien (invasive) species.	Pipelay vessel Crane vessel	• Installation and Testing
Food wastes	Food waste will be ground and passed through 25-mm mesh screen prior to disposal overboard outside 12-nmi zone as required by the MARPOL Convention (i.e., compliance with MARPOL 73/78).	Pipelay vessel Crane vessel Tamar Platform Mari-B Platform Support vessels	• Installation and Testing • Operations (Pre-Commissioning)
Firewater and cooling water	Variable volumes, depending upon frequency of testing. Estimated volumes: 170 gpm.	Tamar Platform	• Installation and Testing • Operations (Pre-Commissioning)

Figure 8 provides a generalized diagram of the various discharge sources for the Tamar Field Development Project. Key components include regeneration systems for MEG and TEG, as well as systems for firewater, sewerage (i.e., sanitary and domestic wastes), and kitchen waste (i.e., food waste). Discharge elements are also noted for each of these key discharge components (e.g., 6 in. open drain caisson for the MEG and TEG residuals processed through the water skimmer; 1,500 bbl of water per day, maximum).

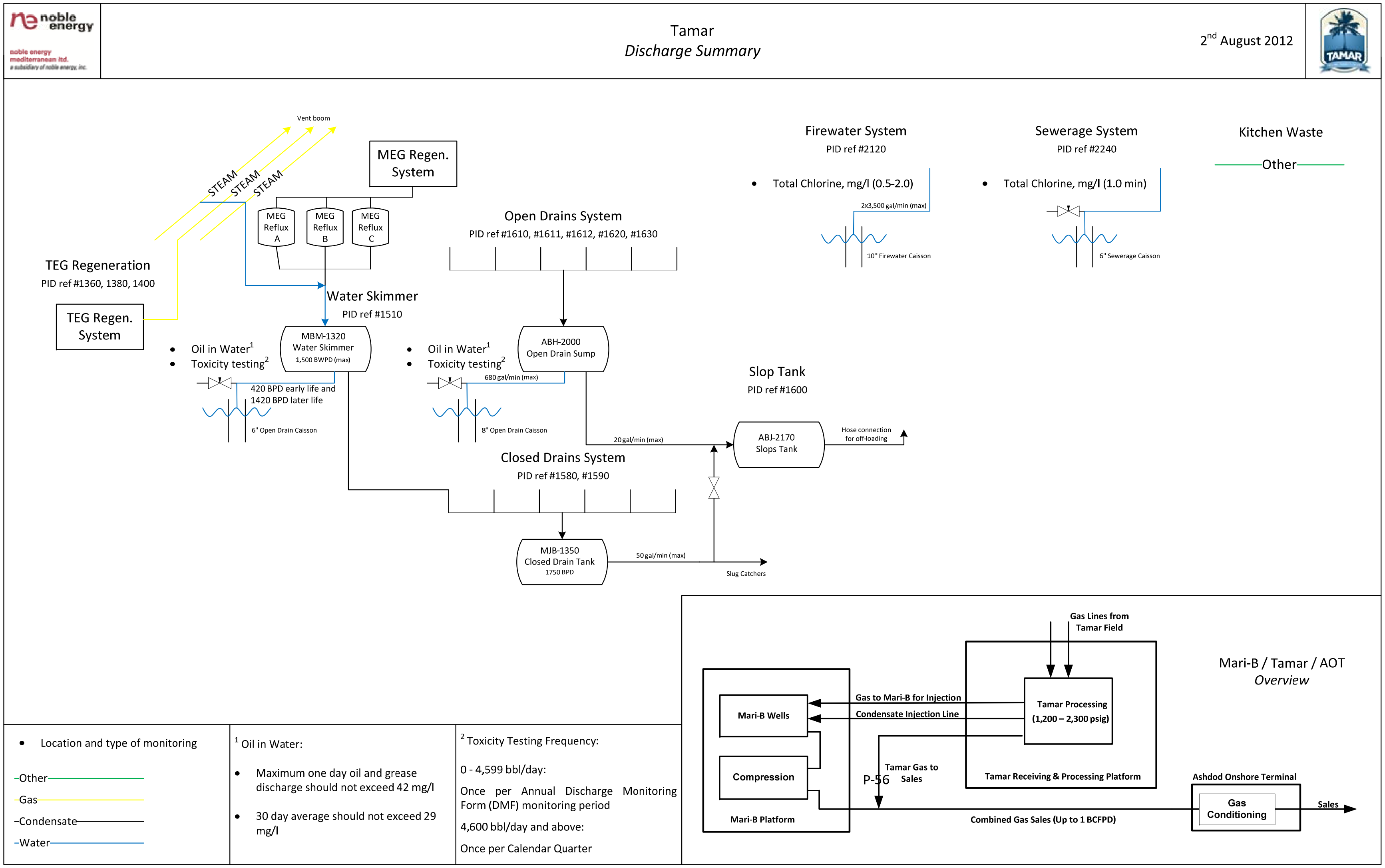


Figure 8. Summary of discharges associated with the Tamar Field Development Project.

Condensed water from MEG and TEG regeneration will be included in deck drainage (see **Section 2.5.2.2**). Seawater for cooling and firewater system pressurization will be release at 170 gpm (5,830 bpd) with hypochlorite (2 to 4 ppm). No other contaminants or pollutants will be present in cooling or firewater system discharges, the latter of which will be discharged through the firewater pump caisson, nominally 10 ft above the water line.

2.6 SOLID WASTE

2.6.1 Mari-B Modification

Solid wastes to be generated from the Mari-B Platform during modification will be packaged or palletized for shipment to shore and proper disposal. No intentional waste disposal will occur at the platform, in compliance with MARPOL restrictions. All project vessels will operate under a Waste Management Plan to ensure adherence to MARPOL. However, occasionally, debris (e.g., welding rods, buckets, pieces of pipe) may accidentally fall overboard and accumulate on the seafloor.

2.6.2 New Tamar Platform

Solid wastes to be generated during installation of the Tamar Platform will be packaged or palletized for shipment to shore and proper disposal. No intentional waste disposal will occur at the platform, in compliance with MARPOL restrictions. All project vessels will operate under a Waste Management Plan to ensure adherence to MARPOL. However, occasionally, debris (e.g., welding rods, buckets, pieces of pipe) may accidentally fall overboard.

2.6.3 Pipelines, MEG Lines, Utility Lines, and Control Lines – Installation/Modification

Solid wastes to be generated during installation of pipelines, MEG lines, utility lines, and control lines will be packaged or palletized aboard installation vessels for shipment to shore and proper disposal. No intentional waste disposal will occur at the platform, in compliance with MARPOL restrictions.

2.7 AIR EMISSIONS

2.7.1 Mari-B Modification

If all existing equipment is required to be in operation concurrent with gas and condensate injection, power generation loads will increase after the installation of the new equipment using the full capacity of two existing generators. It is assumed, however, that after the Tamar Platform is brought online, Mari-B will be used primarily for injection and the required electrical load would be adequately supplied by one generator.

The only modifications to the Mari-B that may affect air emissions are the addition of three Solar Titan 130 turbine compressors and one new natural gas generator. As of April 2011, the compressors had been set on the platform and commissioning was being planned. All new equipment represents replacements for the same units previously installed aboard the platform.

2.7.2 New Tamar Platform Installation and Operation

Emissions for the Tamar Field Development Project activities for 2011 and 2012 and Tamar Platform installation and operations for 2012, 2013, and 2014 through 2044 are provided in **Table 8**. The calculations were made based on the U.S. Federal Regulations [30 CFR 250.303(d)]. The allowable limits are based on the distance of emissions sources to shore.

2.7.3 Pipelines, MEG Lines, Utility Lines, and Control Lines– Installation/Modification

Emissions for the Tamar Field Development Project activities for 2011 and 2012 and Tamar Platform installation and operations for 2012, 2013, and 2014 through 2044 are provided in **Table 8**. The tabular summary includes emissions associated with vessel operations for pipeline, MEG line, control line, and utility line installation/modification.

Table 8. Initial projected annual air emissions for the Tamar Field Development Project, including installation and operation activities (From: Noble Document No. TMA-PM-SEA-PRO-RTA-0001 Rev.02 Supp.).

Year	Pollutant (tons/year)							
	PM	SOx	NOx	VOC	CO	CO_2	CH_4	CO_2 eq
2011	32	146	1,095	33	239	52,421	3.0	52,483
2012	1	5	165	1	9	1,860	<1 (0.1)	1,863
2013	6	1	261	199	107	93,944	3,373	164,769
2014-2044	7	2	301	260	139	122,798	4,412	215,455
Allowable	486	486	486	486	20,310	--	--	--

CH_4 = methane; CO = carbon monoxide; CO_2 = carbon dioxide; CO_2 eq = CO_2 equivalent; NO_x = oxides of nitrogen; PM = particulate matter; SO_x = oxides of sulfur.

2.8 SUPPORT OPERATIONS

The Tamar Field Development Project will be supported through Noble Energy's shorebase facilities in Haifa. The port of Haifa is one of two major Israeli ports with facilities capable of handling container ships, tankers, and large passenger vessels, as well as smaller commercial vessels including supply, crew, and specialized offshore vessels to be used in the Tamar Field Development Project. The port basin encompasses an area of 2 million m^2; the main port land area covers more than 700,000 m^2.

Noble Energy maintains contract service vessels and shore-based storage, handling, and logistics operations at the Israel Shipyards Ltd. facility in Haifa. One of Noble's contract vessels is the M/V *Highland Rover*; vessel specifications are provided in **Appendix A**. Noble Energy has been operating a shorebase at Haifa since 2004.

2.8.1 Mari-B Modification

During normal operations, a maximum of 28 people are on board the facility; it is expected that no additional people will be required to operate the new system aboard the Mari-B Platform. Additional personnel will be aboard the platform during the installation phase. Support vessels are expected to visit the Mari-B Platform once per week, including weekly visits by a supply vessel and a crew boat. Vessels transiting from a support base to the Mari-B Platform are expected to transit at 10 to 15 kn.

2.8.2 New Tamar Platform Installation

Support vessels are expected to visit the Tamar Platform installation site once per week, including weekly visits by a supply vessel and a crew boat. Vessels transiting from a support base to the Tamar Platform are expected to transit at 10 to 15 kn.

2.8.3 Pipelines, MEG Lines, Utility Lines, and Control Lines – Installation/Modification

Within the Tamar Field, several vessels will be utilized to set anchors and provide supply vessel support. An anchor handling towing supply vessel (AHTSV) will be used to set anchors. A candidate vessel for this phase of activity is the *Richard M. Currence*, owned and operated by Tidewater Marine. The *Richard M. Currence* is 85.4 m long. A second AHTSV, the *John P. Laborde*, will be used as a supply vessel, along with the *Worker Bee*, a 64-m long platform supply vessel owned and operated by Beemar. Vessel specifications are provided in **Appendix A**.

The *Sedco Express* semisubmersible rig will be employed to install the subsea trees at the Tamar wells using a Heave Compensated Landing System. Vessel specifications are provided in **Appendix A**.

The pipeline between the Tamar Field wells and the Tamar Platform will be laid by the DP pipelay vessels *Audacia* and/or *Solitaire*. Either vessel may be mobilized from their homeport, or possibly from another Mediterranean port or location following previous contract work. Neither the *Audacia* or *Solitaire* can enter any Israeli port because of draft limitations.

On 20 September 2011, an Israel Ministry of Transport Notice to Mariners No. 37/2011 announced a gas pipe layer project from the Mari-B Platform to the Tamar Field. Mariners were notified that the gas pipe laying project was to commence by the M/V *Solitaire* (pipeline vessel), M/V *Calamity Jane*, and M/V *Highland Rover*. Starting position for the pipelay operation was at the Mari-B Platform. The Notice to Mariners indicated an expected progress for the pipelaying of 3 mi/d, moving in a north-northwest direction.

2.9 BUFFER ZONE

For the purpose of vessel and operational safety, an announcement of proposed pipelaying operations are routinely made to all mariners via printed or electronic media several weeks in advance of commencement of pipelaying activity.

The Mari-B Platform currently maintains a 500 m buffer zone. Entrance of all vessels into the buffer zone requires permission. Commercial vessel operations, including entry into the buffer zone, are closely monitored and controlled. A similar buffer zone will be established around the Tamar Platform.

2.9.1 Mari-B

No anchoring of vessels near Mari-B is planned as part of this scope.

2.9.2 New Tamar Platform

In the absence of definitive data regarding installation activities at the new Tamar Platform, a minimum buffer zone of 500 m is expected around the platform.

2.9.3 Pipelines, MEG Lines, Utility Lines, and Control Lines – Installation/Modification and Operation

On 20 September 2011, an Israel Ministry of Transport Notice to Mariners No. 37/2011 announced a gas pipe layer project from the Mari-B Platform to the Tamar Field. All vessels were requested to stay 8 mi away from the M/V *Solitaire* and 3 mi away from the M/V *Calamity Jane* and M/V *Highland Rover*.

2.10 ABANDONMENT PLANS

2.10.1 Mari-B

Abandonment and removal plans for the Mari-B Platform will consider the Israel regulations in place pertinent to offshore structures. All abandonment and/or removal activities conducted in associated with Mari-B will comply with existing regulations.

2.10.2 New Tamar Platform

The design life of the Tamar Platform is 30 years. Near the end of its life, Noble Energy will evaluate the Israel regulations in place pertinent to offshore structures 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.

2.10.3 Pipelines, MEG Lines, Utility Lines, and Control Lines

The design life of the pipelines, MEG lines, utility lines, and control lines is comparable to the life expectancy of the Tamar Platform – 30 years. As field production in the Tamar Field nears, Noble Energy will evaluate the Israel regulations in place regarding subsea pipelines, flowlines, utility lines, and control lines. Noble Energy expects that abandonment plans will be developed that comply with existing regulations. Possible abandonment approaches include abandonment in place, or complete to partial removal of the lines.

2.11 OIL SPILL RESPONSE

Currently there is no oil spill response equipment located on the Mari-B Platform. Oil spill response equipment is located onshore at the Israel Shipyards Ltd. facility in Haifa. In addition, primary spill response locations include Southampton (Great Britain), Ceyhan (Turkey), Abu Dhabit and Fujairah (Middle East), and Aktau (Kazakhstan). Haifa and Ashdod will serve as pre-planning staging locations for oil spill response equipment, material, and personnel.

3.0 Description of the Environment

The following description of the environment provides regional and, as available, site-specific descriptions of environmental and socioeconomic resources of Israel's coastal, nearshore (within several km of shore) and offshore environments – specifically, those resources that may be affected by project activities. While the study area of interest includes those resources likely to be affected by activities associated with the Tamar Field Development Project (i.e., within several to tens of kilometers from each activity), a regional perspective is important when site-specific data are limited and/or when considering impacts that may extend beyond typical study area boundaries (e.g., transport of project-related pollutants).

3.1 REGIONAL SETTING

The Tamar Gas Field lies within the Eastern Mediterranean, within the southeastern portion of the Levantine Basin. The proposed gas pipeline, MEG pipeline, and control line bundles traverse the upper continental slope and continental shelf off the Israeli coast, terminating at the Tamar Platform approximately 25 km off the coast of southern Israel at a water depth of 234 m (**Figure 9**).

The Levantine Basin is highly oligotrophic and is characterized by relatively high species diversity, very low biomass, and a higher degree of endemism than other oceans due to its relative isolation. Even within the Mediterranean Sea, the Eastern Mediterranean is distinct because of its high salinity, low nutrients, transparency, and the temperature regime of its surface waters, which is higher than other areas of the Mediterranean.

3.2 GEOGRAPHY

The Mediterranean Sea is an enclosed basin. It is surrounded by high peninsulas and mountain barriers from the north, while the southern African coast is a gentle sloping coastal plain. The gaps between the major mountainous regions divert the atmospheric flow and form various scales of atmospheric circulations. These topographic formations, together with the landscape variability, result in the formation of regional climatic conditions that vary significantly from one place to another. This is especially true for the eastern part of the Mediterranean where the Greek and Asia Minor peninsulas are separated by the Aegean Sea. Both the southern and northern areas of the Asia Minor peninsula are characterized by steep mountains (CSA International, Inc., 2010).

Israel is located at the southeastern end of the Mediterranean Sea, bounded by Lebanon to the north, Syria to the northeast, Jordan to the east, and Egypt to the southwest. The country is approximately 20,770 km^2 in area, of which 2% are water bodies.

Despite its small size, Israel is home to a variety of geographic features, from the Negev Desert in the south to the mountain ranges of the Galilee, Carmel, and the Golan in the north. The Israeli Coastal Plain on the shores of the Mediterranean is home to 70% of the nation's population. East of the central highlands lies the Jordan Rift Valley; this forms a small part of the 6,500-km Great Rift Valley.

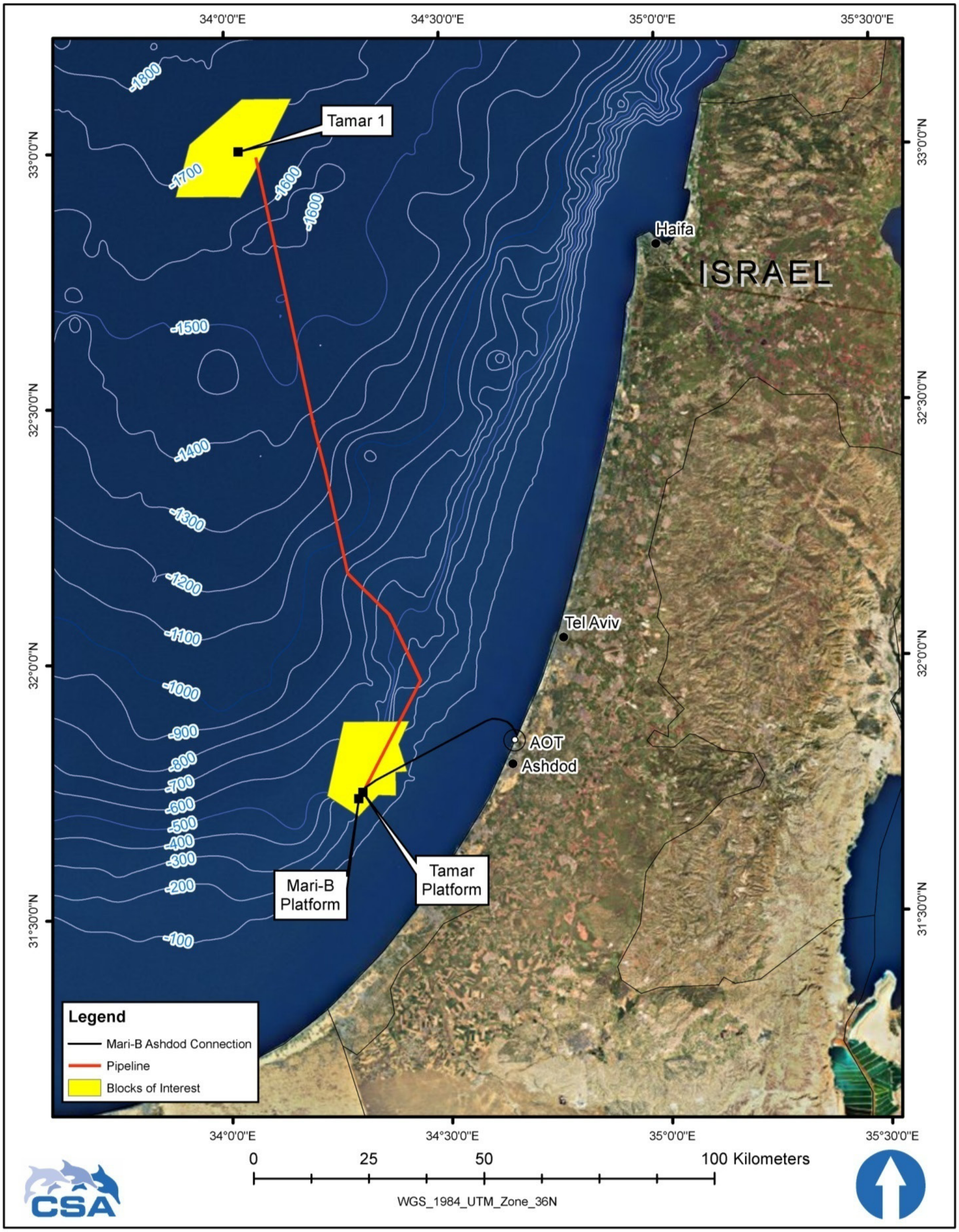


Figure 9. Tamar Field Development Project components (From: Noble Energy Mediterranean, Ltd., 2011). (Water depths are in meters.)

The Matan Block, site of the Tamar Gas Field, lies approximately 80 km west of the Israeli coastline. Water depths within the Matan Block range from ~1,625 to 1,700 m. The offshore-nearshore corridor extends approximately 152 km to the Mari-B/Tamar Platform facility along the upper continental slope. The Mari-B Platform is located approximately 25 km offshore the coast of southern Israel at a water depth of 234 m. The proposed Tamar Platform is positioned near the Mari-B at a similar water depth.

3.3 BATHYMETRY AND TOPOGRAPHY

3.3.1 Seafloor Morphology

The physiography of the Eastern Mediterranean seafloor is complex, being under various geodynamic regimes resulting mainly from the convergence of the African and Eurasian plates (Benkhelil et al., 2000). A tectonic sketch of the Eastern Mediterranean is shown in **Figure 10**.

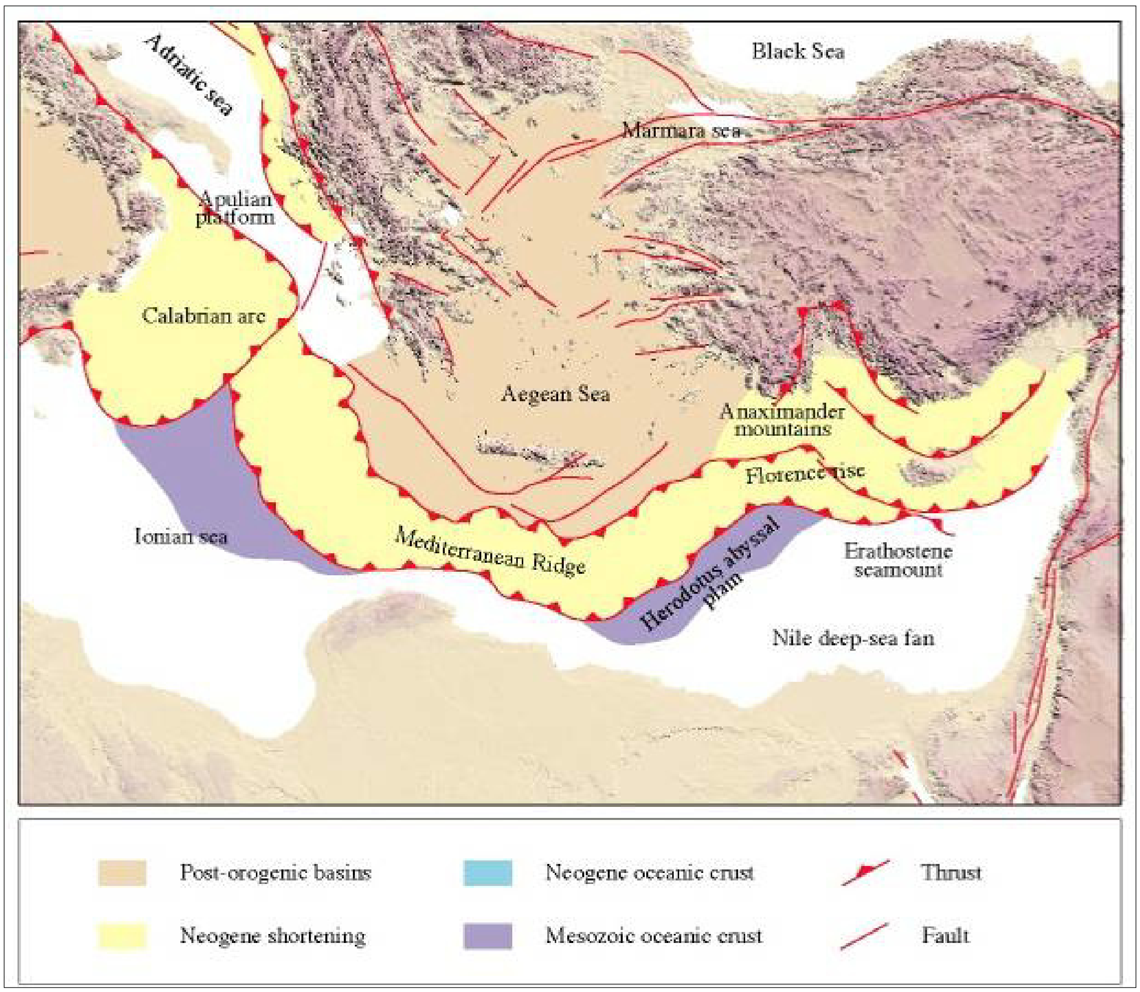


Figure 10. Tectonic sketch of the Eastern Mediterranean (From: Barrier et al., 2004).

The major feature of the Eastern Mediterranean seafloor is a large arcuate swell, the Mediterranean Ridge, which extends over 1,500 km between the southwest of Peloponissos and southern Turkey (French Research Institute for Exploitation of the Sea [IFREMER], 2008). Other prominent topographic features include the Nile cone or fan (off Egypt), the Anaximander Mountains (off southern Turkey and northwest of Cyprus), and the Eratosthenes Seamount and Florence Rise (south and west of Cyprus, respectively).

The Mediterranean Ridge is a wide (100 to 200 km) and voluminous sedimentary construction (up to 10 km thick) that results from the accretion and deformation of thick piles of sediment as a consequence of the subduction during at least the last 20 mega-annum (Ma) of Africa beneath southern Europe (IFREMER, 2008). According to Robertson and Shipboard Scientific Party (1996), the Mediterranean Ridge is an example of a mud-dominated accretionary complex, while Huguen et al. (2006) describe it as a large, arc-shaped sedimentary wedge, more than 1,500 km long and 200 to 250 km wide, which consists of a thick pile (up to 12 km) of offscrapped and stacked elements lying to the west of Cyprus.

The Eratosthenes Seamount is a very prominent bathymetric feature between Cyprus and Egypt. It is a large, elliptical, submerged massif nearly 120 km long and 80 km wide situated on the seafloor of the Eastern Mediterranean about 100 km south of Cyprus, from which it is separated by a deep trough (Mart and Robertson, 1998) (**Figure 11**). This feature lies approximately 150 km northwest of the Matan and Michal Blocks.

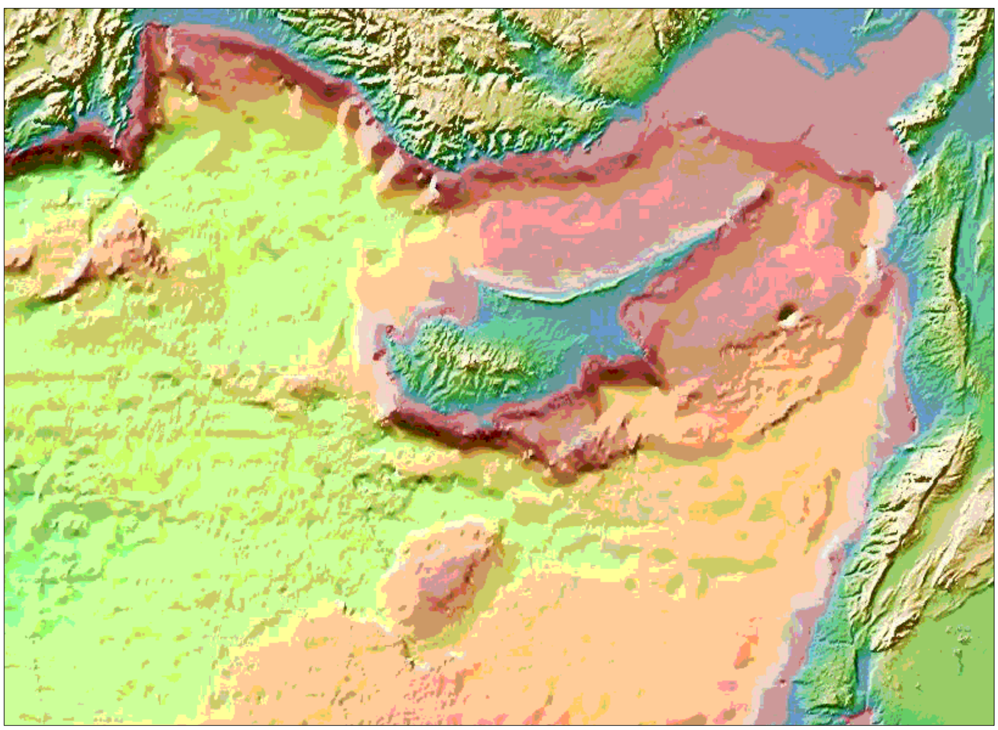


Figure 11. Morphobathymetry of the Eastern Mediterranean Sea (From: Scripps Institution of Oceanography, 2008).

Israel is located in the Levantine or Levant Basin, a deep and long existing geologic structure located in the Eastern Mediterranean Sea southeast of Cyprus and east of the Eratosthenes Seamount and the Nile deep-sea fan off Egypt (**Figure 12**). Mart and Robertson (1998) note that the Levant Basin comprises a gently dipping continental rise. This rise deepens northwestward from the base of the continental slope of the southern Levant and Sinai at depths of 1,000 to 1,200 m, to reach depths of 2,200 to 2,300 m in the trough between the Eratosthenes Seamount and Cyprus.

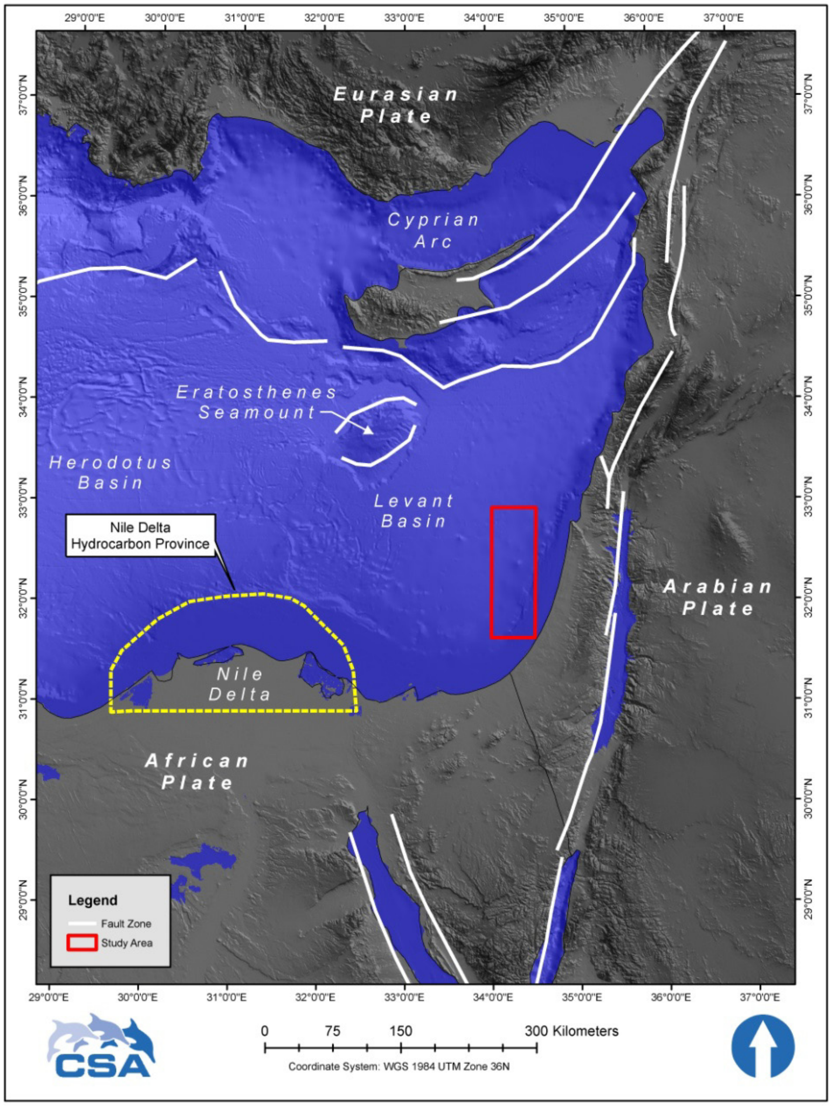


Figure 12. The Levant Basin in the Eastern Mediterranean Sea and location of the Nile Delta hydrocarbon province and recent Pliocene gas discoveries (From: Gardosh et al., 2008a).

The Levant Basin is bounded to the east and southeast by the southern Levant continental margin and by the northeastern African continental margin to the south. Its northern boundary is the continental margin of Cyprus and the Hecataeus-Latakia structural lineament (Kempler, 1994), and its western boundary comprises the Nile deep-sea fan and the Eratosthenes Seamount.

An extensive hydrocarbon province offshore the Nile Delta has been well established in the southern part of the Levant Basin and provided impetus for subsequently successful hydrocarbon exploration offshore Israel. The generally under-explored central part of the basin offshore Israel has been thought to have significant hydrocarbon potential. Recent discoveries of Pliocene gas and various oil shows initiated a basin-scale study by the petroleum commissioner (in the Israeli Ministry of National Infrastructure, now the Ministry of Energy and Water Resources [MEWR]) to further investigate this area (Gardosh et al., 2008b). The study integrated new geophysical data with regional and local geologic data to reconstruct the basin history and to identify favorable hydrocarbon plays.

There are three distinct tectonic stages recognized in the evolution of the Levant Basin:

- Rifting stage – associated with the breakup of the Gondwana plate and the formation of the Neotethys Ocean system that resulted in the formation of an extensive graben and horst system, extending throughout the Levant onshore and offshore;
- Post-rift passive margin stage – associated with cooling and subsidence within the basin. In the Late Jurassic to Middle Cretaceous, post-rift subsidence was followed by the formation of a deep marine basin in the present day offshore and a shallow marine, carbonate-dominated margin and shelf near the Mediterranean coastline and farther inland; and
- Convergence stage – related to the closure of the Neotethyan Ocean system and the Afro-Arabian plate moving towards Eurasia. Inversion of Early Mesozoic structures and the formation of extensive, contractional structures throughout the Levant Basin and margin resulted from convergence during the Late Cretaceous and Tertiary. Uplift, widespread erosion, slope incision, and basinward sediment transport events were also associated with the Tertiary convergence.

The Mediterranean Sea desiccated in the Late Tertiary and resulted in deposits of thick evaporitic blankets later covered by a Plio-Pleistocene siliciclastic wedge. The Phanerozoic basin-fill ranges in thickness from 5 to 6 km on the margin to more than 15 km in the central part of the basin. A variety of potential structural and stratigraphic traps were formed in the Levant Basin during the three main tectonic stages.

3.3.2 Bathymetry and Topography

3.3.2.1 Bathymetry

Bathymetry of the Eastern Mediterranean shown in **Figure 13** illustrates the narrow continental shelf bordering the Levant Basin offshore Israel (Almagor and Hall, 1984). An updated version of regional bathymetry is available in Hall et al. (2005). The Matan Block, located approximately 80 km west of Haifa, is within the upper slope environment. Inshore of the Tamar Gas Field (i.e., in and near the Michal Block), a more pronounced gradient is evident between the

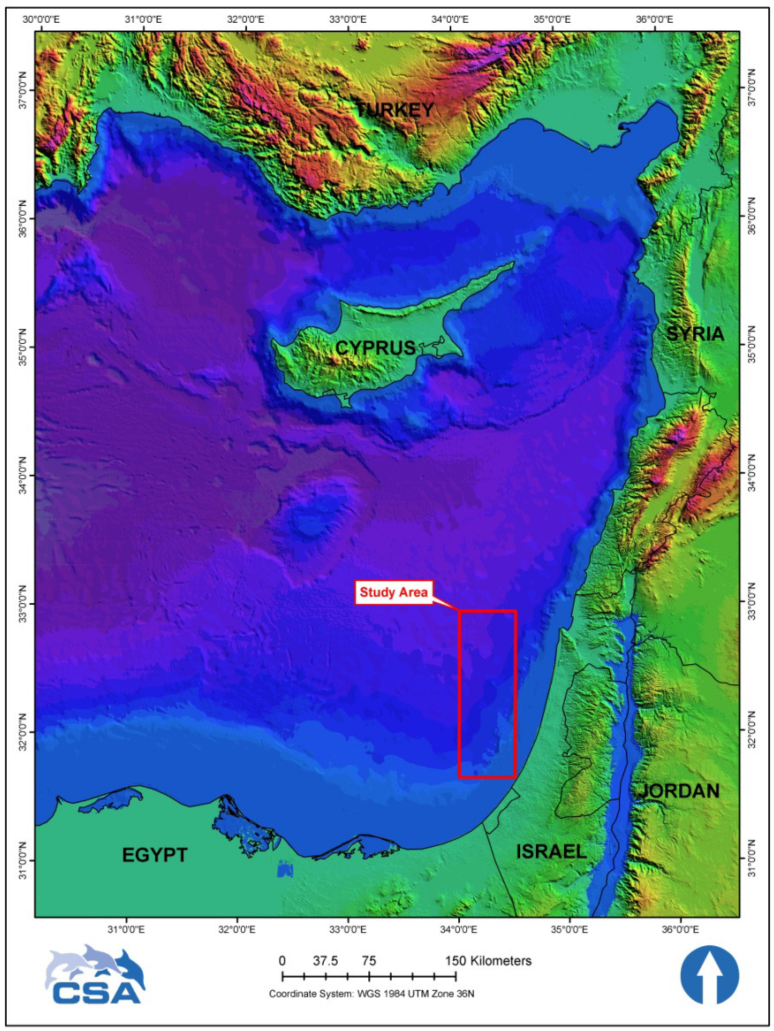


Figure 13. Bathymetry of the Eastern Mediterranean (From: Scripps Institution of Oceanography, 2008).

1,100- and 1,400-m isobaths. Within the Tamar Gas Field, a more gradual gradient is present in water depths beyond the 1,600-m isobath. Bathymetry in the Tamar well area of the Matan Block is shown in **Figure 14**.

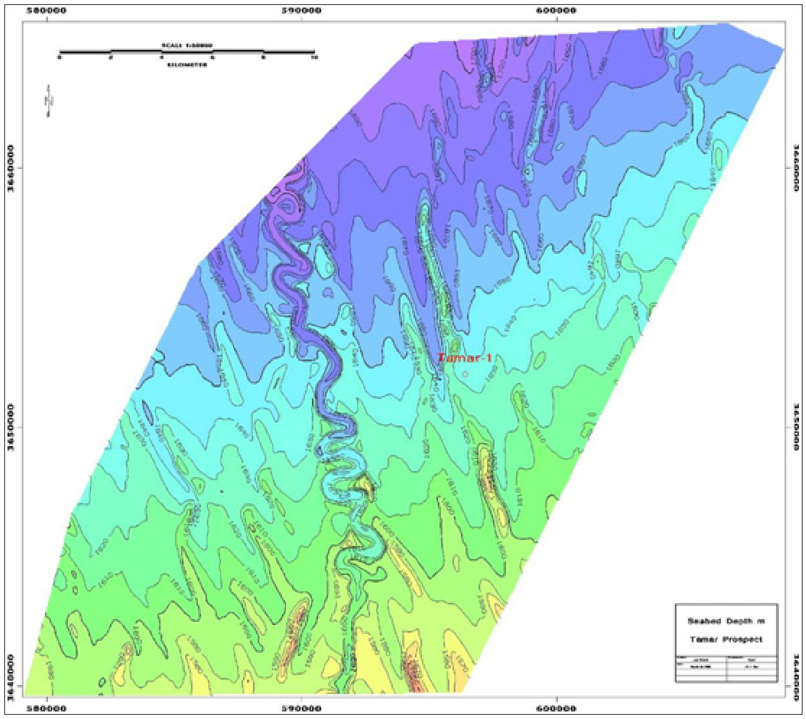


Figure 14. Bathymetry in the Tamar well area of the Matan Block.

In 2008, the Mediterranean Science Commission (CIESM) made available a new CIESM/IFREMER map of the Mediterranean seabed at a scale of 1/3,000,000 (Loubrieu and Mascle, 2008). This new image resulted from a re-analysis and extensive consolidation of previous data gathering efforts in the western and Eastern Mediterranean subbasins. The map provides a detailed morphology of the Mediterranean seafloor. Recent work by Hall et al. (2005) provides further detail regarding bathymetry of the Levantine Basin, including the project area.

3.3.2.2 Topography

Seafloor topography of the area of interest also is illustrated in the previous figures showing bathymetry of the region and the area of interest. The area interest is located along the foot of the westerly-to-northwesterly trending continental rise and slope along the coast of Israel.

The seabottom north of Haifa and southern Lebanon is a steeper continental shelf and slope that becomes less steep south of Haifa. East of the shallower Michal Block, between the 1,000-m isobath and shoreline, the westerly trending slope is generally 3%. Between the 1,000- and 1,400-m isobaths where the Michal Block is located, the west-northwest trending slope is more gradual (1.6%). The Matan Block is located in a northwesterly trending lesser gradient of 0.0005%. The geologic history of the Levant Basin involving extensive periods of desiccation of the Mediterranean resulted in the development of numerous submarine canyons all along its entire margin. In the Levant Basin, submarine canyons have been documented including the Qishon Canyon located northwest of Haifa along with a series of canyons farther north (**Figure 15**).

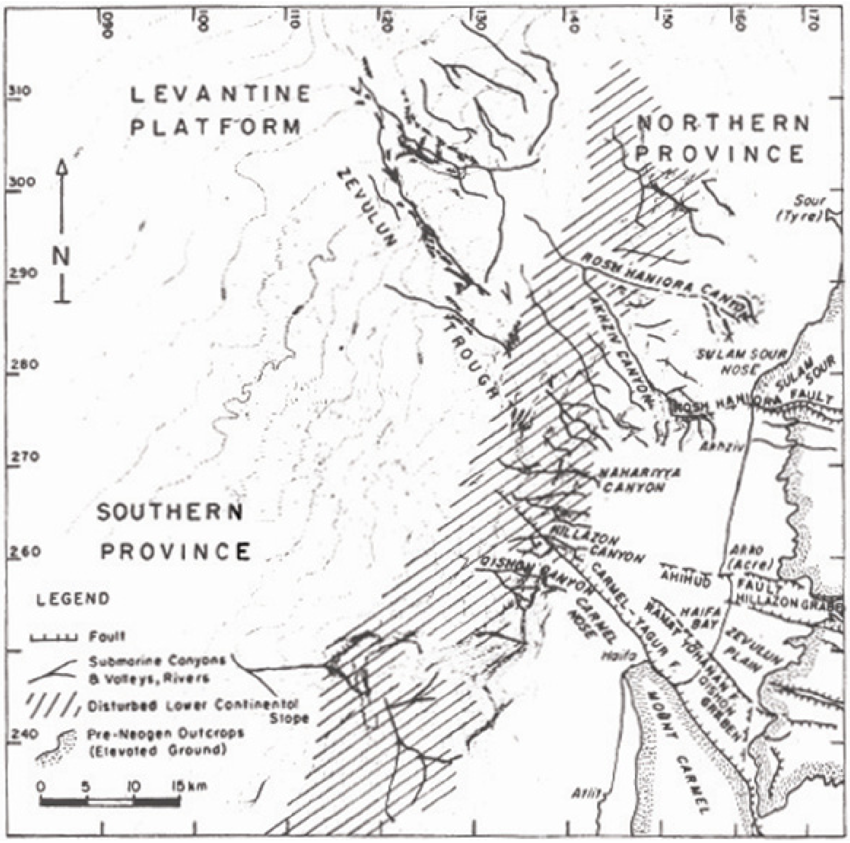


Figure 15. Bathymetry and submarine features in northern Israel and southern Lebanon (From: Almagor and Hall, 1984).

A linear, northwest trending submarine canyon feature is very evident inshore of the Tamar Gas Field (Matan Block), within the Michal Block. At least two submarine canyons or relict river channels are visible in this region, including a highly sinuous relict channel (see **Figure 14**). Apart from the submarine canyons and relict channels, there are few other evident seafloor features characterizing the topography of the Tamar Gas Field area.

3.3.3 Geology

3.3.3.1 Geology of the Eastern Mediterranean

The area of the Eastern Mediterranean has been shaped by the interactions of the African, Arabian, and Eurasian plates since the Permo-Triassic. It has been affected by a multitude of processes such as rifting, seafloor spreading, subduction, strike-slip faulting subduction, and continental collision. Its study continues to raise many controversies and has proven to be a veritable geological laboratory.

The evolution of the Eastern Mediterranean Basin is linked to the formation of Neotethys that developed along the northern end of Gondwanaland in response to the opening of the central Atlantic in the Late Triassic. A number of scenarios have been proposed for the formation of Neotethys, but here only three will be discussed. The three scenarios include:

- Robertson and Dixon (1984) prefer a breakup of the Gondwana margin for the Mid-Triassic dominated by north-northeast trending dextral faults with spreading ridges almost orthogonal to them. The continental blocks that would subsequently become the jigsaw pieces in the geologic collage that is now Turkey are quite evident. According to the authors, the Eastern Mediterranean Basin owes its formation and shape to seafloor spreading and dextral strike-slip faulting. As such, it should most probably have an oceanic crustal basement. By the Early Cretaceous, Neotethys in the Eastern Mediterranean is made up of two rather narrow east-west trending ocean basins. Spreading in the southern basin remained somewhat narrow either because of an extremely low spreading rate or because spreading stopped (Robertson and Dixon, 1984) (**Figure 16**).

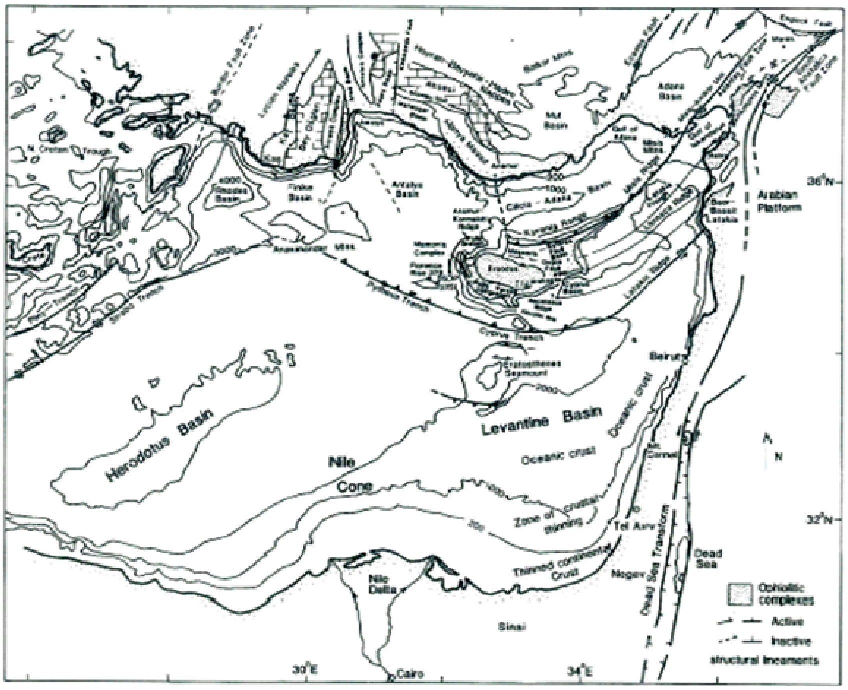


Figure 16. Geological and bathymetric map of the Eastern Mediterranean surrounding regions (From: Robertson, 1998).

- A more recent variation of the same theme is given by Stampfli and Borel (2004). Again, the Eastern Mediterranean Basin is envisaged as having been formed by strike-slip faulting, albeit sinistral in their reconstruction. A puzzling detail on their reconstruction is a small continental protrusion on the Levantine passive margin, presumably the Eratosthenes Seamount, which in later diagrams is seen to be in the initial stages of being rifted from the Arabian plate in the Maastrichtian. Another point of note in this diagram is the collision of the Arabian plate with a north-dipping subduction that led to the obduction of ophiolites along the northern edge of Arabia. To the west of the Arabia promontory, the Troodos Ophiolite, in the absence of a continental margin, was not obducted but merely rotated (Moores and Vine, 1971; Malpas et al., 1992).
- Garfunkel (1998) proposed, on the basis of on-land studies, that the Eastern Mediterranean Basin was formed by rifting of the Levantine passive margin in the Late Permian, accompanied by thinning of the continental crust to the west. The Eratosthenes Seamount would then be a product of the Levantine passive margin by the Levantine Basin. The size of the Levantine Basin precludes continuous extension or spreading since the Late Permian. Recent seismic investigations (Abdel Aal

et al., 2001) show the deep geology in the area of the Nile Delta and beyond (NE Mediterranean Deepwater Block, NEMED) to be dominated by fault-bounded blocks, some of which have been rotated. This would be consistent with the structure determined offshore of Israel and the Gaza Strip. It is the scenario favored in this report.

3.3.3.2 Tectonostratigraphic Elements of the Eastern Mediterranean Basin

The present geotectonic framework of the region is dominated by the collision of the Arabian and African plates with the Anatolian plate. Northward subduction of the African plate beneath Anatolia takes place along the Hellenic and Cyprus arcs. Farther east, the Arabian plate, separated from Africa since the opening of the Red Sea in the Mid-Miocene, is moving at a much faster rate (18 to 25 mm/yr) than the north-northwest African plate, which is moving north at 10 mm/yr. This differential movement between the African and Arabian plates has caused Anatolia to escape westward along two major strike-slip faults: the North Anatolian Fault and the South Anatolian Fault (**Figure 17**). Farther west in the Aegean, extension is dominant in the overlying plate as a result of this westward motion.

a)

b)

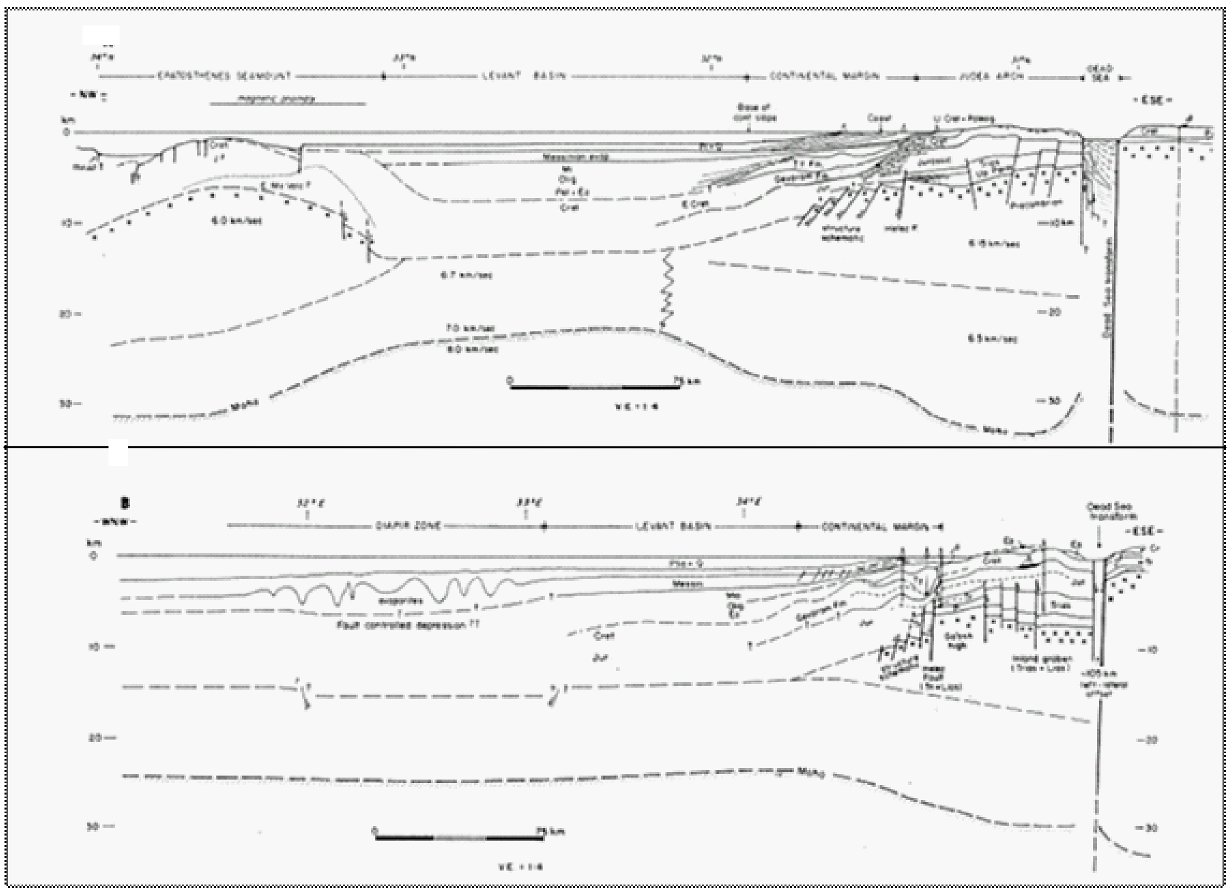


Figure 17. a) Evolution of the Levantine Basin from the Levantine margin to just beyond the Eratosthenes Seamount; and b) Schematic section of the Eastern Mediterranean Basin and its eastern margin.

3.3.3.3 The Levantine Margin

All available information relating to the nature of the Levantine margin comes from its southern portion through the work carried out for on-land and offshore exploration in Israel. Garfunkel (2004) has proposed that north-trending normal faults with large throws to the west, active since the Late Permian, provide the mechanism for the formation of the Levantine Basin. As rifting continued, the underlying continental crust would thin and form the basement to the Levantine Basin instead of oceanic crust as proposed by Makris et al. (1983).

3.3.3.4 The Levant Basin and Nile Delta

The work of Garfunkel (2004) and Abdel Aal et al. (2001) has shown the basement of the Levantine Basin to consist of faulted blocks, making a horst and graben basin floor topography covered by 10 to 15 km of sediments with an age range from the Late Permian to Recent. Their evolutionary model is generation of the Basin by intercontinental rifting and extension that stops short of seafloor spreading and oceanic crust formation.

Under this model, basal sediments everywhere would be shallow water clastics and carbonates. In deeper water, turbidites and pelagic carbonates with shales would be dominant, with basin floor sediments being mostly shales and distal turbidites (sheet sands).

The Nile Cone is chiefly a post-Upper Miocene sedimentary wedge that covers a much older marginal basin sequence. Together they have a thickness of 9 to 10 km, including 1.5 km of Messinian evaporites (Mascle et al., 2006). These post-Messinian sediments, supplied by the Nile River, have undergone significant thin-skin deformation due to downslope movement along slip-surfaces in the underlying evaporites. In the north, the Levantine Basin ends abruptly at the Hecateus and Latakia Rises (**Figure 18**).

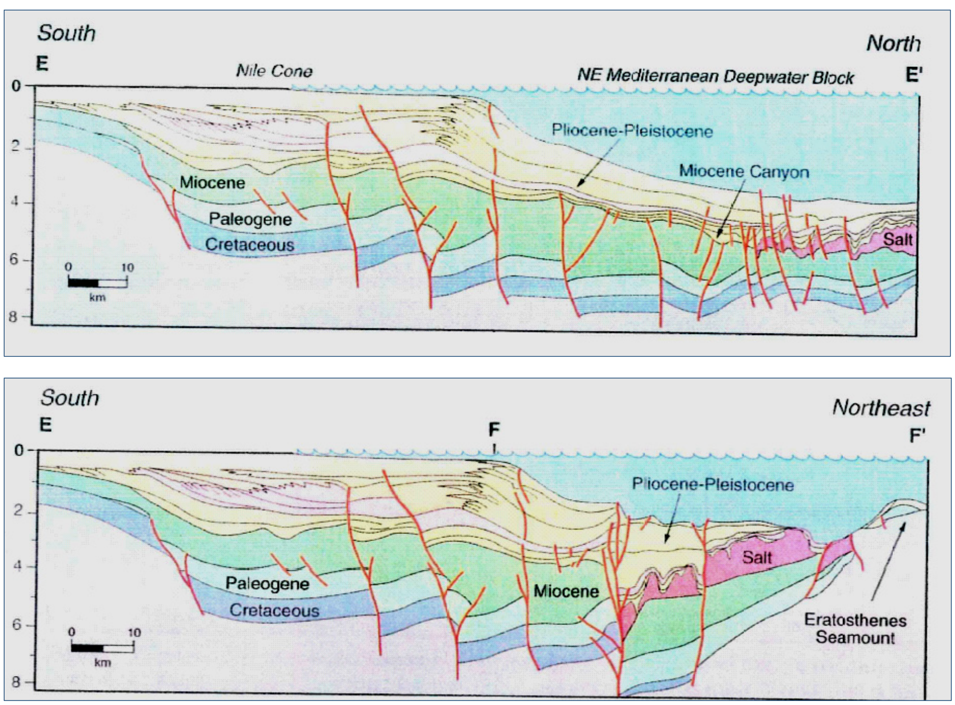


Figure 18. Geological cross-sections through the Nile Cone and the northeastern Mediterranean (From: Abdel Aal et al., 2001). E' and F' depict transect lines.

The Messinian and Plio-Pleistocene sediments continue over both rises with little if any change in thickness, but are faulted and deformed. This would suggest that both the Hecateus and Latakia Rises have been uplifted recently along the eastern segment of the Cyprus Arc.

Deep marine conditions with pelagic carbonate sedimentation (chalks and marls) mark the period between the Maastrichtian and the end of the Oligocene. The Mid-Miocene to the Pleistocene is a period of shallowing seas over Cyprus culminating in the final emergence of the island at the end of the Pleistocene.

Subduction and crustal shortening continued north of Arabia after its collision with the trench of the north-dipping subduction zone over which the ophiolites of the “croissant” formed. By the Miocene, however, most of the slack had been taken up, and this, accompanied by the opening of the Red Sea and by the approach of the Eratosthenes Seamount, led to the establishment of the Cyprus Arc as Africa and Arabia continued moving north (Robertson, 1978).

The sedimentary succession in both the Levantine and Herodotus Basins is on the order of 10 to 15 km thick. Most of the succession predates the Messinian Salinity Crisis and is the least known, being underneath 1 to 2 km of salt deposits. A three-fold subdivision of the succession is made possible by the presence of the following ubiquitous evaporate deposits:

- Plio-Pleistocene;
- Messinian evaporites; and
- Pre-Messinian (Miocene-Triassic?).

3.3.3.5 The Messinian Salinity Crisis

The Messinian Salinity Crisis is not only the most unique oceanic event in the last 20 million years but it is also significant as sediments deposited during this event form a perfect seal to any hydrocarbons present offshore. These evaporite sediments were first discovered by Hsü et al. (1973). Their formation is attributed to the periodic restriction of seawater inflow from the Atlantic, leading to hypersalinity and deposition of gypsum in shallower basins and halite in the deep basins. The Mediterranean did not dry completely, but at times the sea level dropped by as much as 1,500 m. This fall led to dramatic erosion, with the formation of large canyons and deposition of coarse sediments that make good reservoir rocks.

A bulletin published on 21 February 2008 by the CIESM (2008) presents a new consensus from the Messinian Salinity Crisis Workshop. The new scenario divides this very short-lived event into three stages:

- **Stage 1.** The stage from 5.96 to 5.60 my, when evaporitic conditions became established in small embayments of the Mediterranean. Under these conditions, mainly gypsum accumulated, forming the “Lower Evaporites.”
- **Stage 2.** During this stage, which lasted only 50,000 years (from 5.6 to 5.55 my), the connection with the Atlantic was completely severed, causing a dramatic drop in sea level that led to the formation of thick halite deposits in the deep parts of the basins. These deposits are as much as 1,500 to 2,000 m thick in the Levantine Basin. As a consequence of this sea-level drop, much of the Nile Cone and most of the Eratosthenes Seamount were exposed and heavily eroded. In the Nile Delta area, large canyons were incised into the Delta sediments and channeled sands to the basin floors, especially in the Herodotus Basin. This progradation of sand deposition in deep water makes

these sheet sands good exploration targets. In the case of the Eratosthenes Seamount, the canyons emanating from it were filled with coarse carbonate clastics that could prove to be good reservoirs.

- **Stage 3.** The stage from 5.53 to 5.33 my is marked by gradually increasing fluvial input, Lago Mare deposits, and development of gypsum and halite in deeper water.

Pre-Messinian to Cretaceous sediments yielded oil in the Gulf of Suez and both oil and gas from wells in the Western Desert. In the Nile Delta, gas was struck in Miocene sediments and oil found in Eocene deltaic sandstones. Marine shales and shaly limestones are the most likely source rocks for these finds. Within the Herodotus and Levantine Basins, Cretaceous black shales could be a good source for oil. Data on the pre-Messinian successions within the Levantine and Herodotus Basins are extremely scarce or unavailable so any predictions must be speculative, but the fact that oil has been found in more shallow-water facies is encouraging.

3.3.3.6 Geology of the Continental Slope

The subsurface geology of the coastal area and blocks of interest may be gleaned from available bathymetric maps and seismic profiles. The bathymetric map of the Eastern Mediterranean (see **Figure 13**) depicts an evident seafloor feature just west of Tel Aviv. A similar though less evident feature appears west of Haifa. **Figure 19** shows the bathymetry offshore of the Israeli coast between Tel Aviv and Haifa in greater detail to better show seafloor features. These features correspond with identified disturbed areas of the continental slope offshore the southern Levant (Almagor and Hall, 1984). The disturbed areas designated as the Palmachim and Dor disturbance, respectively, where mass slumping occurred is in a zone of diapirs and associated with Messinian drainage systems such as the Palmachim Canyon in Tel Aviv and Caesarea Canyon in Haifa (**Figure 20**).

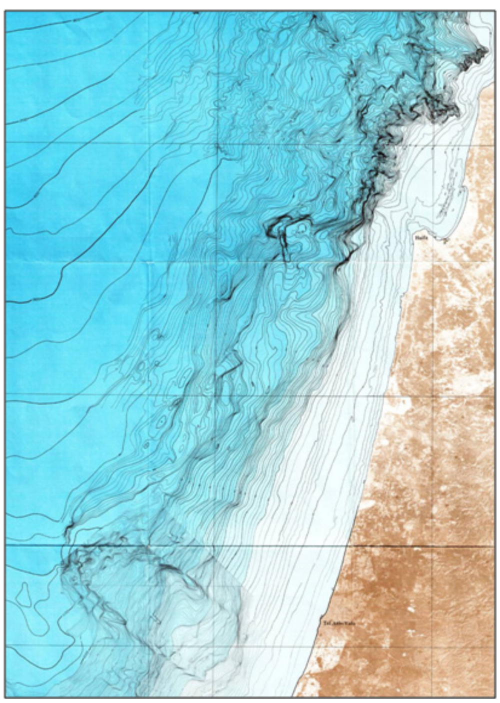


Figure 19. Bathymetry offshore of the Israeli coast between Tel Aviv and Haifa (From: Almagor and Hall, 1984).

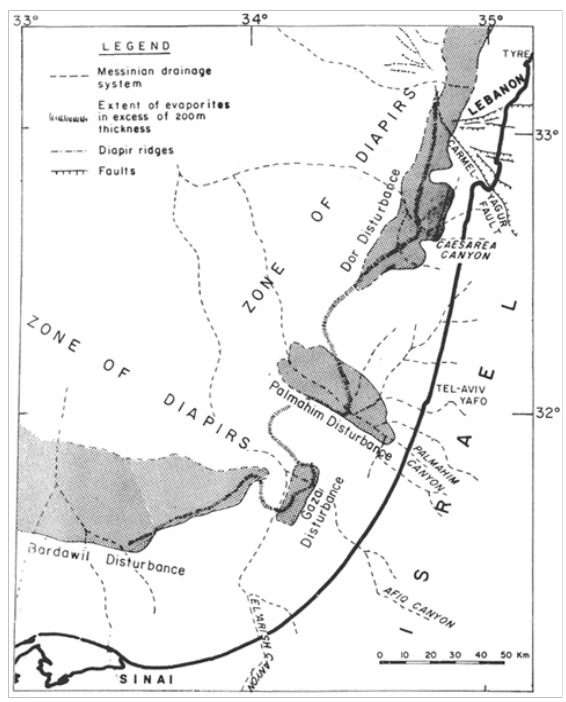


Figure 20. Seabottom features on the continental slope off the Israeli coast (From: Almagor and Hall, 1984).

Gardosh et al. (2008b) detected four regional unconformity surfaces in the seismic records from the continental slope within the Oligo-Miocene succession: 1) Early Oligocene, 2) Middle Miocene, 3) Late Miocene (upper Tortonian), and 4) latest Miocene (post-evaporites) time. The Early Oligocene, Late Miocene (upper Tortonian), and latest Miocene (post-evaporites) surfaces reveal a series of stacked submarine canyons on the Levant slope. Some of the canyons are deeply incised. Other canyons, less incisive, are located along structural lows. The Middle Miocene surface does not coincide with canyon incision. It rather reflects the Serravallian crisis characterized by deteriorated climatic conditions (cooling) and by local lowstand conditions and hardground. The canyons acted as conduits for transporting products of gravity flows from the shelf into the basin.

The relict drainage systems developed and were incised on to the Levant continental slope during the Oligocene and Miocene on through the Messinian and are partly reflected in the present day submarine features. **Figure 21** illustrates the network of submarine and subaerial drainage patterns that have been identified on the continental slope of the southern Levant. The Michal Block is located between the Haifa and Atlit Canyons while the Matan Block is farther northwest at the foot of the present day continental slope.

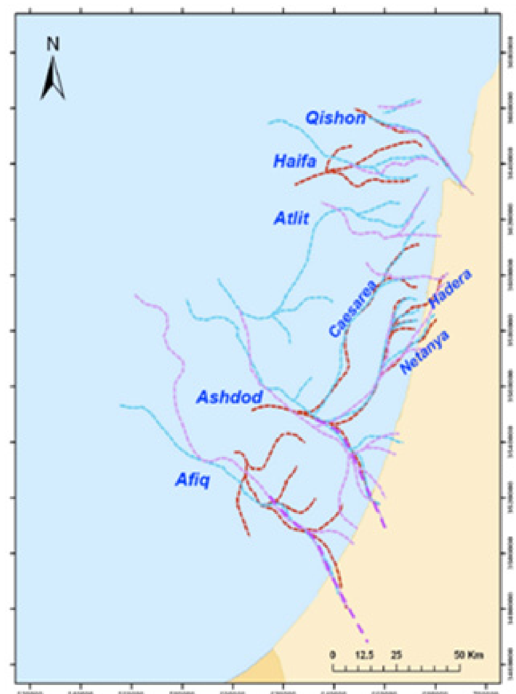


Figure 21. Network of submarine and subaerial drainage patterns during the Oligo-Miocene time that have been identified on the Levant continental slope (From: Gardosh et al., 2008b). Red lines mark the Early Oligocene; cyan lines mark the Middle Miocene; purple lines mark the top Tortonian; violet lines mark the latest Messinian.

The sedimentary succession reaches a few hundred meters onshore, and ~5,600 m in the deep basin, which consists of 3,500 m of clastics, overlain by up to 2,100 m of evaporates. The Early Oligocene incision carved the two major canyons on the continental slope: the Afiq and Ashdod canyons. These two, together with their tributaries, are the main conduits through which most, if not all, the sediment load was funneled down to the deep basin. These two canyons were filled to their rims by Oligocene sediments. Later in Late Tortonian times they were reactivated, deeply incised, and partially refilled by Late Tortonian carbonates and clastics to be later buried by the massive Messinian evaporates overlapping their rims. Unlike the Early Oligocene and Late Tortonian incision events, which took place under a continental slope setting, the latest Miocene (post-evaporites) incision took place subaerially following an 800-m drawdown of the sea level by the end of the upper evaporite deposition, leading to fluvial and lacustrine clastic deposition on the exposed continental slope.

Transport of sands from their provenance in the east and southeast was probably more effective and widespread during the lower Oligocene and most of the Miocene, whereas during the upper Miocene through the Pliocene, basinward transport was more restricted because of increased subsidence in the Dead Sea Rift, which became a major trap for sediments from the east, and the uplift of the mountainous backbone of Israel. Oligo-Miocene sands were deposited under two settings: 1) as channel fill within the canyons in a confined, intra-slope setting or 2) as sheets and lobes in an unconfined setting at the lower slope and basin floor. Channel-fill sands were penetrated by several wells and interpreted from seismic data. Basin floor sands were not yet tested by drilling and their existence is only inferred based on the seismic data. Both occurrences are considered as attractive, potential hydrocarbons traps (Gardosh et al., 2008b).

The subsurface features also are shown in a regional, north-south oriented seismic profile showing the location of Tertiary canyons on the Levant slope (**Figure 22**) that are important to and indicative of the Oligocene, Miocene, and Messinian history of the continental slope. **Figure 23** illustrates a seismic profile that bisects the middle of the Michal Block in a roughly east-west direction showing the Middle Miocene Atlit Canyon (Gardosh et al., 2008b). A similar seismic profile in the area of the Matan Block is not available.

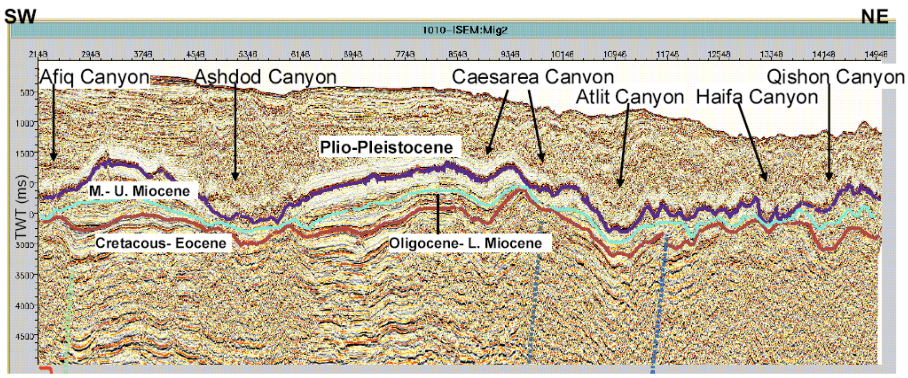


Figure 22. Regional, north-south oriented seismic profile showing the location of Tertiary canyons on the Levant slope (From: Gardosh et al., 2008b).

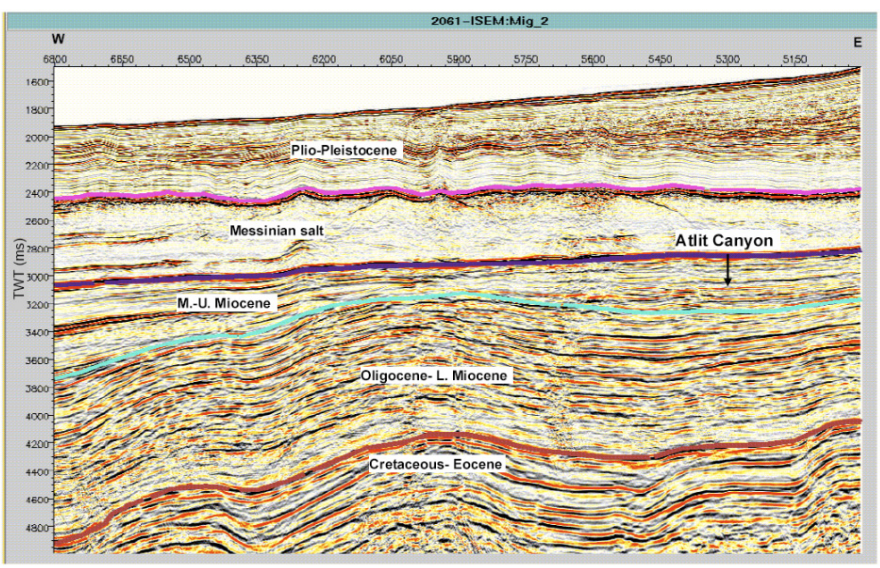


Figure 23. Seismic profile showing the Middle Miocene Atlit Canyon (From: Gardosh et al., 2008b). The existence of a submarine canyon is indicated by the onlapping reflections within a Syrian Arc syncline, interpreted as channel fill. The base Oligocene and base Messinian unconformity do not show evidence for the existence of a canyon in this area.

Sade et al. (2007) noted that the continental margin off northern Israel shows the interplay between past global sea level changes, long-shore sedimentation, and tectonics. The coastline is paralleled by a number of carbonate-cemented quartz/sandstone (Kurkar) ridges. In the north, these rise above sea level and form eight small islands. In deeper waters, there are several raised platforms, some exhibiting curving dune-like bedforms, perhaps of current or eolian origin.

The shelf-break occurs at around 100-m depth, and beyond this many canyons carry sediment out to the deep sea. The prominent Carmel Nose is an extension of Mount Carmel across the shelf. The Western Galilee is cut by a number of east-west trending faults. Offshore these define a series of raised and sunken blocks, and appear to provide preferential courses for the rivers as they breach the Kurkar ridge system. A number of straight or curvilinear trends appear to result from tectonic activity, and may be related to normal faulting. Opposite Haifa Bay, in water depths of 30 m, a broken-up area called the "Brittle Sheet" was mapped, and also may have a tectonic origin. In the far north, the steep Akhziv Canyon cuts deep into the continental margin. Numerous shallow pits and slightly raised mounds characterize the entire shelf and slope.

A study of the mass physical properties of 54 sediment cores from the continental margin of Israel summarized by Almagor (1978) revealed that the sediments, which are of Nile origin, are normally consolidated, although their rate of deposition is high, ranging from 0.5 to 1 m/1,000 years. Variations in the physical properties of the sediments, together with other features such as micro-bedding, and chunks of loose and stiff overconsolidated silty-clays, reflect downslope slumping.

Recent discoveries of biogenic gas and various oil shows indicate that the central part of the basin, offshore Israel has significant hydrocarbon potential. To further investigate this generally under-explored area, a basin-scale study was initiated by the petroleum commissioner in the Israeli Ministry of National Infrastructure (now MEWR; Gardosh et al., 2008b). The study integrated new geophysical data with regional and local geologic data to reconstruct the basin history and to identify favorable hydrocarbon plays. The Oligo-Miocene deep-water system of the Levant Basin overlies Mesozoic source rocks and is overlain by the Messinian evaporite seal. This combination strongly suggests a significant potential for major hydrocarbon discoveries in the Levant Basin.

Possible hydrocarbon play types are: Triassic and Lower Jurassic fault-controlled highs and rift-related traps; Middle Jurassic shallow-marine reservoirs; Lower Cretaceous deepwater siliciclastics; the Tertiary canyon and channel system and associated deepwater siliciclastics found in either confined or nonconfined settings; Upper Cretaceous and Tertiary Syrian Arc folds; and Mesozoic and Cenozoic isolated, carbonate buildups on structurally elevated blocks. Shallow gas discoveries in Pliocene sands and high-grade oil shows found in the Mesozoic section indicate the presence of source rocks and appropriate conditions for hydrocarbon generation in both biogenic and thermogenic petroleum systems. The size, depth, and trapping potential of the Levant Basin suggest that large quantities of hydrocarbons can be found offshore Israel.

The presence of evaporites on the steep sides of the continental slope would provide good slip surfaces for mass flaws to occur. Saturated sand layers on slopes, especially when confined, would also be prone to failure.

Information on seismic sea waves is meager. Ambrasseys (1962) conducted a survey of reported sea waves from Antiquity to 1961 and came to the conclusion that the region from Cyprus to Jubeil and Acre on the Levantine coast is prone to sea waves of light to rather strong intensity. The term “rather strong” on this intensity scale means that the waves would flood gently sloping slopes. The height and destructive power of such waves is by far greater in coastal areas, where they traverse shallow water, than out in the open seas. Kelletat and Schellmann (2002) examined the western and southeastern coasts of Cyprus for tsunami evidence and reported movement of boulders weighing several tons by an event that took place over 200 years ago.

Salamon et al. (2007) constructed a list of 21 reliably reported tsunamis that have struck the Levant coast, along with 57 moderate-to-large earthquakes that have occurred along the DST system, since about the mid second century B.C. Ten of the tsunamis were triggered by earthquakes that originated along the Dead Sea Transform (DST) System, six of which followed moderate earthquakes and four followed large earthquakes. These observations indicate that about 14% of the moderate and 25% to 29% of the large DST earthquakes were tsunamigenic. Salamon et al. (2007) estimated that the threshold of tsunamigenic DST earthquakes likely range from 6 to 6.5 magnitude.

Meral Ozel et al. (2011) have also reported on the tsunami hazard in the Eastern Mediterranean and its connected seas, with an emphasis on Turkey. They provided detailed information on historically and instrumentally recorded significant tsunamigenic events surrounding Turkey, with one primary purpose being to more fully understand the tsunami threat to the Turkish coasts.

3.3.3.7 Geohazards in the Project Area

Several geotechnical surveys have been conducted along the Tamar to Mari-B and Mari-B to Ashdod pipeline corridors (DOF Subsea UK Ltd., 2010; Gardline Geosciences Limited, 2010; Oceana Marine Research Ltd., 2002; Oceana Marine Research Ltd., 2010). Between the Tamar Field and Mari-B, the sedimentary sequence indicated an absence of sand and a predominance of clay. Brown clay generally overlies gray clay, while in many cases a very soft reddish brown clay appears to form a thin veneer (<0.30 m) on top of the sediment surface.

The shear strength of the sediments increases with depth, without exceeding 10 kPa in most cases. In some cases, when passing from dark brownish gray to light brownish gray clay, there is a significant reduction in natural moisture content with an associated increase in shear strength.

Exceptions include the presence (at 927-m water depth) of relatively thick deposits of gravel (>1 m) that lie between distinctive clay layers, possibly indicative of separate mass movement events. At 795-m water depth along the Tamar-Mari-B pipeline corridor, there is a clear step in the shear strength profile that may indicate the repetition of the same geotechnical units. The reddish brown clay that usually forms a thin veneer in very deep waters appears on top and at a depth of 3 m below mudline, followed in both cases by a similar sequence of soils. The repetition of sediments as well as the sudden changes in the shear strength and natural moisture content profiles might suggest the existence of landslide-related materials.

In the Tamar Field region, several geohazards were observed, including 1) slumps, 2) possible strike/slip faults, 3) depressions/shallow faults, 4) a channel, and 5) a possible paleo channel. The Tamar site represents an area of complex geology, with three main types of features dominating the bathymetry, including several northwest-southeast trending ridges, faults aligned in two main directions (northeast-southwest and northwest-southeast), and a distinct meandering channel.

Along the southern portions of the Tamar-Mari-B pipeline corridor, in water depths ranging from 237 to 1,006 m, the following geohazards were observed: 1) faults, 2) a reworked slide area, 3) slope failure structures, and 4) depressions/shallow faults. The southern portion of the pipeline corridor exhibited complex geology, including several east-west and southeast-northwest trending faults, a fault area with slides, and a reworked slide area.

Along the utility line corridor from Mari-B to Ashdod, shallow water segments include both beach rocks and sand stone. Rock formations continue from the shore to a water depth of 15 m. Sandy seafloor extends from water depths of 15 m into deeper water, with a seabed slope of about 1.8 m/km. A change in slope occurs at a water depth of 40 m where the seabed is covered with fine clay and slopes about 3 m/km. From a water depth of 80 to 125 m, some scattered rocks appear, but they do not replace the fine clay and mud covering the seabed. From a water depth of 125 m to the end of the utility pipeline route the seabed slopes steeper, about 12 m/km.

3.3.4 Sediments

3.3.4.1 Pliocene-Pleistocene Sediments

A Late Tertiary desiccation of the Mediterranean Sea was followed by deposition of a thick evaporitic blanket that was later covered by a Plio-Pleistocene siliciclastic wedge. The Phanerozoic basin-fill ranges in thickness from 5 to 6 km on the margin to more than 15 km in the central part of the basin. A variety of potential, structural, and stratigraphic traps were formed in the Levant Basin during the three main tectonic stages.

Pliocene-Pleistocene sediments are unlithified sands and clays with intercalations of organic-rich, thin beds termed sapropels. Almost all of the clastic material reaching the basin floor of the Levantine and Herodotus Basins comes from the Nile Delta. Successful wells have been drilled in the Pliocene turbidites of the shallow-water areas of the Nile Delta. The Pliocene deposits are slope and basin-floor turbidites in the form of channel, channel-levées, and sheet sands. Channels originate on the Delta and funnel turbidite sands down the slope, giving rise to sheet sands on the basin floor.

In the central part of the zone, south of the Eratosthenes Seamount, the Plio-Pleistocene sediments are highly deformed and folded as megaslumps generated by the down-slope movement of the underlying salt. Such folds could presumably make good traps for hydrocarbons. To the east, in the Levantine Basin, distal turbidites in the form of sheet sands would be the main reservoirs.

Pliocene sapropels are the main source rocks in the Plio-Pleistocene succession. Their formation is thought to be climate controlled, with warm periods giving rise to high organic productivity in the photic zone, while stagnant anoxic conditions on the basin floor led to their preservation. Their total organic carbon content varies from 5% to 25%.

3.3.4.2 Nearshore Sediment Quality

Herut et al. (2005), summarizing the sediment quality results of the annual coastal marine monitoring program for 2004, indicated that in general, the level of pollution of Israel's Mediterranean coastal sediments is not high relative to international marine environmental quality guidelines and criteria. A more comprehensive summary has also been prepared by Herut et al. (2010) for nearshore sediment quality along the Israeli coastline, documenting changes over the period 1999-2009.

Monitoring of sediment has been conducted regularly. Herut et al. (1993) summarized trace metals in shallow sediments from the Mediterranean coastal region of Israel. Current environmental indicators include heavy metals (e.g., mercury [Hg], cadmium [Cd], chromium [Cr], lead [Pb], zinc [Zn]) and organic pollutants (pesticides, polychlorinated biphenyls [PCBs], polycyclic aromatic hydrocarbons [PAHs], tributyltin [TBT]) in sediment. While low concentrations of other heavy metals were observed, lead and zinc enrichment relative to other areas occurred. In general, the concentrations of all metals in shallow areas are considered below harmful levels. Several local pollution problems related to sewerage, refinery outfalls, ports, and marinas were noted. Levels of pollution from PAHs, TBT, PCBs, and pesticide residues dichlorodiphenyltrichloroethane (DDT) in the ports, marinas, cooling basins, and other industrial sites were also reported.

In September 2009, the Ashdod Port Authority conducted a reconnaissance study to determine the composition of trace metals and select organics present in harbor sediments (Agriport, 2010). Sediment samples were collected from the upper 20 cm of sediments at 11 locations throughout the port, in water depths ranging from 7 to 17 m. Samples were analyzed for heavy metals, total organic carbon (TOC), PAH, PCBs, and total petroleum hydrocarbons (TPH). The ranges of values obtained for Ashdod Port are presented in **Table 9**. Values for PAHs were below detection limits. The sediment texture of Ashdod Port samples was sand, with 10% (by weight) or less particles finer than 0.06 mm. Agriport (2010) determined that Ashdod Port sediments are quite benign given their determinations relative to effect range low (ERL) and effect range median (ERM) limits.

Table 9. Concentrations of heavy metals, PCBs, and TPH in sediments sampled in Ashdod Port (From: Agriport, 2010).

Reference	Parameter									
	Mercury (µg/kg)	Zinc (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Copper (mg/kg)	Chromium (mg/kg)	Cadmium (mg/kg)	ΣPCBs (µg/kg)	TPH (mg/kg)	PAHs (mg/kg)
Ashdod Port	2.7–58.4	9.9–132	4.1–44	11–21	8.1–66	4.6–68	0.04–1.1	<0.06–39	169–480	BDL
ERL*	150	250	47	21	34	81	1.2	22.7	--	--
ERM*	710	410	220	52	270	370	9.6	180	--	--

* ERL = effect range low; ERM= effect range median. ERL and ERM are criteria used to determine whether dredged sediments are suitable (values < ERL) or not suitable (values > ERM) for disposal at sea. BDL = below detection limit.
PAHs = polycyclic aromatic hydrocarbons; PCBs = polychlorinated biphenyl; TBT = tributyltin.

3.3.4.3 Offshore Sediment Quality

Goldsmith et al. (2001) studied spatial trends in the chemical composition of sediments, particularly the distribution of select metals in various sediment fractions, on the continental shelf and slope off the Mediterranean coast of Israel. The dominant source of particles was Nile-derived material. Patterns in Fe/Al, Ti/Al, and noncarbonate Mg/Al in the fine sand fraction and $CaCO_3$ were consistent with circulation and sediment transport models for the southeast Levantine Basin. The background trend in trace metals corresponds to changes in mineralogy. While the fine sand fraction appeared free of contamination, in the finer fractions there was a significant enrichment of Zn, and Cd towards the north, which is not accounted for by changes in mineralogy. The sediments were also enriched in copper (Cu), Zn and Cd near Tel Aviv and Hadera.

The peaks near Tel Aviv may correspond to waste discharged through the Yarqon and an old sewage pipe, while near Hadera, the Alexander and Hadera Rivers and the terminal for a coal-fired power station may be the source of contamination. There also was clear evidence for contamination by lead (Pb) in the finest sediments. However, there was no enrichment in Pb around point sources of the other trace metals, therefore, it was concluded that the majority of Pb contamination was from the atmosphere.

All trace metal contamination may be subject to “smearing” by sediment transport, particularly in the clay fraction. While a majority of Pb contamination was from the atmosphere, Zn and Cd were derived mainly from land-based point sources. Although some Cu input is from point sources, it is unclear from the evidence available whether there also was some atmospheric input of Cu as well (**Table 10**).

Table 10. Summary of nearshore sediment quality parameters, 2004 (Adapted from: Herut et al., 2005).

Sediment Quality Parameter	Determination	Trends Identified
Heavy metals in sediments	**Haifa Bay**	
	Medium level of mercury pollution in northern part of Haifa Bay; medium to low levels of mercury in Qishon Estuaries.	Mercury pollution decreased compared to the previous decade. In the last decade seems stable. Pollution in the Qishon estuary decreased. Cadmium concentration seems stable in the last 5 years. No significant change in metal concentration of the other river estuaries.
	Decrease in mercury levels in the Oishon estuary compared to 2008, probably the result of deepening diggings in the area.	
	Low concentrations of other heavy metals. Lead and zinc enrichment relative to other areas.	Lead concentrations decreased.
	Along the Coast	
	In general, concentrations of all metals in shallow areas below harmful levels.	No clear trend in Tel-Aviv Region Sewage Treatment Plant (TAS) area (seasonal changes in the level of pollution).
	Several local pollution problems noted: • Medium level of mercury and cadmium pollution in TAS area. • Chromium enrichment along the coast south of Palmachim and in the area of the "Agan Chemicals/Ashdod Refineries" outfall (off Ashdod).	
	Ports and Marinas	
	High level of pollution by mercury in Haifa Port; medium level of pollution by cadmium, arsenic, lead, chromium, copper, zinc in the port of Haifa; by chromium, copper, zinc and nickel in Ashdod port; medium level of pollution by mercury in the marina of Akko; by nickel in the marina of Akko, Michmoret, Eshcol and Ashkelon; by copper and zinc in the marina of Tel Aviv, Ashkelon, Akko, Hadera and Michmoret (only zinc).	Haifa Port: Possible increasing trend of mercury; no clear trend regarding other metals, possible decreasing trend in cadmium concentration. Ashdod port: Chromium, copper, nickel, cadmium and mercury concentration decreasing trend the civil area of the port Marinas: No significant change excluding some enrichment of chromium, copper and nickel in Michmoret.
Organic pollutants in sediments	**Ports and Marinas**	
	Medium level of pollution of PCB's (>ERL). In Ashdod port, Akko and Tel Aviv marina concentration of PCB's detected were higher relatively to other marinas but lower than the harmful ecologic criteria (ERL).	Similar levels of pesticide residues, PCBs and TBT found in the years 2000-2003. Imposex (indicator of TBT pollution) found in snails from Haifa Bay. PCBs level was lower than previous survey on 2001-2005, and equal to the years 2006-2009.
	High level of PCBs pollution in Haifa and Ashdod Ports and Akko marina; medium level of pollution in Qishon Port and Tel-Aviv marina.	
	Medium level of pollution by a few PAHs in Haifa and Ashdod Ports. PAHs concentration detected was lower than the ecologic criteria for rarely harmful influence (ERL). Significant TBT pollution in Haifa, Qishon, and Ashdod Ports, in Akko, Michmoret, Tel-Aviv, and Ashquelon marinas and in the cooling basin of Ashdod Power Plant. The findings indicate continued TBT input.	

DDT = dichlorodiphenyltrichloroethane; PCB = polychlorinated biphenyl; TBT = tributyltin.

PAH concentrations in offshore sediments in the Eastern Mediterranean are shown in **Table 11**. Gogou et al. (2000) reported that atmospheric inputs were the major source of PAHs in the Eastern Mediterranean open marine ecosystem based on a 2-year study involving measurements of dry and wet atmospheric deposition, air-sea exchange, and sediment trap fluxes from November 2000 to July 2002. Dry and wet deposition samples were analyzed for PAH. The concentration of PAHs in settling material at 250- and 1,440-m depth was 468 and 259 ng/g (dry weight), respectively. Phenanthrene was the most abundant PAH at both depths. Concentrations of phenanthrene were 141 and 92 ng/g at 250 and 1,440 m, respectively. Petroleum hydrocarbon concentrations in water and sediment may be elevated in some areas due to natural seepage of hydrocarbons. However, the area is in a region where the potential for such seepage exists.

Table 11. Polycyclic aromatic hydrocarbon (PAH) concentrations in sediment in the Eastern Mediterranean Sea, 1985-1986 and 1995-1996 (From: Yilmaz et al., 1998a).

Period	Station	PAH Concentration (µg/g dry weight)	
		Minimum – Maximum	Mean ± Standard Error
1985-1986	10	0.02–0.77	0.51 ± 0.10
1995	19	0.69–4.8	2.6 ± 0.3
1996	19	0.55–18.7	4.75 ± 1.0

Sediment quality information is available from a study of sewage sludge impacts on sediment quality and benthic assemblages off the Mediterranean coast of Israel (Kress et al., 2004). Distributions of benthic assemblages, heavy metals, and organic carbon in sediments were examined during a long-term study at a sewage sludge disposal site off the Mediterranean coast of Israel.

The disposal of sewage sludge had a marked but localized, seasonally dependent impact on the benthic assemblages and sediment quality. Elevated concentrations of organic carbon, Hg, Cd, Cu, Zn, Pb, and to a lesser degree nickel (Ni) were detected in sediments mostly northward of the sewage outfall, in the direction of the prevalent longshore current. High concentrations of organic carbon and metals were reflected by elevated populations of tolerant and opportunistic polychaetes in spring and by an azoic zone in fall. The impacted area extended mainly towards the north (up to ~4 km) and to a lesser extent south of the outfall (up to ~2.5 km).

No evidence of increased accumulation of sewage sludge with time was found, nor of pollutants associated with it. The seasonal pattern shown by infaunal abundance, anthropogenic metals, and organic carbon were attributed to the stratification of the water column from spring to fall on one-hand and winter storms on the other. Winter storms resuspend and disperse the fine organic particles, sweeping the site clean of sludge; accumulation of sludge takes place throughout the quiescent periods of the year, when stratification is reestablished.

Kress et al. (1998) studied concentrations of Hg, Cd, Cu, Zn, Fe, and Mn in five deep-sea benthic fauna species in specimens from two deep-sea dump sites and a deep-sea control area in the southeastern Mediterranean Sea, 1988-1995. Natural concentrations in the studied species were determined using specimens collected at a control site. The order of the natural metal concentrations found in the crustaceans was: Fe > Cu > Zn > Mn > Cd > Hg, while in the benthic fish the order was different: Fe > Zn > Mn > Cu > Hg ≥ Cd. Natural levels of Hg and Cd were high compared with the levels found in nearshore species, probably a result of specific feeding habits and physiological metal regulation of each species.

Specimens collected at the dump sites were used as biomonitors to assess the impact of waste dumping operations. Rank-score analysis based on metal contents of the fauna gave the lowest sum of scores to the control site, indicating probable effect of the disposal operations.

Kress et al. (1993), sampling at a deep-sea disposal site (close to the Michal and Matan Blocks) conducted sediment metal analyses. Results from the deposition area were variable (**Table 12**), with sediment trace metal values generally higher than reference values (i.e., marine shale).

Table 12. Heavy metal concentrations in surficial deep-sea sediments at the Hadera coal fly ash deposition site on the continental slope offshore Israel (Adapted from: Kress et al., 1993).

Sample	Trace Metals (ppm)					Trace Metals (%)	
	Cadmium	Lead	Copper	Zinc	Manganese	Aluminum	Iron
Deep-sea sediment[1]	0.20 ± 0.04	38.6 ± 3.5	65.5 ± 2.6	88.9 ± 12.1	1,931 ± 52	7.43 ± 0.16	5.28 ± 0.15
Hadera fly ash (HNO_3 digestion)	0.44	30.4	40.7	53.9	--	--	1.91
Hadera fly ash (HF digestion)	0.91 ± 0.07	86.6 ± 1.8	84.3 ± 1.4	111.2 ± 5.7	443 ± 8	14.1 ± 0.2	3.73 ± 0.04
Hadera fly ash (HF digestion)	--	--	--	--	454 ± 11	14.1 ± 0.4	3.71 ± 0.31
P8	--	--	--	--	1,109	10.0	--
P9	--	--	--	--	731	11.3	--
P10	--	--	--	--	1,365	9.21	--
P11	--	--	--	--	1,719	8.19	--
Marine shale[2]	0.2	20	45	95	600	--	4.72

[1] Average value, Stations B1-B5, B10-B11; HNO_3 digestion for cadmium, lead , copper, zinc, iron; total values for aluminum and manganese.
[2] Data from: Turekian and Wedepohl (1961) (total concentration).

Galil and Herut (2003) conducted an environmental survey including sediment chemical analyses at the Mari-B Platform, approximately 2 km from the Tamar Platform location. The objective of the survey was to assess the conditions of the marine environment in the study area (i.e., proposed location of the Mari-B production platform) following exploratory drilling and prior to the commencement of production. The average and range of sediment metals concentrations from the Galil and Herut (2003) survey are presented in **Table 13**. Findings of the survey indicated there was some contamination of the sediments from drilling fluids used during exploration activities. It was assessed that the most contaminated sediment stations were relatively close to the wellsite (Galil and Herut, 2003) but there was no clear contamination gradient based on distance from the wellsite.

Table 13. The average and range of sediment metals concentrations from samples collected from the Mari-B location (Galil and Herut, 2003).

Metal (ppm)	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
Average	0.04	107.00	52.09	0.01	77.27	12.58	99.27
Range	0.03–0.09	88–123	46.3–59	0–0.02	71.3–83.1	10.1–14.6	88–111

3.4 ACOUSTIC ENVIRONMENT

Ambient noise is sound received by an omni-directional sensor that is not from the sensor itself or a result of the manner in which the sensor is mounted. Ambient noise is made up of contributions from many sources, both natural and man-made. These sounds combine to give the continuum of noise against which all acoustic receivers have to detect required signals. Ambient noise is generally made up of three constituent types – wideband continuous noise, tonals, and impulsive noise. Ambient noise covers the whole acoustic spectrum from below 1 Hz to well over 100 kHz (Urick, 1983). Above this frequency, the ambient noise level drops below thermal noise levels.

3.4.1 Natural Sources of Airborne and Waterborne Sound

There are a number of basic mechanisms by which ambient noise is generated from natural sources. All ambient noise sources involve one or more of these basic generation mechanisms.

3.4.1.1 Impact Noise

Impact noise occurs when water strikes water (e.g., breaking waves), water strikes solid (e.g., waves hitting a rock), solid strikes water (e.g., hail hitting the water surface), or solid strikes solid underwater (e.g., sediment noise [saltation]). It is usually a broadband, transient noise, possibly with resonant peaks if solids are involved.

3.4.1.2 Bubble Noise

There are several types of bubbles in seawater. Passive bubbles are quiescent and do not generate noise. Active bubbles are formed during an energetic process such as breaking waves or rain striking the surface. These bubbles oscillate and generate comparatively narrowband signals centered on the resonant frequency of the bubble, typically in the range 15 to 300 kHz. Collective oscillations of bubble clouds, particularly under breaking waves, can have resonant frequencies that are much lower than this.

3.4.1.3 Turbulence

Turbulence associated with surface disturbance or turbulent tidal flow around an obstruction generates low-frequency continuous noise.

3.4.1.4 Seismic

Movement of the seabed can be coupled into the water column and generate very low-frequency noise.

3.4.1.5 Wind-sea Noise

Noise is generated by the interaction between wind and the sea surface. At higher wind speeds, this results in breaking waves that produce noise by impact and bubble mechanisms (Medwin and Beaky, 1989; Medwin and Daniel, 1990). At lower wind speeds, noise results from flow noise as the wind passes over the sea surface and from bubbles entrained at the sea surface. There is likely to be a diurnal and annual cycle in the contribution from wind-sea noise due to changes in meteorological conditions.

3.4.1.6 Precipitation Noise

Precipitation hitting the sea surface generates noise by impacting the sea surface and, in some instances, by oscillation of the bubbles entrained by the impact. Small raindrops generate noise with a spectral peak around 15 kHz due to the entrained bubbles, while large raindrops only generate impact noise. Hail generates a spectrum with a broad peak between 2 and 5 kHz. Heavy snow produces a rising spectrum above 20 kHz. The noise from all forms of precipitation can be modified by increasing winds. In particular, the bubbles formed by small raindrops are less likely to form, so the level of bubble oscillation noise drops significantly as wind speed increases.

3.4.1.7 Surf Noise and Sediment Transport

Noise generation in the surf zone is a highly complex process, but the resulting noise can be heard up to 9 km offshore. The noise results from individual and collective bubble oscillation in the water column, sediment transport in the backwash, splashing, pounding, and turbulence (Voglis and Cook, 1970; Thorne, 1985). The character of noise from surf is dependent on the beach profile, wave direction relative to the beach, and sediment size. If the dominant beach material is cobble, pebble, or gravel, then sediment transport noise will dominate. For small sediment sizes such as sand or clay, bubble noise will dominate. The noise characteristics are further modified by the immediate offshore bathymetry, which will determine the acoustic propagation conditions for the sound out into deeper waters. Sediment transport can also occur away from the shoreline if the water is very shallow (<10 m) and a current is running and/or there is a significant wave height to disturb the seabed.

3.4.1.8 Biological Noise

Many marine organisms can generate noise. Fishes and cetaceans make sounds that contribute to ambient noise levels.

3.4.1.9 Thermal Noise

In the absence of all other sources of noise, thermal noise will dominate. This originates from the thermal agitation of molecules. The noise rises at 6 dB/octave and in a real environment is only important above 100 kHz.

3.4.2 Man-made Sources of Airborne and Waterborne Sound/Noise

There are a number of basic mechanisms by which ambient noise is generated from man-made sources. All of the sources of ambient noise involve one or more of these basic generation mechanisms.

3.4.2.1 Cavitation

Propellers and other fast-moving objects in the water can cause cavitation noise when the pressure in the flow around the moving object goes sufficiently negative. This causes a cavitation bubble that very quickly collapses, causing a loud transient sound. The resulting spectrum is wideband but generally has a peak between 100 Hz and 1 kHz.

3.4.2.2 Machinery Noise

Machinery generally produces a broadband continuous spectrum with tonals superimposed resulting from the rotation rates of the various parts of the machinery. There may also be impulsive sounds.

3.4.2.3 Tonals

Some systems either deliberately, or as a by-product, generate high levels of tonal signals (e.g., sonar systems and seal scarers). Man-made sources of airborne and waterborne sound/noise include various sources, as outlined below.

Aggregate Extraction

The noise resulting from aggregate extraction is made up of three contributions: ship noise, dredge noise, and sediment noise. Dredge noise is that noise from the dredging machinery over and above normal ship noise, while sediment noise results from the movement of the seabed material across the seabed and through the suction tube.

Commercial Shipping and Leisure Craft

Commercial shipping, ferry traffic, and leisure craft also contribute to ambient noise (Wharam et al., 2004). The contribution of commercial shipping to ambient noise has been well studied, particularly in deep water, and the resulting spectra are well understood. The noise spectrum from all powered craft is composed of a low-frequency broadband spectrum with a number of tonal lines resulting from the rotating machinery. Above 1 kHz, machinery noise diminishes and the dominant noise source is caused by water displacement and the resulting entrained bubbles. The noise of distant shipping tends to dominate the 50- to 300-Hz part of the spectrum. Away from the main shipping lanes, a major contribution is likely to come from fishing boats. There are a variety of fishing activities in the study area, ranging from inshore fishing to offshore deepwater trawling. As the fishing boats move around the area, they are likely to provide a significant contribution to shipping noise. Shipping noise will vary on a diurnal cycle (ferry and coastal traffic) and an annual cycle (seasonal activity).

Industrial Noise

Industrial noise can result from a number of offshore activities, including oil and gas production. The military can generate underwater noise by the use of ships, aircraft, explosives, and active sonar transmissions.

Oil and Gas Exploration and Exploitation Activity

Exploitation of oil and gas requires the use of a variety of vessels and offshore equipment, all with the potential to produce sound. Exploration operations may include seismic surveys and exploratory drilling operations. Seismic operations routinely utilize airgun arrays to image the seafloor and shallow and deep structure. Exploration operations require the completion of drilling operations to reach and assess potential reservoirs. Development and production activities typically require installation of a platform, subsea completions, and/or floating production facilities. All structures are then to be removed, either moved off site (e.g., removal of an exploratory drilling rig), toppled in place (for permanent structures, if permitted), or severed at/near the mudline to facilitate structure removal. Severing of conductors and legs is typically completed using explosives. Drilling and dredging rigs produce loud low-frequency noise over a long-term scale. Even when the rig may be idle, visiting supply vessels and transport helicopters are active. In some cases, vessel and helicopter noise sources may be more influence on marine life than the rig itself) so that the noise emitted is continuous (Roussel, 2002).

Sonar

Active sonar generates a high power pulse in the water and then listens for the echo from a desired target to determine range and direction. The most common sonar in use is the echosounder carried by most ships. Other sonars in use include fish finders and fishing gear control sonars, acoustic modems, air guns for seismic geological exploration, and military sonars. The study area is a true deepwater area for acoustic propagation, and seismic surveys can result in basin-scale reverberation.

Aircraft

The noise of fixed wing and rotary wing aircraft can couple into the water, particularly in the case of helicopters operating low over the surface of the water (Urick, 1972).

Fishing Activity

The act of dragging a trawl across the seabed is an inherently noisy operation. Other contributions are from ship noise and fishing sonars.

3.4.2.4 Dominant Noise Sources

Although there is no specific measurement of ambient noise in the study area, the most likely dominant sources of ambient noise across the study area comprising deep, offshore waters will be distant shipping in the absence of wind and precipitation. In addition, the areas affected by different noise contributions likely will vary throughout the year, as acoustic propagation loss varies throughout the seasons. Distant shipping noise is likely to dominate across large parts of the study area. It is also anticipated that under the right conditions, industrial noise (from existing and future offshore oil production installations) could propagate into the study area. It should be noted that just because a particular noise source is dominant in a given area does not necessarily mean that other sources may be neglected in that area: the total noise level from all sources may be significantly higher than the level due to the dominant source alone, different sources may dominate in different parts of the spectrum, and biological receptors may be more sensitive to a less dominant noise source in a different frequency range.

Figure 24 presents a comparative of known ocean noises and their noise levels.

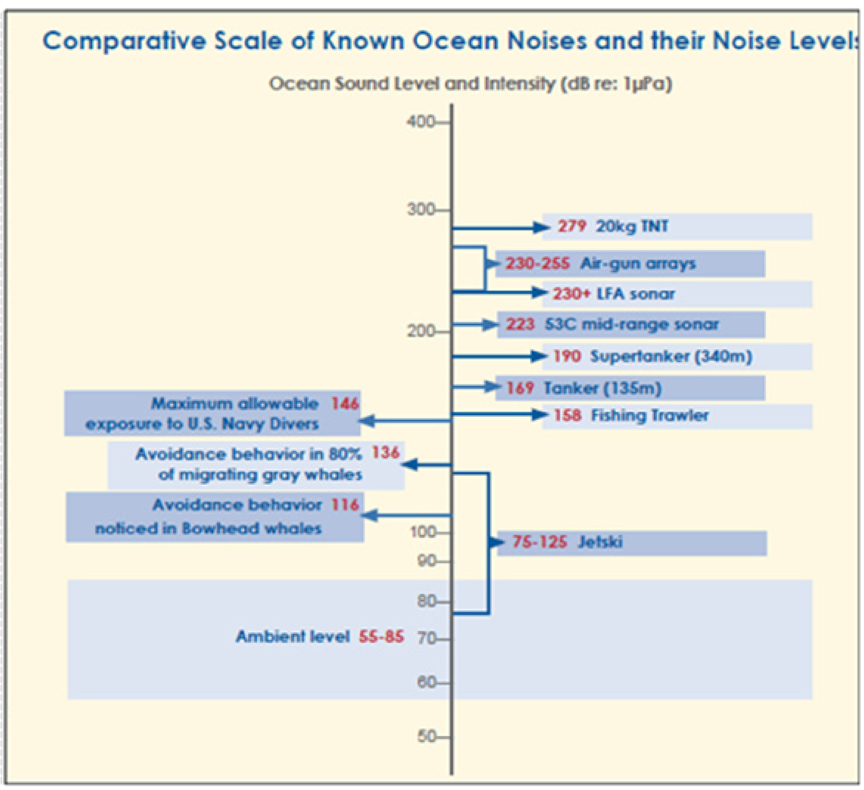


Figure 24. Sound source levels for various offshore anthropogenic noise sources. (LFA = low-frequency active; TNT = trinitrotoluene.)

Galil (2006) broadly characterized the acoustic environment of the Mediterranean and noted that the Eastern Mediterranean region represents 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 has served to significantly increase the volume of shipping traffic, particularly in the Eastern Mediterranean. While shipping noise affects large segments of the world's oceans, noise levels are greatest near well-traveled shipping lanes, straits and canals, and busy ports. According to Galil (2006), the ambient noise in areas of heavy shipping could range between 85 and 95 dB. Supertankers, large bulk carriers, container ships, and cargo vessels produce sound with source levels of approximately 190 dB (Ross, 1976; Richardson et al., 1995; National Research Council (NRC), 2003).

3.4.3 Factors Affecting Ambient Sound/Noise

A number of factors determine the acoustic properties and physics of sound propagation in the ocean. In addition to basin morphology and water depth, the temperature and salinity of the water masses, and pressure and stratification along the sound path are important determinants at which sound is transmitted. Sound speed varies as a function of temperature, salinity, and hydrostatic pressure and the degree of influence of each factor is tied to underlying gradients. Nearer the surface, temperature may vary the most so its influence on sound speed predominates while at depth, pressure changes are more significant, and will influence sound speed to a greater extent.

Given that sound travels five times faster in the water than in the air, this means that a sound will be heard much farther in the water. Moreover, it is well known that the absorption of a sound depends on its frequency as well as the media characteristics. In seawater, a high-frequency sound of 100 kHz looses 36 dB in intensity per km, while the intensity of a medium or low-frequency sound (<1 kHz) does not decrease more than 0.04 dB per km. In this medium, measures of emission intensity are usually made (or inferred) at a distance of one meter from the source. On another side, water masses are numerous and so are their physical characteristics: temperature, salinity, pressure defining their density, turbidity, and so on. Thus, the direction and the distance at which a sound may propagate are likely to vary according to the water masses it goes through, or refracts, or reflects. The combination of all makes sound propagation calculations very complicated (Roussel, 2002).

Mahar (2002) studied the acoustic properties of the Eastern Mediterranean in wintertime and characterized the mean vertical sound speed (MVSS), depth of the sound channel axis, sound speed along the sound channel axis, the range, and the angle of the limiting ray. The location of the sound channel varies within the basin. Generally the sound channel was deeper in the southern part of the Eastern Mediterranean along with higher sound speed. The distribution of the MVSS and also the sound speed along the sound channel axis did not change during winter from year-to-year. The sound channel axis in the Eastern Mediterranean is generally found at depths more than 200 m. This indicates that the sound channel associated with the depth of the Levantine Intermediate Water (LIW). The LIW is sometimes observed in the surface layer and hence the sound channel occurred near or at the surface.

Based on climatological temperature and salinity data, Salon et al. (2003) analyzed the distribution of sound speed in the upper layers of the Mediterranean Sea and reported that propagation is characterized by an upward refraction in winter and an acoustic channel in summer. The seasonal cycle of the Mediterranean and the presence of gyres and fronts create a wide range of spatial and temporal variabilities with relevant differences between the western and eastern basins. Vadov (2004) noted a substantial difference in the long-range sound propagation conditions in the western and eastern parts of the Mediterranean for explosion-generated and tonal sound signals. This difference concerns the vertical sound speed profiles, the time structures of the sound field in the underwater sound channel, the duration of the explosion-generated signal, and the positions of the convergence zones.

3.4.4 Marine Mammals and Noise

The effect of sound on cetaceans in the Mediterranean has received interest of late although much of the research has been conducted in the northwestern parts of the Mediterranean. The presence of whales in the Mediterranean Sea is well documented, with eight species of cetaceans that may potentially be encountered on a regular basis. As a result of this presence and because of a perceived threat to Mediterranean marine mammals by anthropogenic factors, Italy, France, and Monaco created a cetacean sanctuary in the Ligurian Sea in 1999. In 1998, the North Atlantic Treaty Organisation Supreme Allied Commander Atlantic (NATO SACLANT) Undersea Research Centre adopted a marine mammal risk mitigation policy to minimize the impact of the Centre's underwater research activities on marine mammals. At the same time, the Centre initiated a multi-disciplinary research project to understand the presence and absence of cetaceans in the oceanographic context and to improve the knowledge of the affect of active sonar on cetaceans.

In spite of the current state of knowledge and lack of research results, complicated by the inherent difficulties in judging noise effects relative to other threats, several effects of noise on cetaceans have been reported, ranging from local and short disturbance to significant behavioral modifications and mortality. One major problematic issue is quantifying the extent these effects have on cetacean populations.

Current information suggests that anthropogenic noise has the potential to affect cetaceans in a number of ways that reduce fitness at either an individual or population level (e.g., see Simmonds and Dolman, 1999). Noise, either natural or anthropogenic, can adversely affect marine mammals in various ways, including altering behavior, reducing communication ranges or orientation capability, damaging auditory systems (either temporarily or permanently, as in temporary threshold shift or permanent threshold shift [PTS]), producing habitat avoidance, or causing mortality (Richardson et al., 1995; NRC, 2003, 2005; Nowacek et al., 2007; Southall et al., 2007). Noise impacts may also be cumulative, or may be exacerbated by other environmental stressors (Evans and Miller, 2004; Wright, 2008; Racca et al., 2011). Determining the biological significance of noise exposure impacts remains challenging (NRC, 2005), although recent advances in quantifying the effects of noise on marine mammals are evident.

Playback studies have shown that most bowhead whales (*Balaena mysticetus*) avoid drillship or dredging noise with broadband (20 to 1,000 Hz) received levels around 115 dB. In the case of typical drilling and dredging vessels, such levels occur at 3 to 11 km from the source (Richardson et al., 1990). Tolerance of higher noise levels is evident only under conditions where the migration route requires close approach to the sound projector (Richardson and Greene, 1993, in Perry, 1998). It has recently been demonstrated that spatial distribution of bowhead whales was highly correlated to distance from the drilling rig, indicating that the presence of the rig resulted in a significant temporary loss in available habitat (Schick and Urban, 2000). Gray whales reacted in a similar way when 3,500 individuals responded to playback of an oil platform noise (Malme et al., 1983). Avoidance responses began at broadband received levels of 110 dB, and proportions of animals showing avoidance increased with sound intensities, reaching over 80% at received levels >130 dB.

Effects of seismic surveys on cetaceans showed that sperm whales were found to be displaced to a distance of 60 km from a sound source (Mate et al., 1994), with cessation of vocalization at >300 km from relatively weak seismic pulses (Bowles et al., 1994). Malme et al. (1983) reported that 10% of gray whales showed avoidance at 164-dB received level, with 50% of exposed individuals showing avoidance at 170 dB and 90% showing avoidance at 180 dB. Ljungblad et al. (1988) observed initial behavioral changes of bowhead whales more than 8 km away from a seismic source, at received levels of 142 to 157 dB. Common dolphins avoided an area of 1 to 2 km around a sound source (Goold and Fish, 1998, as cited by Goold, 1996). These authors estimated the sound to be audible to dolphins at a distance of at least 8 km. Evans et al. (1993) found a significant decrease in the population of small cetaceans after seismic exploration, although the possibility of seasonal movements cannot be ruled out.

Results of sonar exposure on marine mammals have shown divergent results. For example, a tagged sperm whale (*Physeter macrocephalus*) was exposed to moderate sonar signals. Analysis of the data indicated that no disruption of behavior occurred during sonar exposure up to 120 dB re 1 µPa @ 1 m received level (Zimmer, 2002). Passive acoustic tracking of sperm whales has been conducted in the northwestern part of the Mediterranean Sea using a 128-element towed linear array with real-time beamforming capabilities. The equipment afforded angular separation of sperm whales clicking from different horizontal directions, as well as an enhanced signal-to-noise ratio. Over a total of 279 complete dives, sperm whales were recorded clicking an average of 35 min per dive. The acoustic repertoire heard from diving sperm whales consisted of usual clicks, creaks, codas, and trumpets. Trumpets occurred at the beginning of 45 dives. A total of 131 codas, 98% belonging to the Mediterranean pattern 3+1, was recorded, usually at the end of the dive. In contrast, Miller et al. (2011), evaluating the effects of sonar exposure on beaked, sperm, and long-finned pilot whales, concluded that a large number of changes in behavior were evident. Responses to sonar exposure commonly included indications that tagged whales avoided the sound source or moved away from the path of the source vessel. Changes in diving and surfacing behavior also occurred in some cases, but details of how diving behavior may have changed differed by species. Similar conclusions hold for changes in acoustic behavior when playback of killer whale sounds was conducted. The killer whale playback exposure provided a biologically-relevant acoustic signal against which changes during sonar exposure can be compared. Changes in behavior during playbacks of killer whale sounds were striking and clear for pilot whales and sperm whales, but little change in behavior was observed when killer whale sounds were presented to killer whales themselves (Miller et al., 2011).

3.5 OCEANOGRAPHY AND HYDROGRAPHY

The following discussion of general circulation and oceanography of the Mediterranean was derived from Robinson et al. (2001). Although the Mediterranean Sea is typically viewed as a mid-latitude semi-enclosed sea it is also considered to be a nearly isolated oceanic system. The oceanographic processes that occur in the world's oceans, particularly the patterns of general circulation, are also evident in the Mediterranean. Waters of the Mediterranean exchange water masses, salt, heat, and other properties with the North Atlantic Ocean through the Straits of Gibraltar and, to a limited extent, with the Red Sea through the Suez Canal.

The North Atlantic is the major site for deep- and bottom-water formation for the global thermohaline cell (conveyor belt), which encompasses the Atlantic, Southern, Indian, and Pacific Oceans. The North Atlantic is critical to global thermohaline circulation. By comparison, water masses within the Mediterranean water masses may also affect various oceanographic processes; it has been suggested that the stability of the global thermohaline equilibrium may be affected by what occurs in the Mediterranean (Robinson et al., 2001). As depicted in **Figures 25** and **26**, the Mediterranean Sea can be divided into three basins:

- Western Basin comprising the region west of Sicily containing the Alboran, Balearic, Ligurian, and Tyrrhenian Seas;
- Central Basin containing the Adriatic and lonian Seas; and
- Eastern Basin containing the Aegean Sea and the Levantine Basin (separated from the Central Basin by the Sea of Crete and the Cretan Straits).

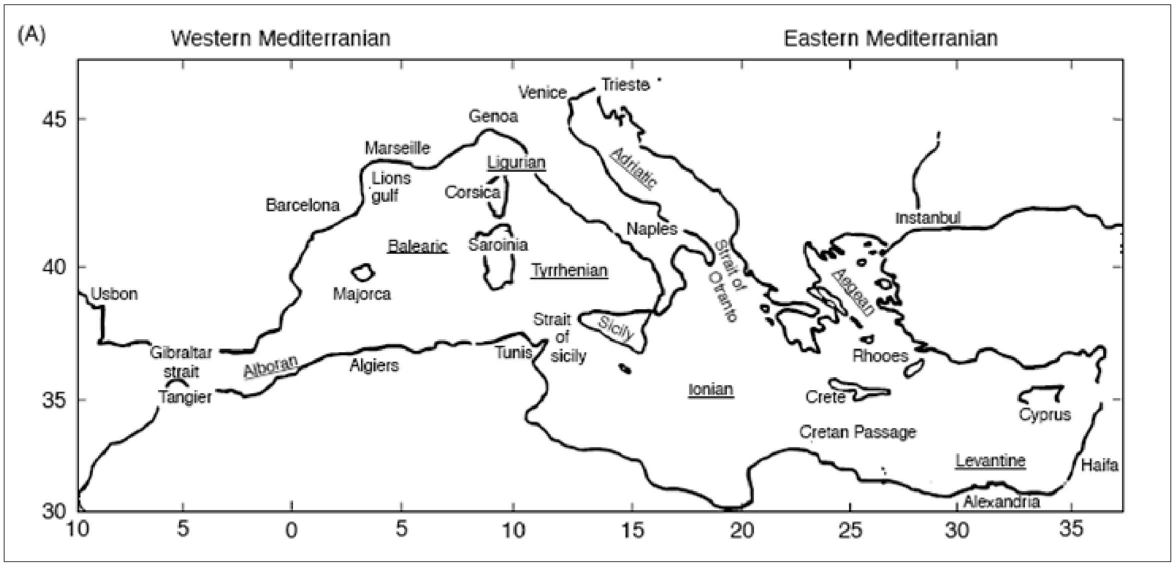


Figure 25. The Mediterranean Sea and its major basins and subseas (From: Robinson et al., 2001).

The oceanography of the Eastern Basin, particularly the physical and chemical oceanography of the smaller Levantine Basin within it, is driven in part and closely tied to circulation within the entire Mediterranean. Understanding the physiography (basin configuration, size, shape, and bathymetry) of the Mediterranean is important in describing the oceanography of the Levantine Basin. **Figure 26** shows the general bathymetry of the Mediterranean.

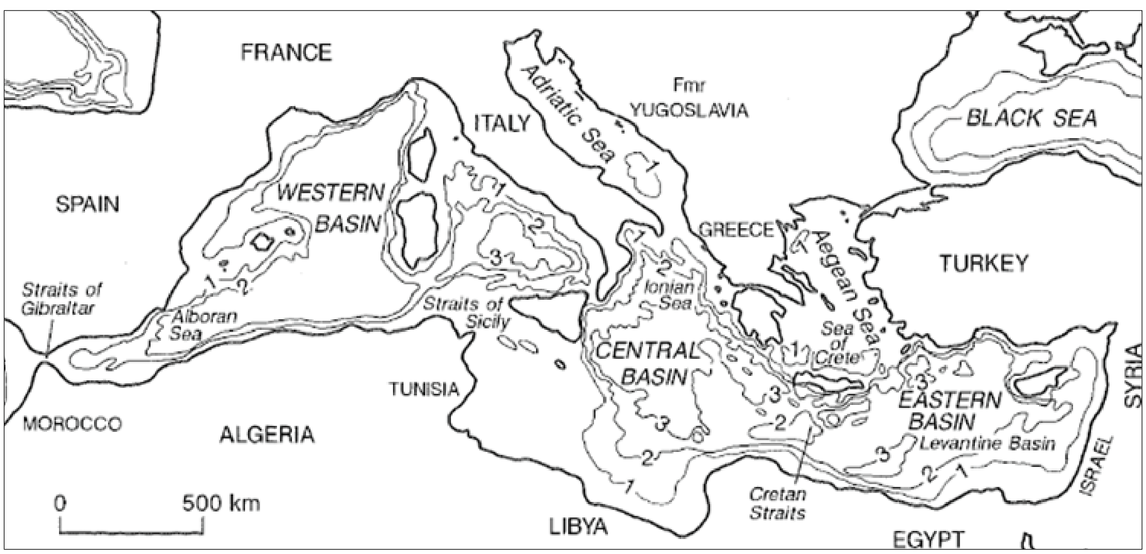


Figure 26. General bathymetry of the Mediterranean Sea and its major basins and subseas (From: Krom, 1995).

3.5.1 Major Mediterranean Water Mass Flows

The Atlantic Ocean provides the only significant input of 'new' seawater into the Eastern Mediterranean. High salinity seawater is also introduced into the Eastern Mediterranean via Suez Canal outflow, although the relative contribution of this source is extremely small. Atlantic Water (AW) is characteristically of lower salinity relative to the Mediterranean waters. Atlantic Water enters the Mediterranean through the straits of Gibraltar at the surface (**Figure 27**). Part of the AW reaches the eastern Basin by flowing eastward approximately along the north coast of Africa at a depth below the summer mixed layer. Levantine Deep Water (LDW) is the other major water mass (originating from the Adriatic Sea with a characteristic salinity of 38.7 (psu) and a temperature of ~13.5°C flowing into the Eastern Basin.

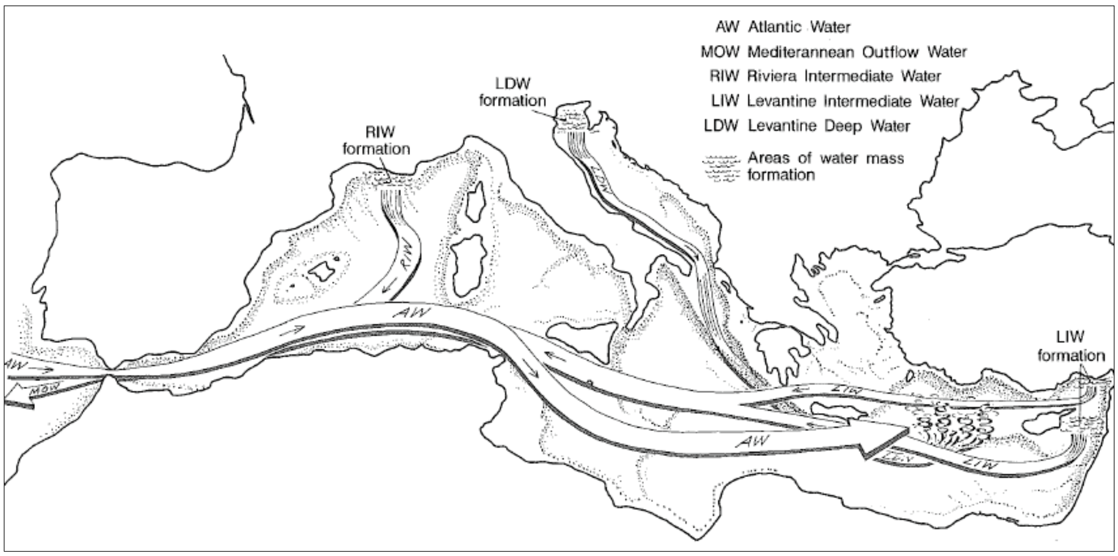


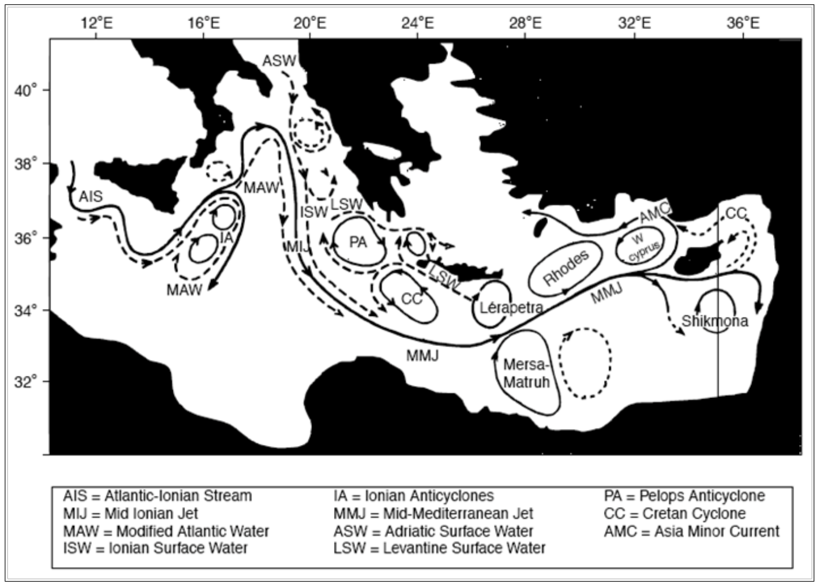
Figure 27. Schematic diagram showing the areas of formation and the main flow patterns of the major water masses in the Mediterranean Sea (From: Krom, 1995).

LDW is formed in winter in the northern Adriatic by cooling and evaporation under the influence of cold dry winds. After sinking, it flows as a relatively narrow jet of water along the western side of the Adriatic and out into the Eastern Mediterranean where it makes up the deep water in the Levantine Basin. Roether et al. (1996) has estimated, on the basis of tritium and Freon measurements, that LDW has a residence time of 50 to 100 years before it is mixed with intermediate water and flows out of the basin.

The Levantine Basin is the principal site for the formation of LIW whose characteristic temperature and salinity are 15°C and 39 psu, respectively. This is an important water mass: having formed in the Eastern Mediterranean, it flows at intermediate depths across the Central Basin and out through the Straits of Sicily, joining with Riviera Levantine Deep Water lntermediate Water (RIW), and eventually becoming the major component of Mediterranean Outflow Water (MOW). It has been suggested that LIW forms mainly in the northern part of the Eastern Basin, south of the Turkish coast; also that its formation may be connected with the eddies and gyres present in the area.

Figure 28a depicts the general circulation pattern in the Mediterranean showing the principal eddies and jets in the region. Circulation occurs in a three-dimensional pattern, as reflected in **Figure 28b**.

a)



b)

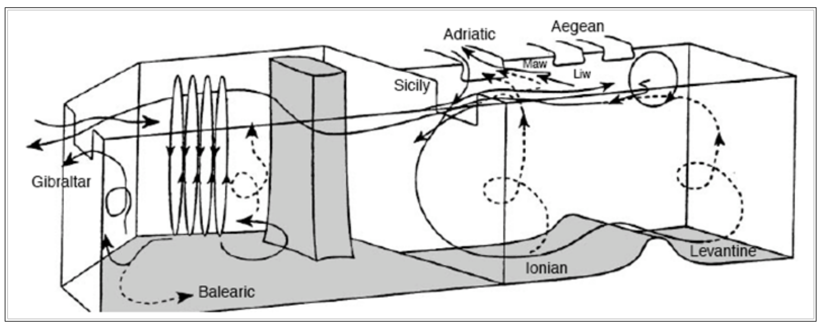


Figure 28. a) General circulation pattern in the Eastern Mediterranean showing the principal eddies and jets in the region; the Mid-Mediterranean Jet (MMJ) is the principal carrier of Atlantic Water into the Eastern Basin; b) system of interconnected gyres in the Mediterranean is depicted in this schematic of three-dimensional circulation among Mediterranean basins (From: Robinson et al., 2001).

3.5.2 Tides and Currents

3.5.2.1 Tides

Tides in the Eastern Mediterranean are in the range of 0.3 to 0.4 m peak-to-peak, with tidal fluctuations along the Israeli coast in the range of 0.4 m (Rilov et al., 2004). Open ocean tides from a tidal model are of similar magnitude. One report presents results for numerical modeling of tidal constituents with data assimilation from tide gauges. For the Levantine Basin, tides are purely astronomically driven (not affected by other ocean basins) and the co-amplitude summed over the first eight constituents is about 30 cm (Kantha et al., 1994).

The dominant frequency is the M2 tidal signal, of which the co-amplitude is shown in **Figure 29** (Kantha et al., 1994). The current associated with this frequency was shown by the same author to be 0.01 m/s in a purely east-west direction for the Levantine Basin.

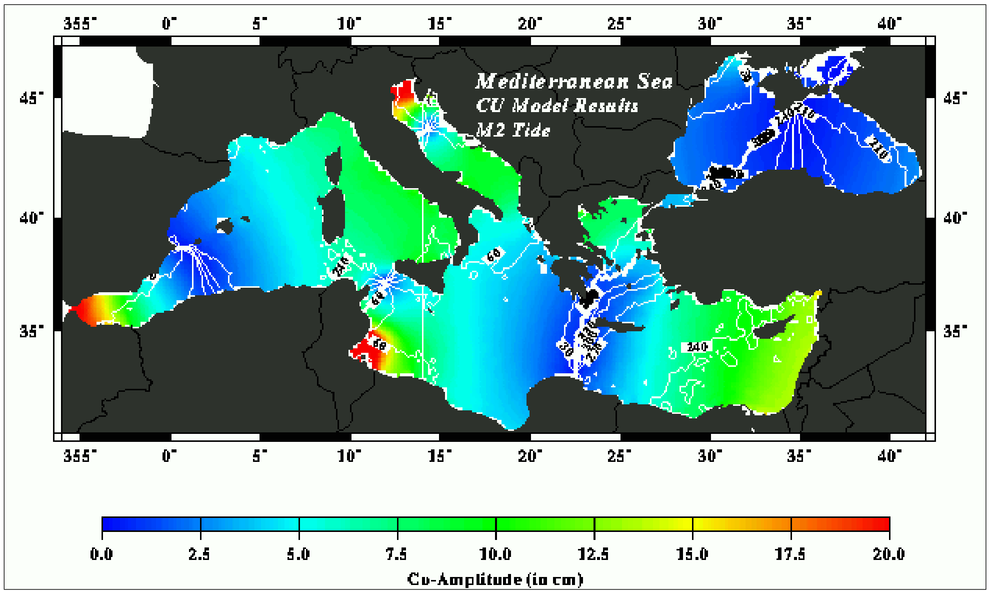


Figure 29. Model prediction for the co-amplitude of the M2 tidal signal in the Mediterranean Sea. In the Levantine Basin, the amplitude is about 0.12 m. Note that another seven constituents have been calculated and their amplitudes sum to about 0.3 m (out of phase) (From: Kantha et al., 1994).

ASL Environmental Sciences Inc. (2009) prepared a desk-top analysis of metocean datasets for the Michal and Matan Blocks (i.e., Tamar and Dalit Fields and potential pipeline corridors connecting the two well prospects with landfall locations along the Israeli coastline from Ashdod to Dor. Relevant summaries of wave, wind, ocean current, and other metocean datasets from the development area were assembled. For the Tamar area, the 1-year and 100-year significant wave height (Hs) values were determined to be 5.1 and 8.2 m, respectively, with associated peak period values of 11.5 and 14.4 s. ASL Environmental Sciences Inc. (2009) also noted that the water level variation in the study area is small due to the small astronomical tides in the Levantine Basin region. Tides usually vary between 0.4 m during spring tides and 0.15 m during neap tides (Rosen, 2001). However, large wind events result in longer period storm surge changes in water levels with changes of up to 0.9 m under extreme conditions. Other factors also affect water levels including steric effects from the warming (expansion) and cooling (contraction) of seawater and from vertical movement of the seabed.

3.5.2.2 Currents

The Levantine Basin is bounded by the Cretan Passage and the Africa, Middle East, and Asia Minor coasts. There are four major water masses in the LIW, AW, Levantine Surface Water (LSW), and Eastern Mediterranean Deep Water (EMDW). The mean properties and main characteristics of the water masses of the southeastern Levantine are discussed in Hecht et al. (1988), Zodiatis et al. (1998), and Lascaratos et al. (1999).

Most oceanographers are of the opinion that the majority of the dynamic activity and subsequent variability of water masses occurs in the upper 500 m. Data for deeper layers is less prevalent. In spite of this, researchers have recently documented a series of interesting transient changes in the deep basins. The Eastern Mediterranean deep water has formed for decades to perhaps centuries in the Adriatic Sea (Pollak, 1951; Roether and Schlitzer, 1991; Schlitzer et al., 1991). It does not communicate with the adjacent deep waters of the Western Mediterranean because of the shallow sill in the Straits of Sicily.

Sometime between the *Meteor* cruises in 1987 and 1995, the Eastern Mediterranean thermohaline circulation experienced a switch of deep water source from the Adriatic to the Aegean, which consequently altered the EMDW from a 13.38°C, 38.66 psu water mass (Schlitzer et al., 1991) to a warmer and saltier (13.88°C, 38.8 psu) water mass (Roether et al., 1996; Klein et al., 1999).

The potential density (σ_θ) of the EMDW also increased from below 29.18 to above 29.2. This change is too large to be accounted for by a change in surface evaporation or precipitation alone (Roether et al., 1996), and turns out to be related to a small change in surface buoyancy loss in combination with a number of extreme winters over the Aegean that resulted in the diversion of LIW from the Adriatic to the Aegean (Wu et al., 2000). Thus, the Aegean could be more productive as a deep-water formation site. The wider effects on the thermohaline circulation of the Eastern Mediterranean remain to be seen. It has been observed (Hainbucher et al., 2006) that deep water formation has returned to the Adriatic as of 2003, but in 2006, the deep water was seen to exhibit yet another set of temperature-salinity (T-S) properties never before observed (Rubino and Hainbucher, 2007).

Lawrence et al. (2011) conducted a metocean study offshore Israel measuring bottom currents at various locations in and near the Tamar Field, along the pipeline route, and near the Mari-B and Tamar Platform locations to determine current speed, direction, and potential seasonal trends. A total of 11 near-bottom current meter deployments, and multiple near surface deployments at a single Tamar location, were conducted between 2009 and 2011. Individual current meter deployments ranged from four to 11 months in duration.

At the Tamar location at a water depth of 1,688 m, the maximum near-bottom current speed of 8.7 cm/s was measured in July 2010, although mean current speeds did not exceed 3.5 cm/s over the period December 2009 through mid-July 2011. Currents at this site and depth are not highly directional, though there is a slight bias to currents from the southwest. A compass rose plot of the directional distribution of currents in the Tamar Field is shown in **Figure 30**.

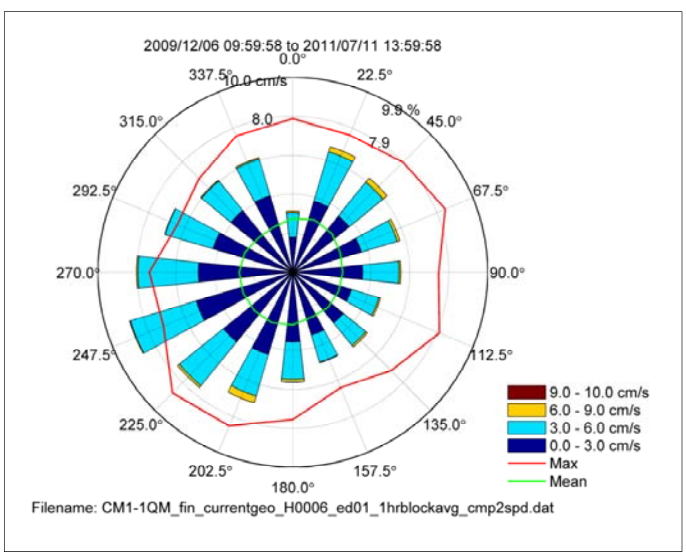


Figure 30. Compass rose plot of the directional distribution of near-bottom currents in the Tamar Field (From: Lawrence et al., 2011).

Currents in the upper water column at the Tamar location were dominated by episodes of strong flow, particularly in the winter. For example, the maximum recorded current speeds at 25-m depth were 53.6 cm/s and 52.8 cm/s, recorded in January 2011 and March 2010, respectively. Lawrence et al. (2011) note that mean current speeds at 25-m depth could be as large as 25 cm/s.

Lower maximum current speeds deeper in the water column were noted at the Tamar location. At 73-m depth, the maximum current speed was 49.1 cm/s, measured in April 2011; mean current speeds at this depth could be as large as 22 cm/s. At 121 m depth, the maximum current speed was 41.5 cm/s as measured in March 2010; mean currents could be as large as 17 cm/s. At 233-m depth, the maximum current speed was 25.8 cm/s in January 2011. Dominant flow direction at the near-surface Tamar location is towards the southwest.

Lawrence et al. (2011) note that mean monthly near-bottom current speeds tended to increase with decreasing depth. With current meter deployments generally following the pipeline corridor, overall maximum current speeds at 1,371 m, 935 m, and 615 m (the latter depth near the Mari-B and Tamar Platform locations) were recorded as 9 cm/s (January), 13 cm/s (April), and 26 cm/s (March), respectively.

3.5.2.3 General Circulation

The Levantine Basin circulation was first depicted in the early 20th century by Nielsen (1912), who described a surface circulation bound to the coast and following a counter-clockwise (cyclonic) path around the basin. Later work by Ovchinnikov et al. (1976) based on hydrographic sampling suggested a system of counter-rotating gyres in the interior of the peripheral cyclonic flow. The flow was reported to be stronger in winter. A similar peripheral flow was identified by Lacombe and Tchernia (1972), with a bifurcation of one branch off the Libyan coast northeastwards towards Cyprus.

In the 1980's, knowledge of the system of gyres and currents of the Levantine Basin increased dramatically with the Physical Oceanography of the Eastern Mediterranean (POEM) cruises (Ozsoy et al., 1989, 1991, 1993; Robinson et al., 1991, 1992; POEM Group, 1992). One gyre (known as the Shikmona gyre system) was identified south of Cyprus: a clockwise (anticyclonic) flow bounded to the north by an eastward flowing current carrying fresher, cooler AW (**Figure 31**).

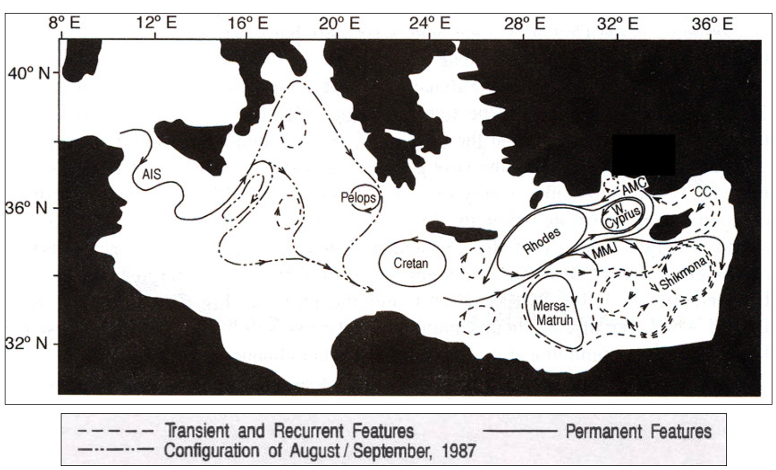


Figure 31. Levantine Basin general circulation as depicted during the 1980's, consisting of a mesoscale flow structure with anticyclonic eddy activity south of Cyprus and the Mid-Mediterranean Jet (MMJ) meandering eastward transferring the Atlantic Water (AW) (From: POEM Group, 1992).

In this currently accepted scheme, AW enters the Levantine Basin through the Cretan Passage and then follows the coast as the North African Current before detaching and flowing northward and eastward towards Cyprus as the Central Levantine Basin Current (Ozsoy et al., 1989), also known as the Mid-Mediterranean Jet (MMJ) (Robinson et al., 1991). The Rhodes Gyre, rotating in the opposite direction, was identified on the northern side of this near-surface current. A second anticyclonic system was observed south of Cyprus, but farther to the west than the Mersa Matruh gyre. Seasonal differences between summer and winter regimes were noted, specifically that anticyclonic activity south of Cyprus generally weakened in the winter, except perhaps near Cyprus' eastern coast (Ozsoy et al., 1989).

It was also noted in these first two POEM cruises that cyclonic gyre intensity lessened with depth while anticyclonic intensity tended to increase with depth (Ozsoy et al., 1989). The key conclusion, however, was that the Levantine Basin is a dynamic, evolving region, with some persistent features and a rich, interacting mesoscale eddy field. Robinson et al. (1991) went one step further to classify a number of features of the dynamically active upper thermocline as permanent (MMJ, Mersa Matruh gyre), recurrent (Shikmona gyre), or transient (southeast Levantine jets and eddies).

Since POEM, a number of studies have elucidated more details on the structure and variability of the Levantine Basin. In general, they support the schematic structure set out by the POEM studies, even if they further emphasize the spatial variability and transient nature of the features described. Some notable exceptions exist in which the historical view of the AW tightly hugging the periphery of the Levantine Basin is promoted (Hamad et al., 2005; Millot, 2005; Millot and Taupier-Letage, 2005). These studies tend not to be based on *in situ* salinity measurements, which would provide direct information on the origin of the observed water mass; however, even these studies recognize the instability of such a current and the resulting field of mesoscale eddies in the basin interior. For example, expendable bathythermograph (XBT) observations made during the Mediterranean Forecast System (MFS) programme confirmed the persistence of the sub-basin anticyclonic gyres in the southern part of the basin but did not find definitive evidence of the MMJ (Fusco et al., 2003). Atlantic Water has also been observed to continue along the African coast, based on satellite observations (Ayoub et al., 1998; Hamad et al., 2005). Remotely sensed sea surface temperatures (SST) can aid in interpreting coarse resolution datasets, however (e.g., main features of the POEM schematic are often visible [**Figure 32**]).

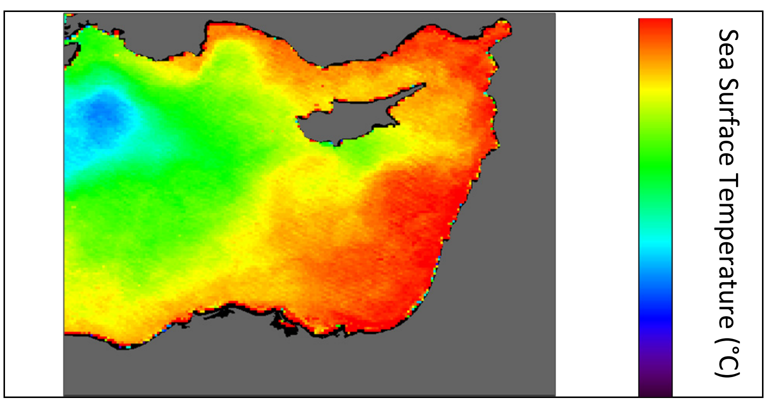


Figure 32. Average sea surface temperature for 2006 in the Eastern Mediterranean as measured by the NOAA AVHRR satellites. Suggestions of the cool center of the Rhodes Gyre west of Cyprus (anti-clockwise) can be seen as well as an anticyclonic eddy (or two) south of Cyprus and the Mid-Mediterranean Jet (MMJ) meandering between the two from southwest to northeast south of Cyprus.

The spatial and temporal variations of the dominating dynamic flow features of the southeast Levantine Basin are illustrated in three schematics of circulation shown in **Figure 33**. The schematics characterize three periods: 1995-1999, 2000-2001, and summer 2001-2003 (Zodiatis et al., 2004). **Figure 33a** shows the Cyprus warm-core eddy as located east of the meridian of 33° E, while **Figure 33b** shows the significant westward shift (about 60 to 80 nmi) of the Cyprus warm-core eddy at the end of 2000 to early 2001. Finally, **Figure 33c** shows the re-establishment of the Shikmona gyre that constituted from warm-core eddies, similar to those found during the 1980s by POEM cruises.

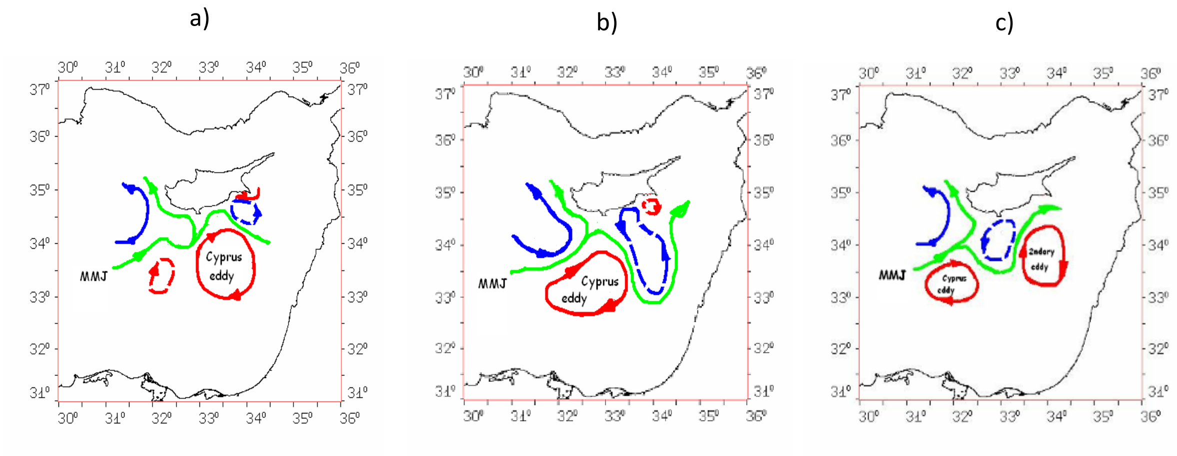


Figure 33. Schematics of the dominated general circulation in the upper 200 m in the Southeast Levantine, based on CYBO and CYCLOPS cruises for the periods a) 1995-1999, b) 2000-2001, and c) summer 2001-2003.

Improved observation programs such as the ongoing autonomous ocean glider project (Hayes et al., 2008) will contribute to knowledge of the general circulation. However, numerical models are becoming increasingly important in covering large areas and time scales simply not possible with observations. In particular, the spatial distribution of ocean currents is difficult to observe instantaneously or in a quasi-synoptic period, especially over wide open deep-sea areas. This type of analysis can be extended to include any desired region or period of interest for the Levantine Basin. Many models have already been used to understand the general circulation in the Mediterranean (Malanotte-Rizzolli and Bergamasco, 1991; Zavatarelli and Mellor, 1995; Wu and Haines, 1998; Zodiatis et al., 2003, 2008). For example, in a study focused on the Levantine seasonal circulation, Alhammoud et al. (2005) found that during summer, the cyclonic coastal circulation gets weaker and the basin interior is dominated by detached coastal current eddies and other meanders and that the eddies in the Mersa-Matruh and Shikmona areas vary greatly in extent, shape, strength, and position from winter to summer.

Zodiatis et al. (2008) have shown favourable comparisons between *in situ* and forecast fields for the Levantine Basin north of 33°N. These results improve knowledge of the relevant physical processes, especially their evolution over weeks, months, and years. The present forecasting ability has been shown to be adequate for a number of applications from search and rescue to oil spill trajectories (Zodiatis et al., 2007).

Direct current measurements, coupled with wind data and integrated into numerical modeling, were summarized for the southeastern continental shelf and slope off Israel by Rosentraub and Brenner (2007). The authors presented the results of a 10-year dataset of concurrent cross-shelf hydrographic transects and coastal wind measurements. Results were presented within the context of the general circulation of the Levantine Basin as simulated with a numerical model. The circulation over the shelf is northward throughout the year with strong seasonal variability; maximum currents are evident in winter and summer. In summer, the strong currents are confined to the upper layer with seaward intensification. Over the slope, a seasonally varying along-slope baroclinic jet also appears during summer and early winter. The shelf and slope current system is part of the general circulation of the Levantine Basin composed of the bifurcating Atlantic Ionian Stream, the Mid-Mediterranean Jet, and the cyclonic basin-wide current that follows the coast. During winter storms, the strong southwesterly winds drive the northward flowing current and downwelling over the shelf. At this time the deeper level currents near the shelf break are also intensified. The alongshore synoptic currents are weakly coherent and strongly affected by the alongshore pressure gradient. In late winter the slope jet remains offshore and does not intrude over the narrow shelf. Both the measurements and the simulations confirmed the strong seasonality and variability of the shelf and slope current system and suggested the potential for intense shelf-open sea exchanges in this region.

Brenner et al. (2007) also developed pre-operational ocean forecast results for the southeastern Mediterranean, addressing the importance of atmospheric forcing mechanisms. Rohling et al. (2009) also provided an update of historical and current characterizations of the local oceanographic processes off Israel.

3.5.3 Waves

Wave heights in the region are generally lower than in the large ocean basins because storms are typically weaker in the region. The Cyprus Oceanography Centre, within the framework of Cyprus Coastal Ocean Forecasting and Observation System (CYCOFOS), runs an operational wave model (3-hourly output, 1/16-degree resolution, daily forecast for 96 hours) that can be used to estimate wave statistics at a point or points in the Mediterranean and the Levantine Basin (**Figure 34**) based on the SKIRON wind fields. While actual wave measurements are preferred, these require significant infrastructure to achieve in the open sea and are presently not available in the Levantine Basin.

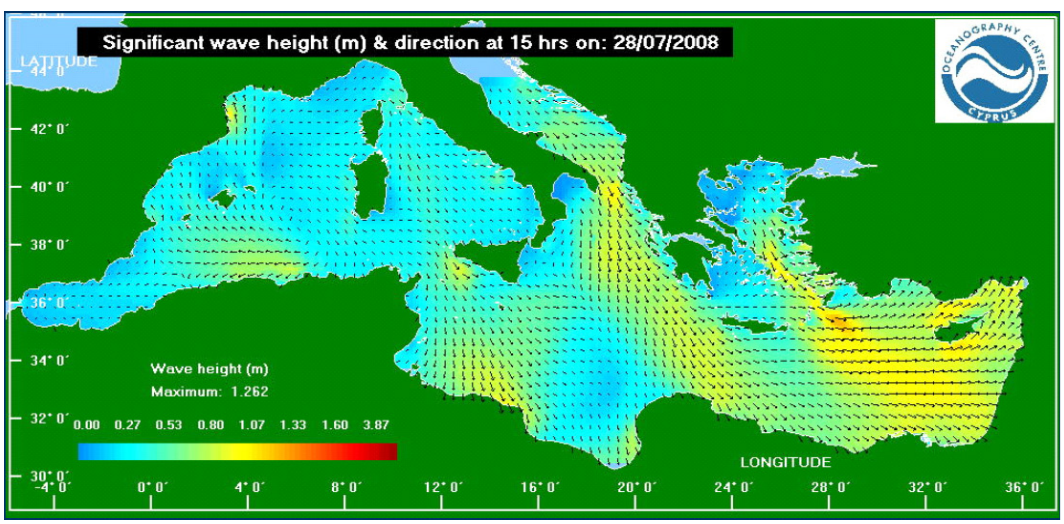


Figure 34. Example of the 3-hourly wave forecasts in the Mediterranean provided by the Cyprus Coastal Ocean Forecasting and Observation System (CYCOFOS) system, using the SKIRON wind fields at 15:00 Greenwich Mean Time (GMT) on 28 July 2008.

Table 14 presents significant wave height distribution for a point near the CYCOFOS MedGoos-3 buoy (lat. 33°42' N, long. 32°08' E; within the Cyprus Exclusive Economic Zone [EEZ]), extracted for the period of July 2005 to February 2008. Nearly all of the waves are less than 1.5 m in height.

Table 14. Significant wave heights and their frequency of occurrence at an open ocean point west of the Eratosthenes Seamount from July 2005 to February 2008.

Wave Height Range[1] (m)	Number of Occurrences	Frequency of Occurrence (%)
0-0.2500	91	1.5230
0.5000	1,132	18.9456
0.7500	2,183	36.5356
1.0000	1,388	23.2301
1.2500	565	9.4561
1.5000	261	4.3682
1.7500	140	2.3431
2.0000	69	1.1548
2.2500	52	0.8703
2.5000	21	0.3515
2.7500	14	0.2343
3.0000	10	0.1674
3.2500	11	0.1841
3.5000	4	0.0669
3.7500	7	0.1172
4.0000	11	0.1841
4.2500	9	0.1506
4.5000	6	0.1004
4.7500	1	0.0167
Total	5,975	100%

[1] Upper limit of bin.

Wave direction is also available and is nearly always due eastward at this location (mean of 116°T, standard deviation of 53°) because of the strong westerly winds. While wave height and direction vary across the basin on a given day, these yearly statistics can be regarded as representative values for the entire basin (**Figure 35**).

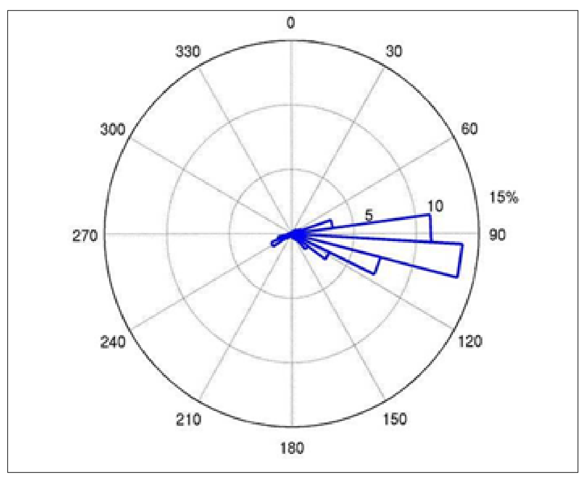


Figure 35. Rose diagram for annual frequency of wave direction. Most of the time, waves typically travel towards the east.

In the southeastern Levantine, several researchers have characterized the wave regimes present near the coasts of Egypt and Israel. Golik and Rosen (1999) characterized wave properties as part of their assessment of Israel's coastal sand resources and bathymetric changes resulting from coastal structures and their effects on sediment transport. Perlin and Kit (1999) also characterized longshore sediment transport along the Israeli coast. As part of the feasibility analysis for offshore artificial island construction, Rosen (2000, 2002) addressed the environmental and sedimentological state of the Israeli coast, evaluated long term remedial measures associated with sediment-related impacts, and provided detailed data regarding the wave climate along the Israeli coastline. Kunitsa et al. (2005) estimated winter currents and their effects along the Israeli continental shelf, addressing modeling of nearshore currents and integrating the contributions of wave-induced nearshore sediment transport. In a site-specific analysis, Zviely (2006) characterized the sedimentological processes operating in Haifa Bay.

Farther south, Frihy et al. (2008, 2010) have provided details of wave climate, seasonal variability, and nearshore processes along the Mediterranean coast of Egypt. Nafaa (1995) also characterized the wave climate along the Nile delta coast.

3.6 PHYSICAL CHARACTERISTICS

3.6.1 Temperature/Sea Surface Temperature and Salinity

Characteristic temperature and salinity measurements of the main water masses present near the Matan and Dalit Fields at depth are shown in **Figure 36**.

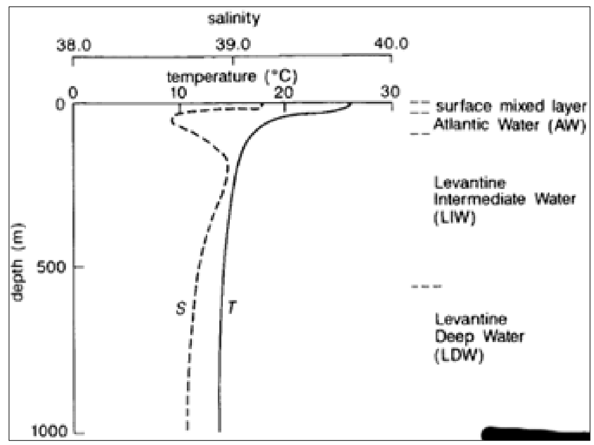


Figure 36. Characteristic temperature and salinity of main water masses at depth.

Figure 37 shows salinity and temperature profiles and diagrams from a summer cruise in 2005 for a location southwest of Cyprus. A thin surface layer (approximately 40 m) of very warm and salty water (up to 27°C and 39.5 psu) is visible, a result of extensive evaporation and intense solar radiation during the summer season. In winter (November to March), winds and convective mixing processes homogenize the water column from the surface downward to subsurface and intermediate layers, in some cases even down to 200 to 350 m (Zodiatis et al., 2001).

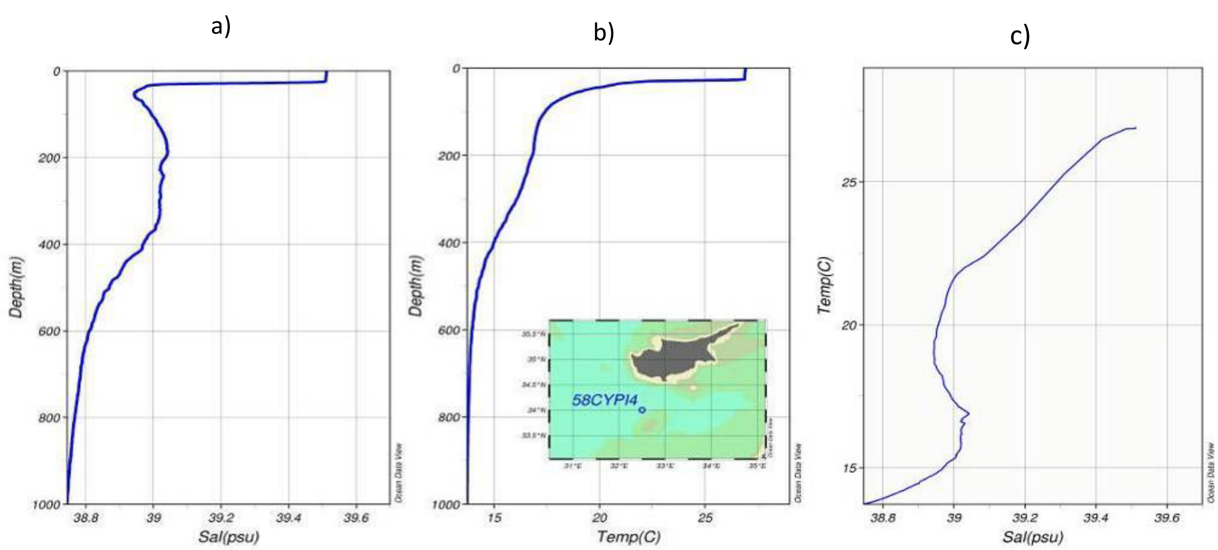


Figure 37. *In-situ* a) salinity and b) temperature profile data in September 2005 (Cyprus Oceanography Centre Cruise CYBO-19); c) temperature-salinity diagram. Water masses are Levantine Surface Water (LSW), Atlantic Water (AW), Levantine Intermediate Water (LIW), and Eastern Mediterranean Deep Water (EMDW).

Surface salinity and temperature throughout the year range from approximately 39.0 to 39.5 psu and 17°C to 28°C, respectively, based on remote sensing averages of temperature over the Levantine and upper 10-m averages of temperature and salinity from cruises (Samuel-Rhoads et al., 2008) (**Figure 38**).

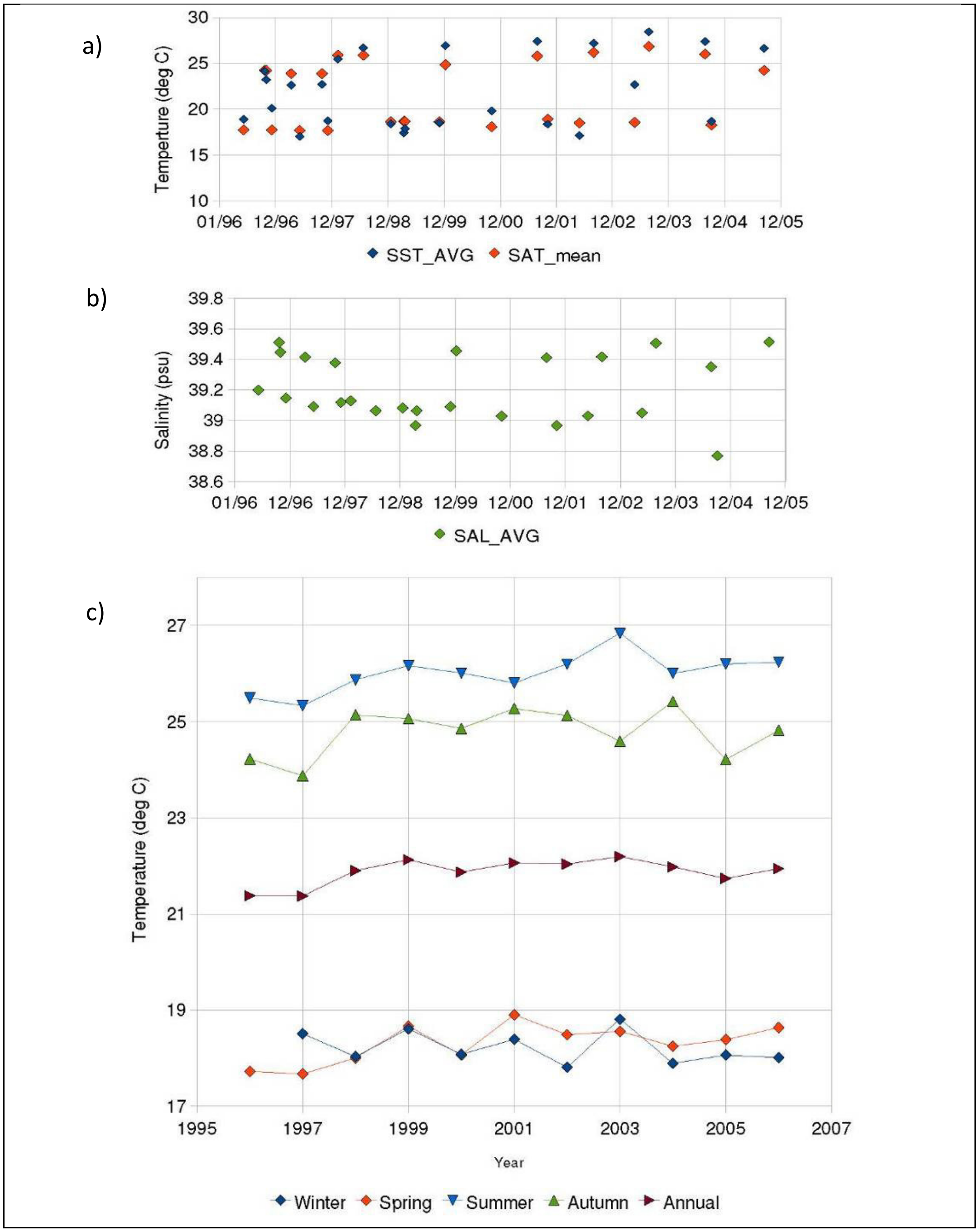


Figure 38. Measurements of a) mean surface temperature from the National Oceanic and Atmospheric Administration 2006 (NOAA AVHRR) satellites calculated over the Mediterranean east of 28° E (orange) and from Cyprus Oceanography Centre cruises (blue); b) salinity averages from Cyprus Oceanography Centre cruises; c) seasonal and annual means of surface temperature from the NOAA AVHRR satellite data (east of 28° E).

The annual cycle of surface water properties can also be seen by examining a time series of upper ocean temperature and salinity. **Figure 39** shows that near-surface (17 m) temperature peaks in late July and has a minimum in mid-February. The deeper sensors show that from April to October, the upper 38 m are stratified (because of surface heating), while for the remainder of the year the sea is well-mixed over these depths (because of winds and surface evaporation).

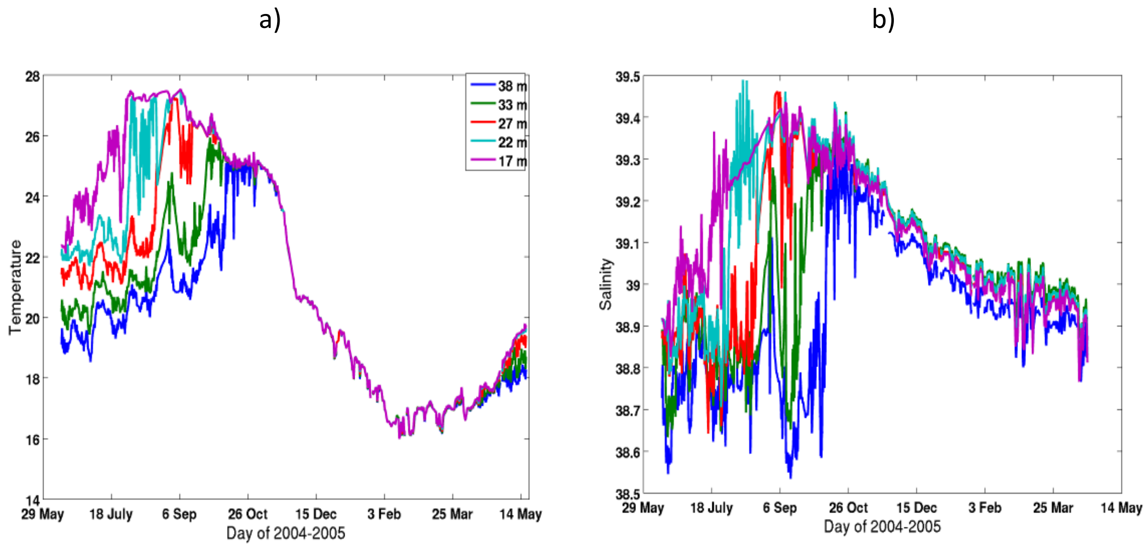


Figure 39. Determinations of a) temperature and b) salinity measured at five depths in the top 38 m at the Coastal Ocean Forecasting and Observation System (CYCOFOS) MedGOOS-3 observatory located just west of the Eratosthenes Seamount. During the winter, all five levels report nearly the same water properties, while during the summer, stratification develops.

In some regions, a meandering jet can be found below the surface mixed layer transferring water of AW origin, identified by a salinity minimum, from the Strait of Gibraltar to the Cretan Passage and into the Levantine (Lacombe and Tchernia, 1960; Oren, 1971; Morcos, 1972). There the AW is most often well pronounced as a subsurface layer with minimum salinity spanning 40 to 80 m and ranging from 38.60 to 38.95 psu (Ovchinnikov et al., 1976; Hecht et al., 1988; Ozsoy et al., 1991). However, surface AW also has periodically been found in the western part of the Levantine with similar salinity values. AW is more often found in summer because in winter, vertical mixing often reaches deeper than its vertical extent. The relatively warm and saline LIW is found from about 200 to 400 m and is the result of winter cooling and sinking of LSW at various locations, including the primary source of the Rhodes Gyre and northern Levantine (Morcos, 1972). Levantine Intermediate Water has a salinity of about 39.0 to 39.1 psu and temperature of 15°C to 16°C, and it is recognized as a subsurface salinity maximum. The LIW spreads from the Levantine Basin throughout the Mediterranean and finally exits from the Strait of Gibraltar into the northeast Atlantic Ocean. Atlantic Water is distributed sparsely as a jet intertwined in a field of propagating and interacting eddies where the more widespread, but patchy LIW is found. Both the AW and LIW are closely tied to the general circulation.

3.6.2 Water Quality

3.6.2.1 Nearshore Water Quality

Water quality in Israel's nearshore and coastal waters (Mediterranean and Red Sea) is well documented and data are readily available. The Israel Ministry of the Environment is responsible for Israel's National Monitoring Program for the Mediterranean Sea, conducted by Israel Oceanographic and Limnological Research Ltd., with guidance from the Ministry's Marine and Coastal Environment Division. The monitoring program, first initiated in the mid-1970s, was one of the first to be implemented in the Mediterranean Sea Basin. The monitoring program generates data that are provided to the Programme for the Assessment and Control of Pollution in the Mediterranean region (MEDPOL) under a Memorandum of Understanding signed in 2004 (Israel Marine Data Center , 2009). The overall objective of the program is to provide a scientific basis for decision-making with regard to protection of the coastal environment, including enforcement of relevant national legislation and international conventions. The program includes the following components:

- Monitoring of heavy metals in coastal waters, implemented in 1978;
- Monitoring of nutrients and particulate metals introduced into coastal waters through coastal rivers, implemented in 1990;
- Monitoring of atmospheric fluxes of nutrients and heavy metals into coastal waters, implemented in 1996;
- Monitoring of nutrient levels and algal populations in the shallow area of the coastal waters, implemented in 2000;
- Monitoring of benthic communities along the coastline, implemented in 2005;
- Monitoring of the biological effects of pollution on the sea (i.e., biomarkers), implemented in 2005;
- Environmental mapping of the coastal waters area from Satellite-based Information System on Coastal Areas and Lakes Program (SISCAL), implemented in 2005; and
- Estimation of the overall pollution load introduced into the coastal waters derived from a database on point sources of pollution, implemented in 2002.

Results of monitoring activities conducted in 2004 reveal that, in general, the level of pollution of Israel's Mediterranean coastal waters is not high relative to international marine environmental quality guidelines and criteria (**Table 15**). The trends of decreasing pollution identified in previous years continued in 2004, however, significant quantities of anthropogenic materials continue to be introduced into the coastal waters both from point sources (i.e., from marine outfalls and coastal rivers) and from nonpoint, diffuse sources (e.g., runoff waters, atmospheric deposition). As a result, a number of local pollution problems exist along the coastline.

Dassenakis et al. (2009) have characterized the Eastern Mediterranean as oligotrophic, with notable localized eutrophication phenomena, increased transportation of oil products and concomitant accident occurrence, localized river discharges and coastal "hot spot" areas, and distant influences to nearshore water quality (e.g., from the Black Sea outlet through the Dardanelles; from the Western Mediterranean through the Straits of Sicily). These characteristics result in a west-to-east gradient of decreasing surface chlorophyll *a* that is readily visible from space. The authors advocate implementation of a marine pollution-monitoring project that would combine remote sensing techniques with chemical analytical measurements, providing an effective tool for the environmental protection and sustainable management in this ecologically sensitive area.

Table 15. Summary of nearshore water quality parameters, 2004 (Adapted from: Herut et al., 2005).

Water Quality Parameter	Status in 2009	Trends Identified in last decade
Heavy metals in sediments (mercury, cadmium, copper, zinc, lead, nickel, chromium)	**Haifa Bay**	
	Medium level of mercury pollution in the northern part of Haifa Bay.	Mercury pollution decreased until the previous decade. In the last decade seems stable.
	Medium to low levels of mercury pollution in the Qishon Estuary.	
	Decrease in mercury levels in the Qishon Estuary compared to 2008, probably the result of deepening diggings in the area.	
	Lead concentration might increase.	Lead concentrations decreased. In the last years concentration seems stable and might be increasing.
	Low concentrations of other metals.	
	Coastal Rivers	
	Medium level of pollution by chromium and nickel in Bezet River; by mercury, copper, zinc and chromium in Naaman River; by copper, zinc, nickel, and chromium in the Qishon River and cadmium in the lower reach of the river; medium level of pollution by copper and nickel in Alexander and Poleg Rivers; by copper, nickel, and chromium in Hadera River and lead in its estuary; by copper, zinc, and nickel in the Yarkon River; and medium level of pollution by zinc in Lachish River and lead in its estuary.	Pollution in the Qishon Estuary decreased. Cadmium concentration seems stable in the last 5 years. No significant change in metal concentration of the other rivers estuary.
	Along the Coast	
	In general, the concentrations of all metals in shallow areas are below harmful levels.	
	Several Local Pollution Problems	
	Medium level of mercury, copper, and zinc pollution in the Tel-Aviv Region Sewage Treatment Plant (TAS) area.	No clear trend in TAS outlet; (seasonal changes in level of pollution).
	Chromium enrichment in the area of Agan Chemicals/Ashdod Refineries pipeline outlet (source unknown).	
Heavy metals in sediments (mercury, cadmium, copper, zinc, lead, nickel, chromium)	**Ports and Marinas**	
	High level of pollution by mercury in Haifa Port; medium level of pollution by cadmium, arsenic, lead, chromium, copper, and zinc in Haifa Port; by chromium, copper, zinc, and nickel in Ashdod Port; medium level of pollution by mercury in the marina of Akko; by nickel in the marinas of Akko, Michmoret, Eshcol, and Ashkelon; by copper and zinc in the marina of Tel Aviv, Ashkelon, Akko, Hadera, and Michmoret (only zinc).	Haifa Port: Possible increasing trend of mercury; no clear trend regarding other metals, possible decreasing trend in cadmium concentration. Ashdod Port: Chromium, copper, nickel, cadmium, and mercury concentration decreasing trend in the civil area of the port. Marinas: No significant change excluding some enrichment of chromium, copper, and nickel in Michmoret.

Table 15. (Continued).

Water Quality Parameter	Status in 2009	Trends Identified in last decade
	Haifa Bay, Coastal Rivers, and Along the Coast	
Heavy metals in suspended particulate matter	Relatively high concentrations of mercury, cadmium, copper, lead, chromium, and zinc in several rivers. However, the measurement method shown large errors.	No significant trend. Cadmium concentration in southern Haifa Bay decreases as of July 2000.
Heavy metals in fish	Mercury enrichment in inshore fish from Haifa Bay relative to fish from other areas.	Mercury concentrations stabilized at a lower level than in previous decade, but presenting an increasing trend in the last years.
	Mercury extension relative to the severe standard for edible fish was found in 5% of examined coastal fish, in the area of Haifa Bay the extensions were about 11%.	
	Cadmium and lead concentration smaller than the guiding lines of the Food Authority. Arsenic concentrations detected in 18% of the fish was higher than 10 ppm, which might indicate higher inorganic arsenic than the guiding line of the Food Authority (required further examination).	
	Trawl Fish: Metals concentration varied in different areas along the coast.	
	Haifa Bay and Akko	
Heavy metals in benthic organisms	Mercury enrichment in bivalves and gastropods relative to other areas. In bivalves, concentration in the north part of the bay was higher than the southern.	Mercury concentrations in bivalves decreased during 1980-1992, then started increasing trend in the bivalves of Akko area.
	Copper and zinc concentration were higher in the southern part of the bay.	
	Bivalves' arsenic concentration was equal all over the bay area.	
	Cadmium enrichment in gastropods from Haifa Bay (excluding Kiriat Yam) relative to other areas along the coast.	Cadmium concentrations in the Qishon Estuary decreased as of 2000.
	Along the Coast (selected sites)	
Heavy metals in benthic organisms	Copper enrichment in gastropods from Ashdod area and mercury in Palmachim relatively to other sites along the coast (except of Haifa Bay).	Cadmium concentrations in the Qishon Estuary decreased as of 2000.
Heavy metals in air (dust)	Concentrations similar to Europe and higher than in open sea areas.	Lead and cadmium concentrations decreased (cadmium in the last 5 years).
		No clear trend of change in copper and zinc concentrations.
	Ports and Marinas	
Organic pollutants in sediments	Medium level of pollution of PCB's (>ERL). In Ashdod Port, Akko, and Tel Aviv Marina concentration of PCB's detected were higher relatively to other marinas but lower than the harmful ecologic criteria (ERL).	PCB levels were lower than previous survey on 2001-2005, and equal to the years 2006-2009.
	Dioxin concentration was lower than the quantitative detection limit of the assessment.	
	PAHs concentration detected was lower than the ecologic criteria for rarely harmful influence (ERL).	
	High level of pollution of TBT and derivatives (>100 ng/g) was detected in Haifa and Ashdod Ports and in the Akko, Michmoret, Hadera, Tel Aviv, and Ashqelon Marinas.	

Table 15. (Continued).

Water Quality Parameter	Status in 2009	Trends Identified in last decade
Organic pollutants in seawater	**Ports and Marinas**	
	Concentrations of volatile and semi-volatile pollutants were below detection limits or below harmful levels at all sites sampled.	No significant change during the period 2002-2009.
	PCB's and organochloride pesticides were below detection limits (<20 ng/L). In the marina of Akko and Michmoret, the material diuron was detected, and in Haifa Port and Akko Marina, the herbicide Terbutryn was detected.	
	Measurable value of TBT was found in Ashdod Marina solely. Samples from Haifa and Ashdod Ports, Eshcol, Tel Aviv, and Michmoret Marina's contained DBT (TBT degradation product). The concentrations were higher than the Israeli water quality standard.	The port's concentration decreased during the period 2002-2009.
Nutrients in rain water	Nitrogen and phosphorus fluxes into the coastal waters smaller than in Europe but higher than in open sea areas.	Nitrogen and phosphorus fluxes depend on annual precipitation. No significant change in nitrogen flux in the last decade.
Nutrients in coastal rivers (outlet areas)	Medium to high levels of pollution in most rivers.	In the last decade some decrease in nutrient concentrations (especially in Soreq and Qishon Rivers). No significant change in the last 5 years except for significant increase in phosphorus and ammonium in Hadera River Estuary.
Nutrients in coastal waters	**Haifa Bay**	
	Enrichment close to the coast, in Akko and in front of Qishon Estuary.	Possibly decreasing trend since 2002; The last years present a change (i.e., increase) in N:P ratio of the Qishon River Estuary.
	Along the Coast	
	Silica enrichment south of Ashkelon. Generally, nutrient concentration decreasing with increasing distance from shore.	
Nutrient load from point sources	Marine outlet > Coastal river estuaries. Especially for P.	No significant change during the last 5 years.
Microalgae in coastal waters	**Haifa Bay**	
	High concentrations relative to other areas. Especially high concentrations in the Qishon River Estuary.	Monitoring started in 2000; possibly beginning of a decreasing trend.
	Potentially toxic species found.	Potentially toxic species found previously in Haifa Bay.
	Along the Coast	
	Relatively high concentration in shallow water (<10 m) compared to deeper water (30 m).	From the average multi-annual distribution (2001-2008), it seems that the biomass in Yarkon Station is the highest and lowest in Alexander Station.
	Genera that might include toxic species found along entire coastline. Average variety index is significantly smaller in the southern stations (Yarkon, Soreq, and Ashqelon) compared to northern stations during 2002-2008.	

Table 15. (Continued).

Water Quality Parameter	Status in 2009	Trends Identified in last decade
Benthic communities (indicator for organic matter enrichment)	**Haifa Bay**	
	Indications for organic matter enrichment opposite Akko in the north and the Qishon Estuary in the south.	Monitoring started in 2005.
	Along the Coast	
	Indications for organic matter enrichment in the area of the TAS outfall, Herzelia outlet and Soreq Rivers.	Monitoring started in 2005 (no monitoring on 2006).
Biological effects monitoring	In 2009, the opposite of previous years, no significant difference in effects of metals concentrations and organic pollutants on fish from Haifa Bay compared to fish from Dor area.	
Metallothionein (heavy metals), cytochrome P4501A (organic materials), choriogenin, and vitellogenin (reproduction disruptors)	Effects on reproduction disruptors not found in all fish.	

DDT = dichlorodiphenyltrichloroethane; ERL = effect range low; PCB = polychlorinated biphenyl; TBT = tributyltin.

As may be noted in the monitoring activities under the Israel's National Monitoring Program for the Mediterranean Sea conducted in 2004, the waters offshore of Ashdod and Ashkelon are relatively pristine, with pollutant concentrations within natural concentration ranges.

3.6.2.2 Ashdod Area Monitoring

There are a series of industrial facilities in the Ashdod area that either utilize seawater or discharge into nearshore waters with potential effects on nearshore water quality, including the Ashdod Port, the Eshkol Power Station, and the Ashdod industrial area. Environmental documentation was compiled for a proposed desalination facility in the Ashdod area by Mekorot Development & Enterprise Ltd. (Mekorot, 2009). Significant discharges have been noted for the treated wastewater from the Agan Chemicals factory and the Ashdod refinery, fuel tanker connections, the Ashdod wastewater treatment plant, the cooling water outfall at the Eshkol Power Station, cooling water from the Ashkogen Company, and brine waters from Israel Electric Company Gezer outfall (Mekorot, 2009).

As part of the desalination permit process, background monitoring of the marine environment was performed in October 2007 by the Israel Oceanographic & Limnological Research (IOLR). The report constituted a completion supplement to the environmental document that was submitted in January 2008. The objective of the background monitoring was to characterize the marine water quality, seafloor, and biota in two areas: the discharge outfall area (where concentrated brine will be released) and the seawater intake area. Monitoring results indicated that all examined parameters were within the natural concentration ranges that are characteristic of the area with no deviations from the recommended seawater standards of the Ministry of Environmental Protection. Volatile organic substances were found at all points that were sampled, but at low concentrations and with no correlation with location or water depth. The marine environment in the area of the desalination plant is monitored on a permanent basis pursuant to the conditions of the permits for ocean discharge by the Ashdod refinery, Agan Chemicals, and the Eshkol Power Station.

3.6.2.3 Offshore Water Quality

Mediterranean waters are, in general, oligotrophic (i.e., nutrient poor, phosphorus limited, and low primary production) except in the neighborhood of land-based sources. Consequently, eutrophication is a local rather than a regional problem and excessive eutrophication is not a significant issue in Mediterranean coastal waters (Yilmaz et al., 1992a,b). According to Robarts et al. (1996), the pelagic waters of the Levantine Basin are among the world's most oligotrophic, with exceptionally low primary productivity (Berman et al., 1984a,b), chlorophyll, and nutrient concentrations in summer (Salihoglu et al., 1990; Krom et al., 1991; Yacobi et al., 1995). Further, there is strong stratification evident, with significantly higher nutrient concentrations (i.e., 5 µM nitrate, 0.2 µM phosphate) present beneath the nutricline, at approximately 200 m. These deeper water nutrients are advected into the upper mixed layer during deep mixing events in winter (Hecht et al., 1988); increased nutrient concentrations may also be found in summer as a result of upwelling (Robarts et al., 1996).

Surface waters of the Eastern Mediterranean are almost devoid of nutrient elements necessary to sustain a reasonable amount of production. Surface waters down to the bottom of the euphotic zone are poor in nutrients and this is attributed to photosynthetic consumption and subsequent export of biogenic particles into lower layers. Furthermore, because of the prevailing current system, midwaters that are relatively enriched in nutrient elements flow to the Atlantic Ocean. In general, PO_4, NO_3+NO_2, and reactive silicate (Si) concentrations in offshore surface waters are low; the higher values are those measured at coastal waters.

The vertical distribution of nutrients in the Eastern Mediterranean is principally determined by the duration and the intensity of winter turbulent mixing in the quasi-permanent cyclonic and anticyclonic eddies. It has been shown that a permanent nutricline is located between specific density surfaces (σt=29.00 to 29.05 and 29.15) throughout the whole basin, even though it appears at different depths. The nutricline is much sharper and shallower in the cyclonic regions (e.g., Rhodes gyre) that coincide with the lower boundary of the euphotic zone. The nutricline is observed far below the euphotic zone, as deep as 200 to 700 m, depending on the intensity of winter mixing in the frontal zones and in anticyclonic gyres.

In the seasons of stratification, a nutrient poor aphotic layer is formed between the lower boundary of the euphotic zone and the permanent nutricline, but this feature nearly vanishes in the core of the cyclones. The molar ratio of nitrate to phosphate (NO_3/PO_4) exhibits well defined peak values (as large as 40 to 120) at the top of the nutricline, corresponding to nearly the depth of the 29.05 isopycnal surface where the onset of the phosphocline is located, while the nitracline onset appears at the 29.00 isopycnal surface throughout the whole basin. Below the nutricline, the NO_3/PO_4 ratios decrease regularly and reach an almost constant value (=28) in the deep waters where the density is greater than 29.15 (Yilmaz and Tuğrul, 1998).

The whole water column in the Eastern Mediterranean is well oxygenated; even the deep waters (e.g., 1,000 m depth) have saturation values greater than 70% to 80%. Dissolved oxygen (DO) concentrations range from 200 µM at the surface and up to 275 µM at the subsurface maximum. The DO maximum observed in the euphotic zone usually coincides with the depth of the primary production maximum, and then the concentration slightly decreases below the euphotic zone. Deep-water DO concentrations range from 175 to 200 µM (Yilmaz and Tuğrul, 1998; Yayla, 1999). Anoxia is not an issue in Mediterranean offshore waters although associated with deepwater brine areas.

Water clarity offshore is good. The Eastern Mediterranean is one of the most transparent water bodies among the world oceans. The compensation depth (i.e., depth to which 1% of the surface light reaches or practically the lower boundary of the euphotic zone) is relatively deep in the basin and shows temporal (shallower in winter) and spatial (shallower in cyclonic regions such as Rhodes gyre) differences. The compensation depth is determined to be in the range of 55 to 95 m, with an average value of 80 m for the whole basin for the period 1991-1994 (Ediger and Yilmaz, 1996). Average total suspended solids (TSS) in the northeastern Mediterranean surface waters ranged from 0.6 to 1.7 mg/L (the overall average being 1 mg/L for the whole basin), excluding polluted bays, river mouths, etc. Hotspots associated with land-based sources had very high concentrations of TSS (e.g., in the vicinity of sewerage outfall the average TSS concentration in near-surface waters was 11.8 mg/L) (Yilmaz et al., 1998b).

The Mediterranean is one of the most oil-polluted areas in the world as the countries surrounding the Mediterranean, especially in the east and the south, are oil-producing countries. The Eastern Mediterranean coastline also is significantly industrialized, supporting many industries such as textile, food, metal, ferro-chrome, paper and pulp, iron and steel, paint, plastic, wood, soda, fertilizer, and petroleum. Along with shipping are several coastal discharges of domestic, commercial, and industrial wastes in the region and these generate point-sources of petroleum pollution (Yilmaz et al., 1997). PAHs have been monitored for several years in the Eastern Mediterranean as part of the MED POL Program (the Marine Pollution assessment and control component of MAP) with PAH concentrations in seawater were determined fluorometrically as chrysene equivalents.

Previous sampling by Yilmaz et al. (1991), extending from the Rhodes Basin to the far eastern portions of the Levantine (off Lebanon and Israel), revealed dissolved/dispersed petroleum hydrocarbons (DDPH) levels ranging from of 0.2 to 0.8 µg/L in surface waters during March 1989. Measured hydrocarbons were attributed to both biogenic and anthropogenic sources.

Table 16 summarizes PAH concentrations in surface waters of the Eastern Mediterranean Sea measured in 1985-1986 and 1995-1996, with values ranging from 0.01 to 4.14 µg/L. Tsapakis et al. (2006) reported PAH concentrations of 60 to 470 pg/L in seawater in the Eastern Mediterranean (i.e., 70 km east of Crete) and documented higher concentrations of PAHs in the atmosphere in areas closer to urban centers.

Table 16. Polycyclic aromatic hydrocarbon concentrations in surface water in the Eastern Mediterranean Sea, 1985-1986 and 1995-1996 (µg/L) (From: Yilmaz et al., 1998a).

Period	Station	Minimum – Maximum	Mean ± Standard Error
1985-1986	10	0.1 – 0.77	0.28 ± 0.07
July 1995	36	0.66 – 4.14	0.35 ± 0.05
September 1995	34	0.01 – 1.36	0.20 ± 0.06
October 1995	34	0.01 – 0.79	0.22 ± 0.03
May 1996	28	0.01 – 1.00	0.13 ± 0.04

As is the case in the western Mediterranean, the distribution of dissolved Ni, Cu, and Cd in the Eastern Mediterranean is governed by the general water circulation and local input. Saager et al. (1993) reported dissolved metals in seawater from the upper surface water (down to 200 m) from the Eastern Mediterranean of 0.6 to 2.6 nM/kg Mn; 1.89 to 3.12 nM/kg Cu; 70 to 79 pM/kg; and 4.36 to 4.75 nM/kg Ni.

Metals enter the Mediterranean from both land-based and atmospheric sources. Total mercury input into the northeastern Mediterranean (i.e., Turkey offshore waters) from land-based sources was estimated to be 7.3 tons/year for the 1980s (Yemenicioğlu et al., 1993). This finding is consistent with the United Nations Environmental Programme (UNEP, 1984) estimation of 7.1 tons/yr. Atmospheric input for the same region for the 1980s was estimated at 5 tons/yr (Salihoglu et al., 1989). The total input is estimated as <1 tons/yr for the 1990s (Yilmaz et al., 1997). This decrease was not due to the decrease in input from land-based sources, but rather was a result of analytical problems such as contamination and high detection limits during analysis that caused overestimation for the 1980s. More than half of the mercury (about 80%) introduced to the sea is in particulate form. After entering the sea, most of the introduced mercury is expected to settle by precipitation of the particulate materials and be incorporated into the sediment. Mercury and its compounds are very toxic to living organisms and are biomagnified through the food chain; thus, it is one of the metals that receive great concern. Total mercury concentrations for Turkish waters of the northeastern Mediterranean range between 2.5 and 27 ng/L, with an average of 11 ng/L. The higher concentrations were measured at coastal stations under the influence of land-based sources. The estimated cadmium input from land-based sources to the northeastern Mediterranean is 6.3 tons/yr for the 1980s; about 90% of this is carried by rivers. About 70% of the cadmium introduced to the region is in the particulate form (Yemenicioğlu et al., 1993).

3.6.2.4 Chemical Oceanography

The geochemistry of the eastern Levantine Basin is characterized by high oxygen levels throughout the water column and extremely low concentrations of nutrients in surface waters. Oxygen levels in the Levantine Basin are highest in surface waters (**Figure 40**), where phytoplankton are the most productive.

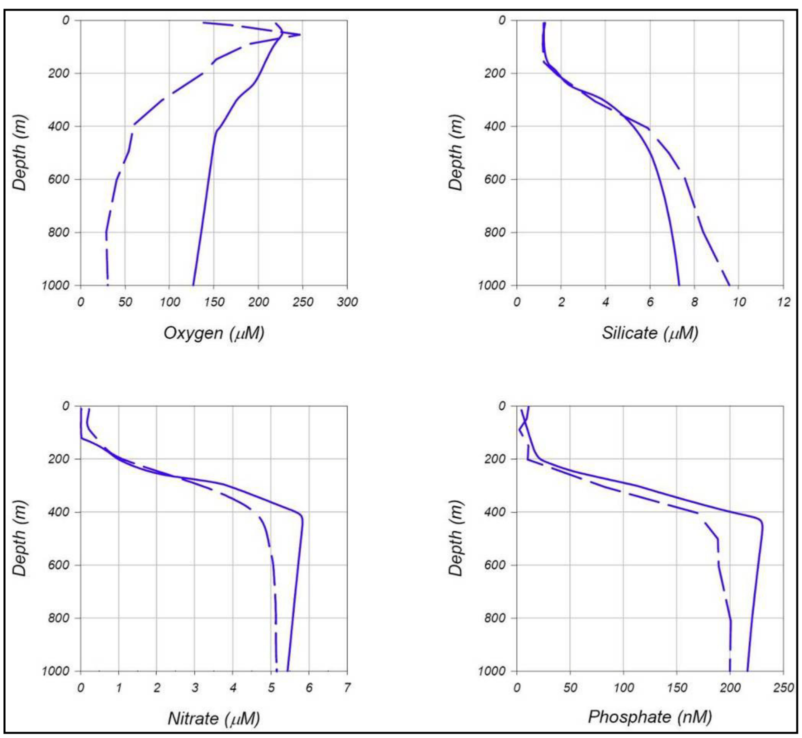


Figure 40. Vertical profiles of oxygen and nutrient concentrations in the Eastern Levantine Basin. Data from Yacobi et al. (1995) (dashed line: lat. 33°30' N; long. 30°30' E, autumn) and Krom et al. (2005) (straight line: lat. 33°43' N; long. 32°13' E, early summer).

During all seasons, oxygen levels are close to saturation. Oxygen levels decline with depth through the mid-water region (250 to 500 m), largely due to microbial and zooplankton consumption of sinking organic material and respiration. However, there is only a very small oxygen minimum in mid-waters, in contrast to the large oxygen minimum observed in many other marine systems (Krom et al., 2005). This is because the amount of organic material sinking from surface waters in this system is very small and, consequently, microbial respiration is restricted (Krom, 1995). Deep waters (>500 m) are oxygenated at constant levels (**Figure 41**, Krom et al., 2005). Overall oxygen concentrations in the upper 3,000 m of the water column range from 170 to 250 mM (Yacobi et al., 1995; Kress and Herut, 2001; Krom et al., 2005).

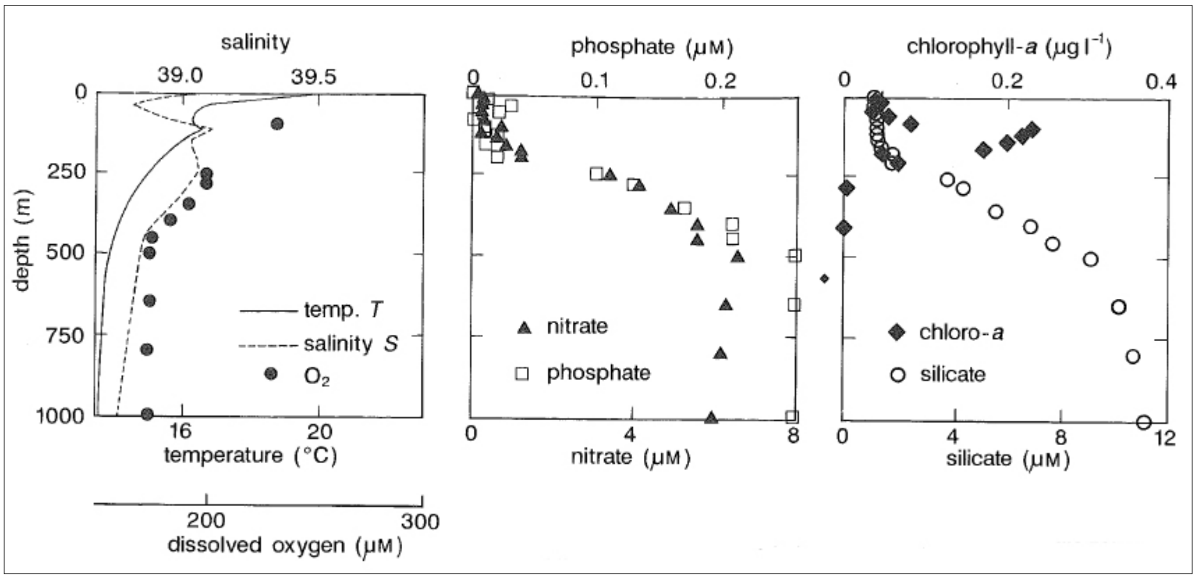


Figure 41. Typical profiles of physical, chemical, and biological parameters for the Eastern Mediterranean from a station located immediately north of the Cyprus Eddy, in early summer (From: Krom, 1995).

As previously mentioned, the eastern Levantine Basin has extremely low levels of nutrients, and the region is considered "ultra-oligotrophic." Nitrate and phosphate concentrations in the LSW in the Eastern Mediterranean (see **Figure 40**) are one-half their concentration in the western basin (Bethoux et al., 1992).

This severe nutrient depletion is due to the very low net supply of nutrients to the Mediterranean Basin because 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). Although nutrient concentrations change seasonally (**Table 17**), measurements of surface water (0 to 200 m) nitrate concentrations are at detection limits (typically 0.3 to 0.6 mM), and phosphate levels are typically undetectable by conventional methods (see **Figure 40**; <0.1 mM; Krom et al., 1991, 2005).

Table 17. Chemical characterization of water masses in the Mediterranean Basin. Average values (with standard deviation) are shown for nutrient concentrations and N:P ratios. Data from Kress and Herut (2001).

Water Mass	Season	Nutrient Concentration (µM/kg)			N:P
		Si $(OH)_4$	NO_3	PO_4	
Surface	Summer	1.09 (0.36)	0.06 (0.11)	0.02 (0.02)	5.2 (8.5)
Surface	Spring	1.16 (0.41)	0.20 (0.15)	0.02 (0.03)	14.2 (10.7)
Surface	Winter	1.23 (0.48)	0.60 (0.50)	0.01 (0.01)	52.2 (55.7)
Intermediate	Summer	1.20 (0.50)	0.55 (0.65)	0.03 (0.02)	20.5 (16.8)
Intermediate	Spring	1.81 (0.87)	1.99 (1.02)	0.05 (0.04)	54.0 (32.9)
Intermediate	Winter	1.70 (1.17)	1.19 (1.22)	0.03 (0.04)	44.3 (13.1)
Deep	All	10.44 (0.60)	5.57 (0.30)	0.23 (0.03)	24.7 (2.7)

NO_3 – nitrate; N:P = nitrogen to phosphate ratio; PO_4 = phosphate; Si $(OH)_4$ = silicic acid.

A nutricline, or rapid change in nutrient concentrations, begins at 130 to 160 m (**Figure 41**), and concentrations of all major nutrients (i.e., nitrate, phosphate, and silicate) increase simultaneously through the LIW to a mid-water maxima at approximately 500 m (the position of the oxygen minimum, **Figure 41**). Nutrient concentrations are then constant or decrease slightly in the EMDW.

The only nutrients that do not follow this profile are ammonium, which is relatively high in surface waters and decreases below the nutricline, and nitrite, which forms a sharp peak just above the beginning of the nutricline (Krom et al., 2005). In the deep water of the eastern Levantine Basin, and during the winter and spring months, nitrogen-to-phosphorus ratios can be very high (**Table 17**).

Chemical oceanographic research in the eastern Levantine Basin has focused on the warm-core eddy to the south of Cyprus (Krom et al., 1991, 2005) and stations at the southern edge of the Cyprus EEZ (Yacobi et al., 1995; Kress and Herut, 2001), which are within ~100 km of the Tamar Gas Field. In the Levantine Basin, there is a chlorophyll maximum but no oxygen minimum layer. Oxygen and nutrient distributions at the southeastern parts of the basin are less well known.

According to Robarts et al. (1996), pelagic waters of the Levantine Basin are among the world's most oligotrophic, with exceptionally low primary productivity (Berman et al., 1984a,b), chlorophyll and nutrient concentrations in summer (Salihoglu et al., 1990; Krom et al., 1991; Yacobi et al., 1995). Further, there is strong stratification evident, with significantly higher nutrient concentrations (i.e., 5 µM nitrate, 0.2 µM phosphate) present beneath the nutricline, at approximately 200 m. These deeper water nutrients are advected into the upper mixed layer during deep mixing events in winter (Hecht et al., 1988); increased nutrient concentrations may also be found in summer as a result of upwelling (Robarts et al., 1996).

Herut et al. (2001) assessed the role of the atmospheric dry fallout as a source of new nitrogen and phosphorus to the surface Levantine seawater. The authors determined that the similarity of atmospheric and burial fluxes of phosphorous in the Levantine Basin reinforces the hypothesis that the atmosphere is the dominant source of phosphorus to the sediments in the deeper parts of the basin. It was estimated that the leachable fluxes of inorganic phosphorus (from dry and wet deposition) and inorganic nitrogen (dry deposition) can support potentially significant new production (1-4 g C m^{-2} y^{-1}) in the southeast Mediterranean. This new production results from dust events and stratification. This input may also contribute significantly to the relatively high N:P ratios in Levantine deep water.

According to Krom et al. (2004), the Eastern Mediterranean is phosphorus-limited, with a nitrate to phosphate ratio in deep water of approximately 28:1 (Krom et al., 1991). With mixing of deep water and its associated nutrients with near surface and surface waters, phytoplankton blooms follow during winter and then diminish when surface waters are depleted of phosphate; however, measurable amounts of nitrate remain (Krom et al., 1991; 1992). Additional evidence of phosphorus limitation in Eastern Mediterranean surface waters is provided through observations of bacterial and phytoplankton activity (Zohary and Robarts, 1998).

3.6.2.5 Real-time Nearshore and Offshore Oceanographic Data

Real-time oceanographic data for Israeli coastal and offshore waters is available online through IOLR, based in Haifa. One particularly relevant tool is SISCAL, an internet-based service for the on-demand generation and distribution of earth observation (EO) data products on aquatic ecosystems. SISCAL was created as a 3-year research and development project funded by the European Commission. It is currently being operated by two members of the former SISCAL consortium: Informus GmbH, Berlin, and IOLR.

In its current operational state, SISCAL provides maps on several oceanographic parameters, including sea surface temperature (SST), chlorophyll-*a* (Chl-a) concentration, total suspended matter (TSM), and Secchi depth (SEC). These data are obtained from operational ocean observing instruments mounted aboard satellites such as moderate resolution imaging spectroradiometer (MODIS), medium resolution imaging spectrometer (MERIS), or advanced very high resolution radiometer (AVHRR).

For ocean currents, ASL Environmental Sciences Inc. (2009) determined that no site- or block-specific ocean current data are available for the development drilling area. It was recommended that an ocean current measurement program be implemented to provide the necessary data for ocean current design and engineering requirements.

For possible pipeline routes, extensive data holdings of the Israeli Oceanographic and Limnological Research facility for water depths of 25 to 500 m were examined through tabulated summaries available via the internet. These data are applicable to the near-bottom extreme currents along the pipeline route. The near-bottom ocean currents reached speeds of up to 67.5 cm/see over the 7 years of available measurements. ASL Environmental Sciences Inc. (2009) determined that further analysis is required, preferably from the original datasets after quality control, to determine extremal value near-bottom currents by ranges of water depths and the associated statistical distributions.

3.6.2.6 Air-Sea Interactions

The air–sea CO_2 flux, the carbon export to the deep layers and more generally the carbon budgets, are poorly characterized in the Mediterranean Sea. D'Ortenzio et al. (2008) recently proposed an approach to simulating these fluxes at a regional scale based on an array of unconnected one-dimensional physical–biological–chemical coupled models. The relevance of this type of analysis rests with the potential insight afforded into the coupling between physical/chemical and biological systems.

3.7 CLIMATE AND AIR QUALITY

The Mediterranean Sea is closed from all sides and surrounded by high peninsulas and mountain barriers. The gaps between these major mountainous regions divert the atmospheric flow and form various scales of atmospheric circulations. These topographic formations, together with the landscape variability, result in the formation of regional climatic conditions that vary significantly from place to place. This is especially true for the eastern part of the Mediterranean where the Greek and Asia Minor peninsulas are separated by Aegean Sea. Both the southern and northern areas of the Asia Minor peninsula are characterized by steep mountains. Israel is located along the eastern part of the Mediterranean between Lebanon and Egypt.

The Eastern Mediterranean is located on the lee side of the Asia Minor peninsula where the flow always exhibits a cyclonic type of circulation and is an area of cyclogenetic activity that is the subject of forced anti-clockwise circulation initially along the Aegean and then around the Asia Minor peninsula over a relatively warm sea. The climatic conditions of the Eastern Mediterranean region can be roughly divided into cold and warm periods. The cold period of the year (December–March) is characterized by the low index circulation that is associated with intense cyclogenetic activity. During the cold period, cyclogenesis is a common characteristic in some locations. The anticyclonic type of circulation during this period is associated with cold core anticyclones laying over the central Europe or the Balkan region.

The warm period (June–September) is characterized by high index circulation where the North Atlantic lows pass over Europe and only edges of the fronts reach the northeast 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 towards the Mediterranean) and the monsoon activity over the Indian Ocean and the Middle East. A pressure gradient between the western and eastern part of the Mediterranean ranges from 10 to 40 hPa, with 20 hPa being the more typical gradient (Millan et al., 1997; Kallos et al., 2007).

During the transient seasons of spring and autumn, the synoptic circulation varies between cold and warm-types. Each of the transient seasons extends for approximately two months, April and May for spring and October and November for autumn.

Kostopoulou and Jones (2007a) characterized the dominant daily circulation patterns governing the climate variability in the Eastern Mediterranean, based on analysis of a 42-year dataset. The authors found that, during winter and spring, large-scale features situated in northern Europe affect the atmospheric circulation over the Eastern Mediterranean, whereas the Atlantic (Azores) anticyclone and the Asian Thermal Low define most of the observed circulation types in summer. In autumn, the area exhibits a rapid transition from the warm to cold season showing climatic features from both extreme seasons. Similarities between winter and spring/autumn patterns were detected; correlation analyses between these spatial patterns revealed that similar circulation patterns occur among the three seasons, which usually appear more pronounced during winter. Frequencies and trends of the proposed circulation types were examined for each season. A linear trend analysis for the overall period (1958-2000) exhibited a significant increase in the anticyclonic types, particularly in winter. Statistically significant negative trends in cyclonic types were found in all seasons especially for types associated with depressional activity in the central Mediterranean.

Kostopoulou and Jones (2007b) completed a comprehensive analysis of climatic variability in the Eastern Mediterranean, addressing the relationship between atmospheric circulation patterns and surface climate measurements. Their findings indicated that winter patterns generally exhibited more pronounced structures – atmospheric circulation associated with anticyclonic features typically leads to cold air moving into the Eastern Mediterranean accompanied by dry conditions. Conversely, cyclonic circulation results in southern maritime airflows into the region, accompanied by increased temperature and rainfall. During the warm season, generally warm and dry weather is associated with most of the circulation patterns; surface patterns do not reveal very pronounced structures.

Typical tracks of the low-pressure (i.e., storm) systems that occur in offshore Israeli waters are:

- From the west along the central Mediterranean and south of Crete. These lows are generated in the western Mediterranean (mainly in the Gulf of Genoa or Gulf of Lions and at the lee side of Atlas Mountains) from the northwest following a path over the Greek Peninsula and north of Crete. Such lows are relatively weak but are rejuvenated in the south Ionian and/or Aegean Sea. These systems are the result of cold outbreaks from central and eastern Europe initially moving towards the Balkan and Black Sea regions and then along the Ionian and Aegean seas. They are synoptic systems that provide significant amounts of precipitation.
- From the south-southwest to southwest. These are lows generated in the area of the Atlas Mountains or the Gulf of Syrtis that move eastward along the North Africa coast. These lows are one of the major suppliers of rain in the Middle East. These systems appear very often during the spring season.

Alpert et al. (2004) described the synoptic patterns and seasons for the Eastern Mediterranean region. The dominant synoptic system in summer is the Persian Trough (PT) that persists northeast of Israel, along with the subtropical high that borders the PT from the southwest (Alpert et al., 1990a). The most significant meteorological system in winter is the Cyprus low, which regularly penetrates the Eastern Mediterranean or is formed there in this season (Alpert et al., 1990b). In autumn, the Red Sea Trough (RST) is most common (Kahana et al., 2002), whereas the Sharav lows are specific to spring (Alpert and Ziv, 1989).

Characteristics of the three major synoptic weather types, as described by Dayan and Levy (2002), include:

- Red Sea Trough – a situation attributed mainly to intrusions of a low-pressure trough, in shallow atmospheric layers, extending from Sudan toward the Middle East with a north-south oriented axis lying over Israel. This synoptic system is a dominant feature regarded as an extension of the African Monsoon, which occurs mainly during the fall. This mode brings to the region regimes of light winds transporting hot and dry air from eastern origins.
- Anticyclone or Cyprus Low – a weak pressure gradient due to anticyclonic conditions. A high-pressure ridge that extends from northeast Turkey towards northeastern Africa develops into a closed high-pressure system and moves eastward to Israel. This pronounced anticyclone occurs mainly during the spring and is often accompanied by an upper-air ridge and leads usually to stagnation caused by the very weak pressure gradient formed over Israel.
- Shallow Persian Trough (SPT) – a synoptic pattern typical for the summer whenever the extensive North-African upper-air subtropic anticyclone advances to the region leading to subsidence and stabilization of the atmosphere. These conditions are characterized by a subsiding dynamic inversion and accordingly a shallow mixed layer. Due to the weak pressure gradient, the winds are usually quite feeble at most of the atmospheric profile. These weak winds blowing within the limited mixed layer result in poor ventilation conditions and rather elevated concentration of airborne pollutants. These spells end usually as a result of the gradual deepening of the shallow trough, which inflates the marine turbulent boundary layer.

In addition to these synoptic patterns, the regional component of the flow is also considerable due to thermal circulation patterns that develop in the area. More specifically, the North Africa land mass is nearly void of vegetative cover and is located closer to the equator, resulting in higher levels of solar radiation received during daytime hours (i.e., land surface is heated to high temperatures). In contrast, southern Europe has extensive vegetation coverage and is located 10° to 15° higher in latitude than North Africa (i.e., southern Europe is not heated to the same extent as North Africa). Mediterranean water temperatures are significantly lower than land temperatures and remain constant day and night. Thermal circulations form, and during the daylight hours, sea-breeze cells develop with variable strength. Sea breezes during daylight hours are strong over the North African coast and penetrate deep inland. Sea breezes over the European coasts are not as strong and in many places do not develop at all due to steep topography. The combination of synoptic circulation with a strong component from north to south and thermal circulations like the sea breezes have the effect of the weakening European-coast sea breezes and strengthening other breezes along the North African coasts. This differential heating between the land of North Africa and southern Europe with the Mediterranean waters has a resulting strong net flow from north-to-south and is associated with large-scale subsidence over the Mediterranean waters. This mechanism is much stronger during the warm period of the year.

Israel's subtropical location between 29° and 33° north of the Equator along the Eastern Mediterranean 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 Levant or Eastern Mediterranean. The northern and coastal regions of Israel show Mediterranean climate characterized by hot and dry summers and cool rainy winters. In contrast, the southern and eastern areas of Israel are characterized by an arid climate. The hottest month is August when average temperatures range from 18°C to 38°C, while January is the coldest month (temperatures range from 5°C to 10°C).

Rainfall varies greatly within the country and from season-to-season and from year-to-year, particularly in the Negev Desert. Rainfall varies from north-to-south with the highest rainfall observed in the north and central parts of the country and decreases toward the southern part of Israel where from the Negev Desert to Eilat rainfall is negligible. The northern parts of Israel have an average annual rainfall of 1,128 mm (44.4 in.) while in the extreme south the annual rainfall averages less than 100 mm (4 in.). Typically areas that receive annually more than 300 mm (11.8 in.) of rainfall are cultivated, representing only one-third of Israel's land area. The rainy season extends from October to early May with rainfall peaks in December through February. Much of the rainfall (about 70%) falls between November and March while no rainfall occurs June through August. A majority of the rainfall occurs during violent storms resulting in erosion and flooding events. Snow at the higher elevations of the central highlands contributes to precipitation in some areas during January and February. Heavy snow falls only in the northernmost part of Golan Heights where the Mount Hermon summit (2,224 m above sea level) remains generally snow covered from December to March. Snowfall rarely occurs in other parts of the country.

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 eastwards 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.

There are no long-term weather records for the offshore-specific areas of interest. Weather data from the airport in Haifa (located 85 km generally east of the Tamar Gas Field) are available for reference and selected parameters are summarized in **Table 18**. Weather records for Ashdod are summarized in **Table 19**.

Table 18. Summary of weather records from the Haifa Airport (Station Haifa, Israel; lat. 32°48' N, long. 035°02' E; 30 ft above sea level) (From: U.S. Department of the Navy et al., 1996).

Month	Temperature (°C)			Precipitation (mm)			Relative Humidity (%)		Prevailing Wind (kn)	
	Maximum	Minimum	Average	Mean	Maximum	Minimum	AM	PM	Direction	Speed
January	16.1	11.1	13.9	129.5	243.8	5.1	70	64	E	15
February	15.6	11.1	13.9	68.6	139.7	12.7	74	66	E	14
March	18.3	13.3	16.1	58.4	160.0	12.7	74	67	W	10
April	21.7	15.6	18.9	20.3	43.2	5.1	75	65	W	9
May	23.9	18.3	21.1	5.1	15.2	0	80	69	NNW	8
June	26.7	22.2	24.4	0	0	0	83	69	WSW	9
July	28.9	24.4	26.7	0	2.5	0	81	67	WSW	10
August	29.4	25.0	27.2	0	0	0	81	67	W	8
September	28.3	23.9	26.1	2.5	20.3	0	77	66	W	8
October	26.7	21.1	23.9	7.6	25.4	0	73	66	NNW	8
November	22.8	17.2	20.0	86.4	149.9	15.2	65	63	E	14
December	17.8	12.8	15.6	119.4	271.8	25.4	70	64	E	15
Annual	23.3	18.3	20.6	523.2	123.9	581.0	75	66	W	11
POR (years)	11	11	11	10	10	10	7	8	8	8

POR = period of record.

Table 19. Summary of weather records for Ashdod (From: www.meoweather.com).

Month	Temperature (°C)				Average Rainfall (mm)		Average Snow Days	Average Fog Days
	Average		Absolute		Daily	Monthly		
	Maximum	Minimum	Maximum	Minimum				
January	17.8	8.0	29.2	0.0	3.4	105.3	0	0
February	18.6	8.1	34.0	-3.1	2.6	72.7	0	1
March	21.5	10.1	38.5	3.3	1.4	44.1	0	1
April	25.7	12.8	41.1	4.0	0.4	11.3	0	1
May	28.5	16.0	42.8	7.8	0.1	1.7	0	2
June	30.7	19.5	43.5	11.3	0	0.3	0	1
July	32.3	22.0	39.2	12.1	0	0.2	0	0
August	32.6	22.6	39.0	17.0	0	0	0	0
September	31.5	21.1	42.9	12.0	0	0.7	0	0
October	29.3	18.2	39.8	5.6	0.6	19.3	0	0
November	25.0	13.5	35.2	1.0	1.4	40.7	0	0
December	20.1	9.8	31.2	2.8	2.9	90	0	0

The mean and extreme temperatures are moderated by Haifa's coastal location, with January and February being the coolest months (13.9°C) and highest average temperatures evident during August (27.2°C). A similar trend is evident in Ashdod.

3.7.1 Wind

During most months, the dominant wind direction is from the north-northwest to west-southwest sector due to the general circulation and local thermal circulations. In general, during the winter the winds are from the east. During spring, winds are from the west while during the summer and autumn they are from the west-to-northwest.

Sea/land breezes develop over the coastal areas due to temperature contrasts between the land and water. In general, these sea breezes are stronger during the warm period of the year when they start early in the morning and last until evening. The maximum wind speed occurs during late afternoon. The onset and cease times of sea breezes depend on the orientation of the coastline, orientation of the cell with respect to the synoptic scale flow, position, and characteristics of nearby orographic barriers, landscape, and other factors. Sea breeze rotation is either clockwise or anticlockwise depending on the orientation of the coastline. In general, in areas where the land is to the west of the sea, rotation is clockwise, and where the land is to the east of the sea, rotation is anticlockwise. Sea breezes can penetrate inland by a few tens of kilometers, but this is subject to the existence of topographic barriers, especially near the coastline. Sea breezes are supported by anabatic winds that are due to the slopes and orientation (azimuth) of the topographic formations and the time of day.

Land breezes appear after late evening until the first morning hours. The onset and cessation of land breeze cells are subject to the season and slopes of the topographic formations as well as the azimuth of their slopes. These cells are relatively low-speed circulations that are difficult to separate from katabatic and drainage flows. In general, all coastal areas are windy, due either to exposure in the synoptic or local forcing.

ASL Environmental Sciences Inc. (2009), in their analysis of available metocean data for the Tamar and Dalit Fields and potential pipeline corridors to shore, noted 1- and 100-year hourly wind speeds, extremal values, of 16.2 and 22.7 m/s, respectively.

3.7.2 Precipitation

Mean precipitation is highest during December (119 mm [4.7 in.]) and January (130 mm [5.1 in.]) and lowest from June through August (0 mm). The annual average wind direction is from the west at 11 kn. The highest monthly average winds occur November through February from the east when speeds are 14 to 15 kn while the lowest winds occur during May and August through October at 8 kn. Humidity is highest during the mornings from May to August. Conditions during May through October, when temperatures are still high (24°C to 26°C) and winds are relatively low, lead to high humidity levels, especially in the coastal areas.

3.7.3 Air Quality

3.7.3.1 General Characteristics

The primary pollutants involved in the photochemical cycles that determine air quality are nitrogen oxides (NO_x), mainly nitric oxide (NO) and nitric dioxide (NO_2), and volatile organic compounds (VOCs). Another important group of air pollutants are the oxidants (e.g., ozone [O_3] or peroxyacetal [PAN]), which are by-products of the aforementioned primary compounds. The various air pollutants react with other chemical species in the atmosphere, forming a large variety of other species. Some of these chemical processes are induced by insolation. Different chemical cycles (e.g., nitrogen or carbon cycles) may compete, and the products might be completely different. During the last two decades, aerosols in the atmosphere came more under scrutiny because of implications that range from disturbances in the radiation budget and cloud formation (and therefore climate) to health. Aerosols and, in general, particulate matter (PM) are of different origin, and their compositions and properties vary significantly. One category of aerosols is associated with photochemical processes, especially gas-to-particle conversion. Another category is associated with natural sources. PM from natural sources arises from soil dust, sea salt spraying, pollen from trees, etc.

Air quality measurements in coastal Israel have shown consistent decline during the last century. This is especially true for the Eastern Mediterranean region for many synergistic reasons. Historically, the primary sources of air pollution were industrial-type pollution sources mainly associated with industrial activities and central heating. During the last few decades, however, industrial and heating emissions have been replaced by photochemical pollution, which primarily originates from traffic and is associated with internal combustion engines (i.e., sources of NO_x and unburned hydrocarbons). During recent years, other types of air pollution sources such as shipping and airport activities (i.e., vessel and aircraft emissions, support operations) have also come into consideration (Maritime Communication Services, Inc. et al., 2008).

The transformation processes of air pollutants in the atmosphere, and in particular, photochemical processes, are highly nonlinear because of the sensitivity exhibited by the primary cycles of reactions (mainly nitrogen and organic compounds). Because of different rates of production/destruction of oxidants from the primary cycles of reactions, the distribution of various air pollutants involved in the photochemical cycles exhibits significant spatial and temporal variations. Such variations could also be due to the spatial and temporal distribution of the emissions. In addition, other important factors controlling these variations are meteorological conditions and landscape characteristics, mainly spatial variations (orography, vegetation cover, and soil properties). These are the most important factors controlling the air quality in urban or rural areas; their roles are briefly described below.

3.7.3.2 Spatial-temporal Distribution of Air Pollutant Sources

The spatial and temporal distributions of various sources of air pollutants directly influence the observed concentrations and associated transformation processes. Spatial or temporal variations in emission patterns might significantly affect air quality in an area, and in the neighboring region. This problem is more pronounced in urban areas where the introduction of new technologies in the automobile industry (e.g., the use of catalytic converters) as well as changes in traffic regulations or modifications in city planning might cause significant modifications in emission patterns and therefore might affect the air quality, both locally and regionally. The construction of an emission inventory is a very complicated problem where several uncertainties might be introduced. Spatial/temporal distributions of emissions can deviate significantly from average conditions that are considered during the compilation of emission inventories. Emission inventories are frequently used in photochemical modeling, but because of the many uncertainties in emission estimates, modeling results can vary significantly.

3.7.3.3 Rates of Production/Destruction

The rates of production/destruction of oxidants from primary cycles of reactions are controlled by various parameters such as the ratios between primary pollutant concentrations and meteorological conditions. All branches in the main chemical mechanisms have not been fully understood, and some rate constants are approximations rather than exact estimates. Because of existing uncertainties in emission inventories, ratios between some primary pollutants, especially NO_x/VOCs, might vary significantly. Such a variation might lead the photochemical calculations towards another direction entirely. This is especially true in cases where polluted air masses of different ages are mixed or high amounts of PM are present. Such cases are common in the Mediterranean region where urban or industrial plumes travel long distances within the marine boundary layer or within the lower troposphere where they are mixed with local sources.

3.7.3.4 Meteorological Conditions

Meteorological conditions of various scales are considered very important because they control the transport, transformation, and removal processes. Without a detailed description of the meteorological fields, the photochemical processes cannot be accurately described. Most urban air quality studies consider a region of about 100 km around the city under study. The main reason for that is the consideration of thermal circulations in the vicinity around the city limits. This has been shown to not always be correct (Kallos et al., 1993, 1994; Rao et al., 1995) because the so-called mesoscale circulations, which exhibit diurnal variations, cover areas larger than the urban areas. Even the so-called regional-scale phenomena exhibit significant diurnal variations due to differential heating. Local weather conditions (at urban scale) and the associated circulation results from synoptic, regional, and meso- and microscale interactions. Inaccurate consideration of any of these scales in air pollution modeling can affect the local circulations and therefore local conditions. These are cases that will be seen in prognostic model simulations (Kallos et al., 1994). Local meteorological conditions of an urban area are affected significantly by the topographic characteristics existing in the vicinity. The shape and orientation of the coastline or topographic ridges (hills, mountains) in a region around the urban area of interest are key parameters for the formation of local circulations. Large-scale topographic ridges can create channeling of the synoptic- and regional-scale flow, which might significantly modify local atmospheric conditions in an area. Such local flow characteristics play very important roles in urban and regional air quality.

In the offshore environment of the Eastern Mediterranean where the Matan and Michal Blocks are located, several tens of kilometers west of the Israeli coastline and urban areas, air quality is expected to be good. These blocks lie beyond the normal transport pathways for pollutants generated onshore. No site-specific air quality measurements are available for the two development blocks of interest.

3.7.3.5 Meteorology and Air Quality

The three major synoptic weather types that are conducive to short-term air quality problems are evident in coastal Israel, as described by Dayan and Levy (2002), include:

- Red Sea Trough (RST) – occurs 29% of the time, mainly during the fall, brings to the region regimes of light winds transporting hot and dry air from eastern origins;
- Anticyclone – occurs 25% of the time, mainly during the spring and is often accompanied by an upper-air ridge and usually leads to stagnation caused by the very weak pressure gradient formed over Israel; and
- Shallow Persian Trough (SPT) – occurs 20% of the time; typical for the 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 RST (1%), and undefined (2%).

Segal et al. (1981) conducted pollutant transport analyses at three different elevations during summer and during advective Sharav conditions and determined that 1) offshore transport patterns for nocturnal pollutant emissions are evident up to 10 to 15 km offshore; and 2) during morning hours, pollutants are recirculated onshore. Dayan and Levy (2005), in their analysis of the Influence of meteorological conditions and atmospheric circulation types on PM_{10} and visibility in Tel Aviv, noted that the frequent passage of Sharav cyclones during spring causes natural dust outbreaks with extreme values that result in a much higher PM_{10} annual mean (57 $\mu g/m^3$) compared with other larger cities around the world. Limited offshore movement of air pollutants generated onshore strongly suggests that air quality at the offshore blocks will be good.

3.7.3.6 Landscape Characteristics

Landscape characteristics, mainly spatial variations, play a significant role in the formation of local atmospheric conditions and in the removal of pollutants. The effects of landscape characteristics, especially horizontal variations, on the boundary layer growth were the subject of several studies (Segal et al., 1988, 1989 and references therein; Avissar and Pielke, 1989; Pielke et al., 1991; Pielke and Uliasz, 1993). The association of landscape variability with dispersion characteristics was an important subject of a previous study conducted by Pielke and Uliasz (1993). Kallos (1995) discussed the relationship among land use changes, city planning, and air quality. It was demonstrated that changes in land use can cause climatic changes at a local or regional scale according to the scale of intervention. In an urban environment, such landscape variations can control local atmospheric conditions and therefore air quality. Landscape characteristics will not be applicable for offshore operations in the Tamar Field, however, local topography may influence air quality along the coastal zone where support operations originate.

3.7.3.7 Transformation Processes

Transformation processes, especially photochemical, exhibit latitudinal and longitudinal variations. Latitudinal variations are associated with the amount of solar radiation reaching the lowest atmospheric layers and the ground, and longitudinal variations are associated mainly with regional landscape characteristics. Such variations were found to be very important in Europe and especially in the Mediterranean region. It was found from various research programs (Meso-meteorological Cycles of Air Pollution on the Iberian Peninsula [MECAPIP], South European Cycles of Air Pollution [SECAP], Transport and Transformation of Air Pollutants from Europe to the Mediterranean [T-TRAPEM]), and urban plumes keep their characteristics for hundreds of kilometers away from their sources (Millan et al., 1992; Kallos et al., 1995). According to these research findings, photochemical pollution is an urban-scale problem as well as a regional problem. A brief description of the results obtained thus far in the Eastern Mediterranean region is given below.

3.7.3.8 Long-range Transport in the Mediterranean Region

The climatic conditions in the Greater Mediterranean Region (GMR) are known to have significant regional scale characteristics capable of long-range transport. The climatic patterns and physiographic characteristics of the GMR force air quality in the area to exhibit remarkable spatiotemporal variability. The major pollutant sources of anthropogenic origin in the Mediterranean region are located in Europe. The existence of mega-cities in the Eastern Mediterranean region (e.g., Istanbul, Cairo), industrial activities, and energy production/consumption in the area have resulted in elevated emissions of several pollutants such as NO_x, sulfur (S), carbon monoxide (CO), nonmethane hydrocarbons, and ammonia (NH_3), etc.

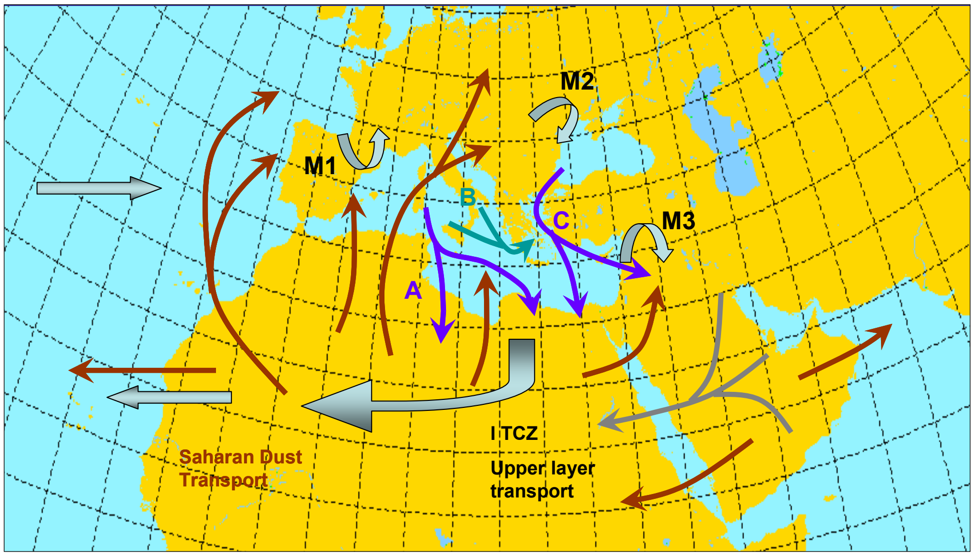
It is evident that sources of anthropogenic pollutants are located mainly in central and southern Europe, with minor contribution from North Africa and the Middle East (Asaf et al., 2008). Besides anthropogenic particulates, the marine environment also contributes to the particular matter load via production of salt spray and dimethylsulfide (Kouvarakis and Mihalopoulos, 2002). Atmospheric input of airborne nutrients to the marine environment is just as important as inputs from rivers (Guerzoni et al., 1999; Herut et al., 1999; Carbo et al., 2005).

Concentrations of various pollutants (primary and/or secondary) are significant in remote locations and may occur in multiple-layer structure up to a few kilometers above the surface. For the GMR, the term "tropospheric ozone transport" and its precursors should be of great interest, as well as the role of O_3 in the production of several other pollutants, such as mercury (Hg). Several recent studies have focused on the important role of aerosols in air quality of a specific area due to the potential impact on human health and ecosystems. Aerosol concentration and deposition patterns are important, along with O_3 and its precursors, especially in predicting air quality degradation episodes. Desert dust is another crucial component that contributes to air quality degradation of the GMR.

A considerable amount of work has been devoted to analyzing and studying the paths and scales of transport and deposition of O_3 and aerosols in the GMR, resulting from both natural and anthropogenic influence. Levels of atmospheric gases and aerosol are monitored in ambient air quality networks because of their potential impact on human health, visibility, and climate. As suggested in previous studies (Kallos et al., 1995; Kallos, 1999; Millan et al., 1997), the synoptic/regional circulation during summer favors the long-range transport of air pollutants released from southern and Eastern Europe and the central Mediterranean towards the Eastern Mediterranean, North Africa, and Middle East.

Regional, broad scale projects such as MECAPIP, SECAP, and T-TRAPEM provided the first information about recirculation mechanisms, layering, paths, and transformation processes that may affect the Eastern Mediterranean region, mainly for photooxidants (Kallos et al., 1997, 1999; Millan et al., 1997). The mechanism of Saharan dust transport towards the Mediterranean and Europe has been the subject of study for other projects (e.g., Mediterranean Dust Experiment, MEDUSE; Haminou et al., 1997). These cooperative efforts continued by providing the framework for other projects, including Biogenic Emissions in the Mediterranean Area (BEMA), Mediterranean Atmospheric Mercury Cycle Systems (MAMCS) (Pirrone at al., 2003), subgrid scale investigations of factors determining the occurrence of ozone and fine particles (SUB-AERO; Lazaridis et al., 2006), and Atmospheric Deposition and Impact of the Open Mediterranean Sea (ADIOS; Loye-Pilot and Benyahya, 2003). Monitoring and predicting the transport of Sahara dust into the Eastern Mediterranean has been summarized by Michaelidis et al. (1999).

Several studies in the past have identified the paths and scales of transport of gases such as O_3 and NO_x in the atmosphere. A large amount of gases and aerosols (e.g., sulfur dioxide [SO_2] and sulfates [SO_4]) from anthropogenic activity contribute to increased concentrations of pollutants in the atmosphere and to the reduction of visibility. This is mainly attributed to fine particles that are capable of long-range transport influencing the air quality in remote locations. In addition, natural aerosols, whose main source of origin is the Sahara desert, significantly contribute to increased particle concentration in the atmosphere. The findings of research conducted during the last 20 years on the long-range transport of air pollutants over the Mediterranean, especially the eastern part, are summarized in the recently published work of Kallos et al. (2007). Emphasis is placed on the convoluted effects of both anthropogenic and naturally produced air pollution and on air quality degradation at various scales. Long-range transport over the Eastern Mediterranean is summarized in **Figure 42**.



A, B, and C = air mass transport paths; M1, M2, and M3 = thermal circulation paths; ITCZ = Intertropical Convergence Zone.

Figure 42. Characteristic paths and scales of transport of air masses in the Euro-Mediterranean Region. Arrows indicate transport pathways of anthropogenic pollutants in the Euro-Mediterranean Region (ozone sulfates, etc.). Gray arrows are associated mostly with the upper layer transport while the blue and green arrows depict movement of pollutants in the lower troposphere layers. Red-brown arrows indicate transport of desert dust from the North Africa region (From: Kallos et al., 2007).

More specifically, **Figure 42** also illustrates the following:

- Transport of air masses from Europe towards the Mediterranean Sea, Middle East, and North Africa occurs during all seasons, with summer being the most efficient (transport paths A, B, and C).
- Air quality in various locations in the Mediterranean Region, especially near the coast, is mainly defined by thermal circulations (diurnal cycle) (paths M1, M2, and M3), but the long-range component is also considered to be significant.
- Venting of urban or industrial plumes located near the coastal zone occurs through two different paths:
  - Towards the free troposphere with the aid of the upslope flows during daytime hours.
  - Towards the marine boundary layer, where plumes are trapped and travel long distances until they reach land.
- The transport over Mediterranean waters mainly occurs within the Marine Boundary Layer (MBL). Polluted air masses from the MBL are injected in the free troposphere, and in several locations the existence of islands acting as chimneys significantly contributes to the described behavior.
- Some locations of the Mediterranean Region act as “temporal reservoirs” where air pollutants are “concentrated” and “aged enough” before they are re-advected again (e.g., Black Sea and Western Mediterranean) (path C).
- In the Western Mediterranean, vertical transport is considerable and leads to multiple layering (path M1), while in the Eastern Mediterranean the horizontal component of transport dominates.

- In general, the time scale of transport of air masses from Europe to the Middle East is approximately 2 to 3 days (transport paths A, B, and C). Transport from the western part of the Mediterranean to southeast Europe is in the range of 1 to 2 days. Transport from the western part of the Mediterranean to the Middle East and northeast Africa is, in general, longer (3 to 4 days) (transport path A).
- Air quality in urban areas of southeast Europe, North Africa, and the Middle East is significantly affected by the long-range transport patterns because the time scales are still within the life span of most air pollutants.
- During summer, the Intertropical Convergence Zone (ITCZ) is located in North Africa, south of the Mediterranean coast (25° to 30° N), over southern Libya and Egypt where strong convergence lines occur.
- Air masses from Europe should reach the mid-tropospheric layers of the Equatorial Zone within 4 to 6 days. This results in a massive upward transport of various aged pollutants.
- Mixing aged pollutants with dust particles existing in the area can produce new types of particle formations.

The Sahara is the largest desert in the world, and frequently large amounts of dust generated in intense dust storms can reach as far as Europe. Therefore, dust particles affect the air quality of a specific region mainly as episodic phenomena. Several studies in Europe and other parts of the world suggest that fine desert particles (around 2.5 µm in size) comprise a considerable portion of the entire dust production and can travel thousands of kilometers, affecting remote locations (Prospero et al., 2001; Uno et al., 2001; Kallos et al., 2007).

3.7.3.9 Long-range Transport and Influence of Air Quality Offshore Israel

Offshore waters of Israel are affected by the long-range transport of air pollutants of both anthropogenic and natural origin. Air pollutants of anthropogenic origin that reach Israeli waters originate mainly upstream of the main flow patterns. These pollutants are emitted from sources located in eastern Europe, the Black Sea, and the Balkan area as well as the Western Mediterranean, Greece, and Turkey. Short-range transport occurs from the coastline of Egypt, Israel, Lebanon, and Syria due to the blocking of flow along the Middle East coastlines and deflection towards the north, especially during the night hours (Wagner et al., 2001). The short-range transport of anthropogenic pollutants is more efficient during the warm period of the year because of trade winds and the absence of precipitation. As it was found in Luria et al. (1996), the amounts of sulfates reaching Israel during summer are very high compared to other selected locations, with the highest amounts observed during the warm period of the year. Dispersion patterns of polluted air masses released from various sources in Europe are shown in **Figure 43**. These patterns are typical for gaseous emissions as well as for PM of anthropogenic origin.

Photochemical pollution in the Mediterranean results in the formation of high O_3 concentrations as well as aerosols. Typical patterns of O_3 concentrations are shown in **Figure 44**. Sulphate (PSO_4) produced during the previous days is transported and remains almost untouched during the night hours over the sea, as reflected in **Figure 45**.

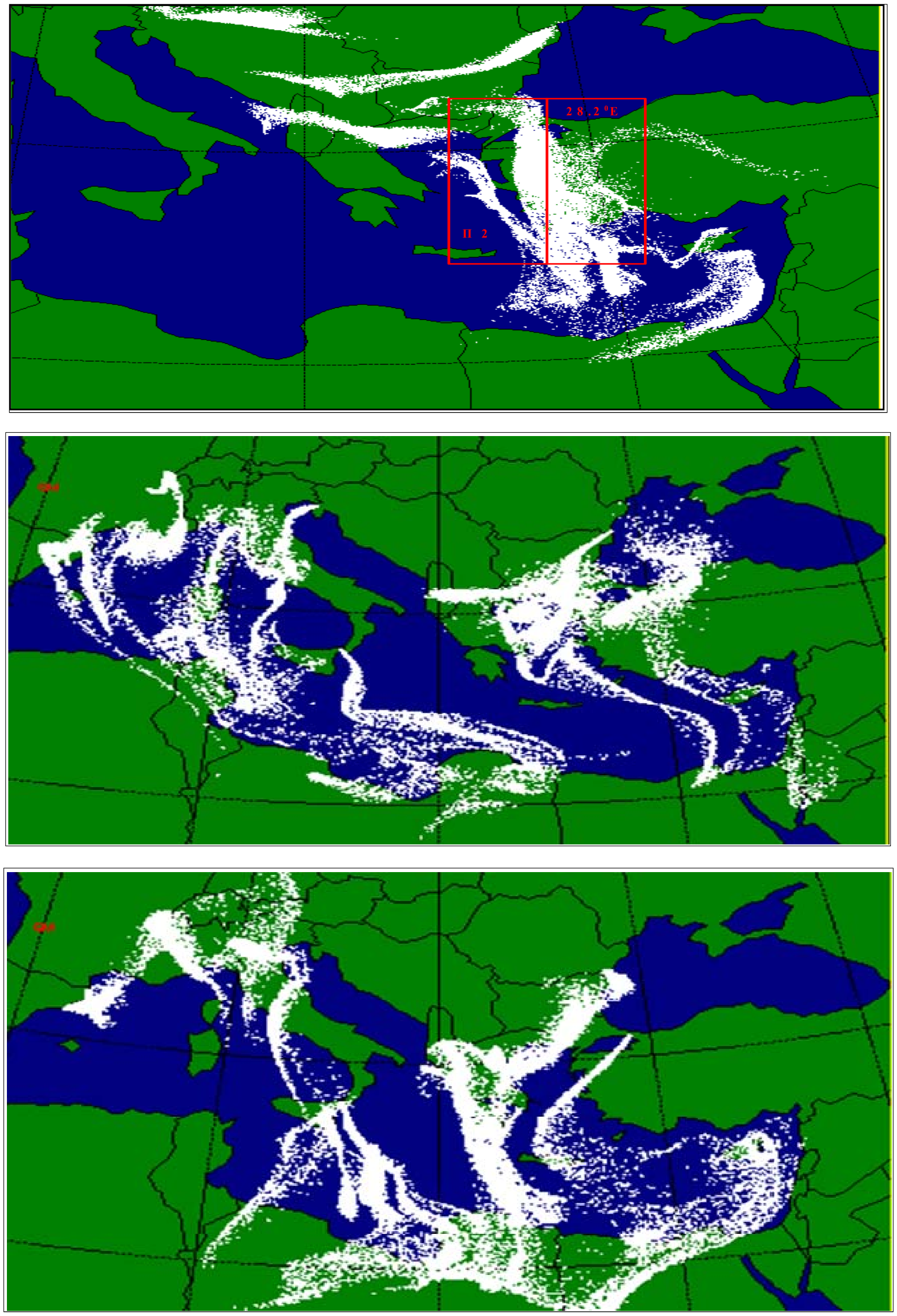
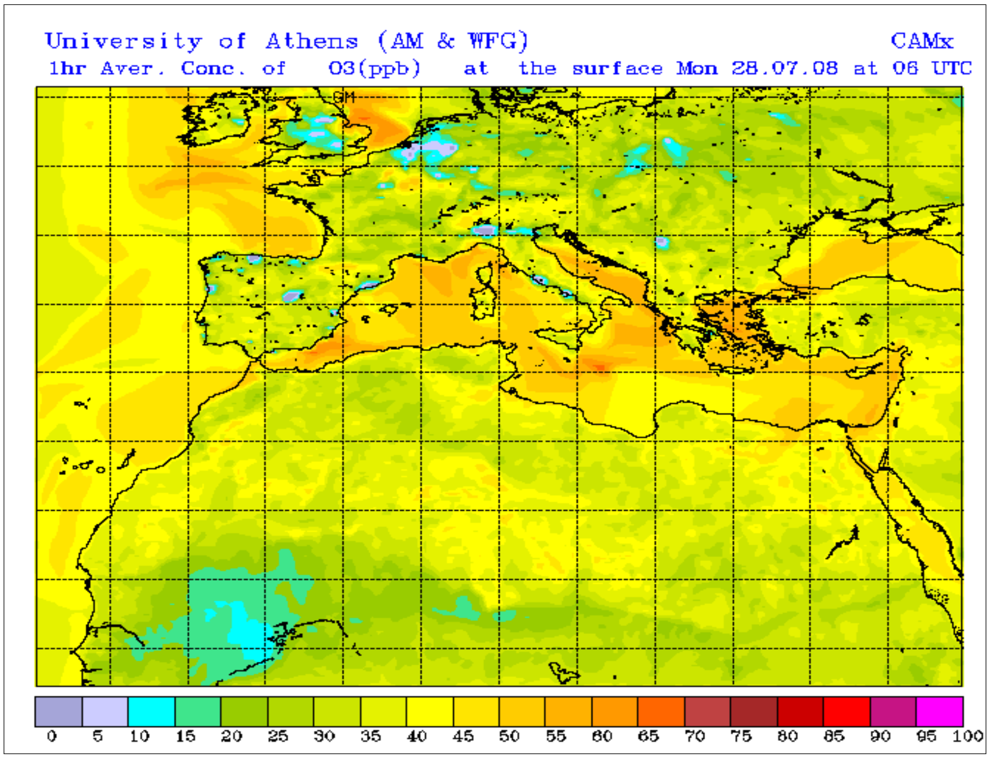


Figure 43. Dispersion patterns of air polluted air masses released from various sources located in Europe.

a)



b)

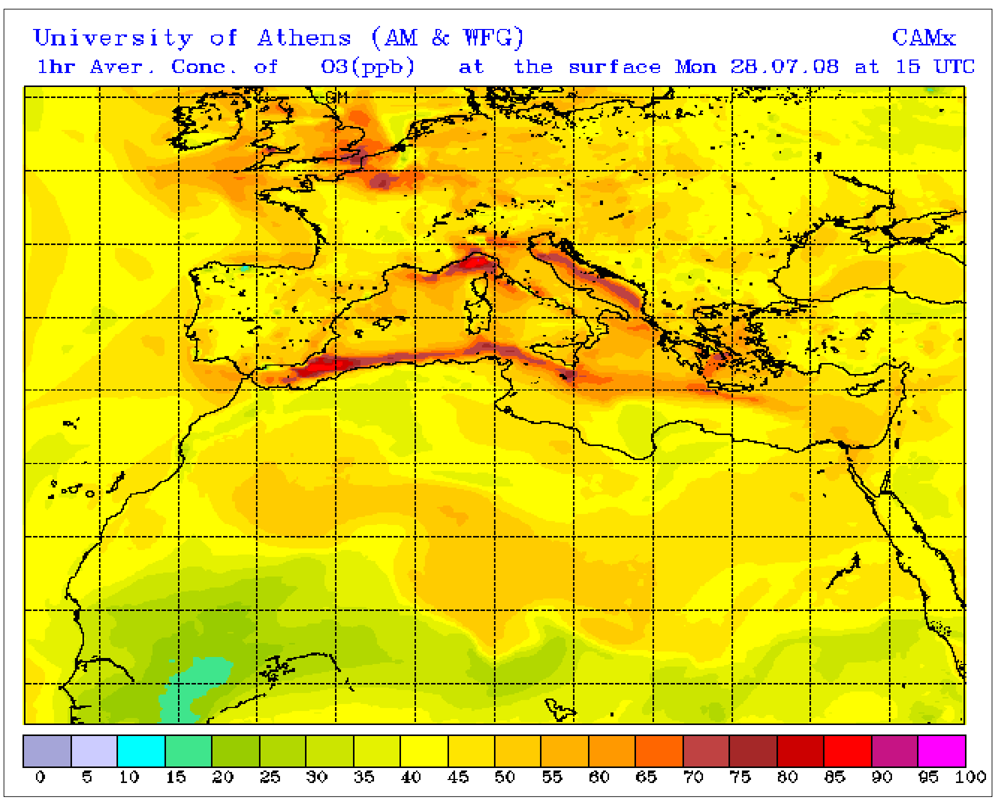


Figure 44. Ozone (O_3) concentrations (ppb) in the Mediterranean Region during a) morning and b) afternoon hours.

a)

b)

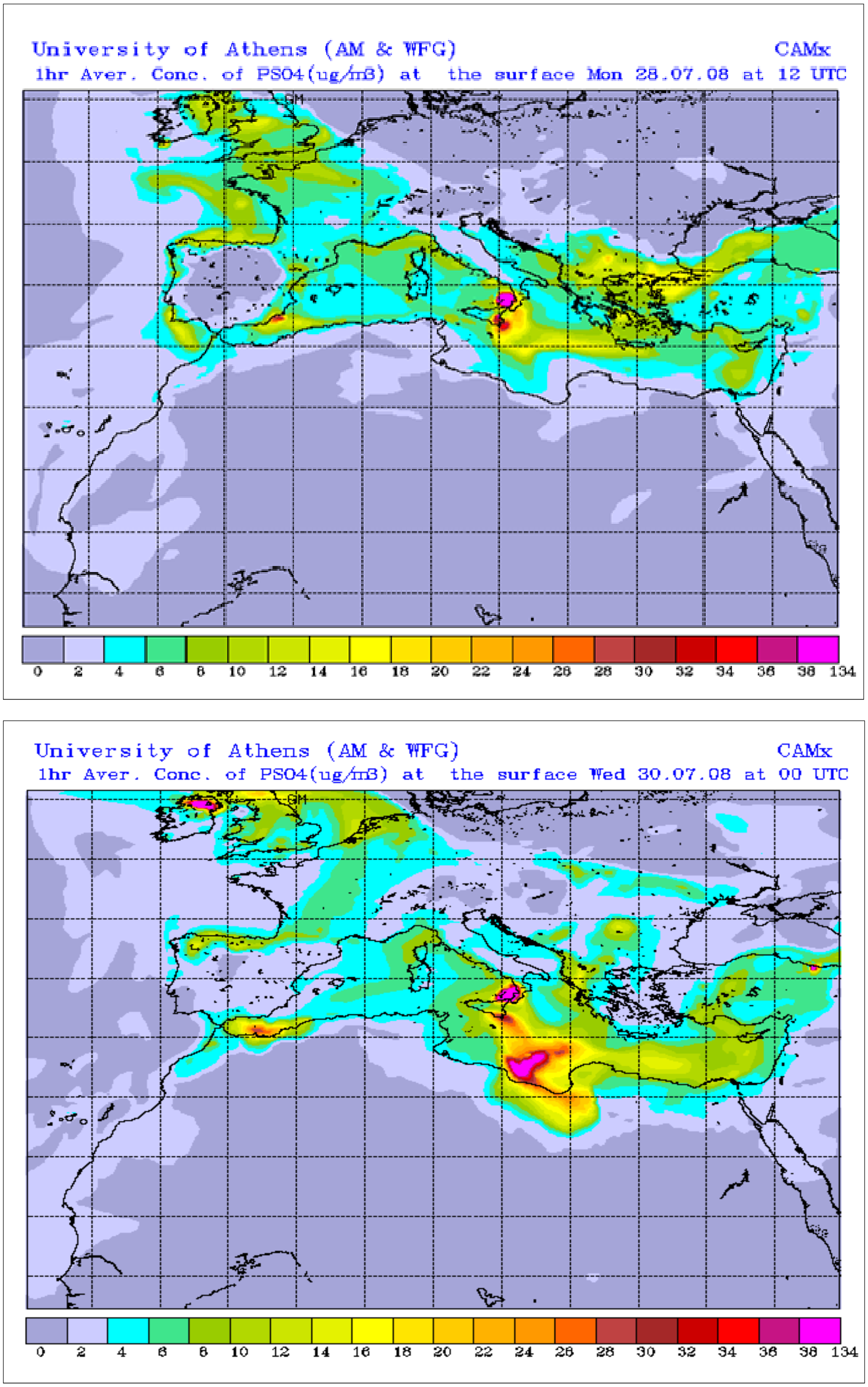


Figure 45. Sulfate (PSO_4) concentrations ($\mu g/m^3$) in the Mediterranean at a) noon and b) midnight.

Desert dust that arises from the Sahara is transported offshore into the Mediterranean mainly during the transient seasons of spring and autumn (Michaelidis et al., 1999). It occurs secondarily from sources in Syria and Turkey when a low system is located over the Middle East. Dust transport is a rather episodic phenomenon. Dust is usually transported from the Sahara northward under anticyclonic conditions or ahead of a trough.

Under such circumstances, air masses within the lowest few kilometers of the troposphere are warm and dry and therefore favorable for stable conditions and formation of stagnation. In such cases, local air pollution sources do not disperse; sunshine and moisture within the marine boundary layer assist in aerosol formation. This aerosol formation and the simultaneous dust transport increase PM concentration in the atmosphere and reduce visibility (Maritime Communication Services, Inc. et al., 2008).

In Israel, anthropogenic sources (stationary and mobile) include the most important industrial installations such as energy production, transportation, and industry, with airports and seaports also prominent installations that may represent significant sources of air pollution. The Israel Ministry of the Environment (2009), in cooperation with the Central Bureau of Statistics, has prepared annual estimates of the countrywide quantities of pollutants emitted into the atmosphere from fuel combustion. Efforts are also currently focusing on developing means to estimate air pollutant emissions from production processes.

An analysis of air pollution trends revealed increases in emission levels of most pollutants. **Table 20** identifies the relative contribution of each sector to air pollution in Israel according to type of pollutant – suspended PM, SO_2, NO_x, and CO_2.

Table 20. Major sources of air pollution in Israel (From: Israel Ministry of Environmental Protection, 2009, citing Central Bureau of Statistics, 2002 and 2004).

Pollutant	Chemical Formula	Percent Contribution by Sector			
		Industry	Electricity Production	Motor Vehicles	Space Heating
Particulate matter	PM	31	38	30	<1
Sulfur dioxide	SO_2	25	70	4	1
Nitrogen oxides	NO_x	5	39	55	<1
Carbon dioxide	CO_2	14	59	22	5

PM is emitted from diesel-powered vehicles, quarrying, industry, power stations, and refineries with electrical production contributing the most. Electrical power plants also are the primary source of SO_2 and are a major contributor to emissions of NO_x and PM. Industry is responsible for significant emissions of PM and SO_2. Motor vehicles are the predominant source of NO_x and are a major contributor to CO_2 emissions. A majority of the CO_2 emissions originate from generating electricity.

Additionally, the following species emitted by stationary and mobile sources impact air quality:

- Hydrocarbons from transportation, refineries, fuel storage and transport facilities and plants using solvents;
- CO from gasoline-powered vehicles; and
- Lead from vehicles using leaded gasoline.

O_3, a secondary air pollutant formed through photochemical reaction between NO_x and hydrocarbons exposed to sunlight, is also a significant contributor to air quality degradation.

Israel has standards promulgated to monitor and improve air quality. Ambient air quality standards were first issued under the Abatement of Nuisances Law in 1971 and were revised in 1992. The regulations provide maximum and annual and/or hourly average ambient air concentration levels for O_3, SO_2, CO, NO_x, sulfate, settling dust, phosphate, suspended particulate matter, respirable particulate matter, three metals in particulate matter, and eight air toxins. Criteria pollutants standards are shown in **Table 21**.

Table 21. Israel ambient air standards for criteria pollutants.

Pollutant	Chemical Formula	Concentration (µg/m^3)	Time Period
Sulfur dioxide	SO_2	1,000 500 280 60	0.5 h (absolute) 0.5 h (statistical) 24 h Annual
Ozone	O_3	230 160	0.5 h 8 h
Nitrogen oxides (as NO_2)	NOx	940 (500 ppb) 560 (300 ppb)	0.5 h 24 h
Respirable particulate matter	PM_{10}	150 60	24 h Annual
Carbon monoxide	CO	60 mg/m^3 (52 ppm) 11 mg/m^3 (9.6 ppm)	0.5 h 8 h

A national monitoring system maintained by the Israel Ministry of Environmental Protection along with some municipal environmental associations provides annual statistics that show the following air quality issues in 2007:

- Annual exceedance of the target standard for $PM_{2.5}$ in all monitoring stations that measure fine respirable particles smaller than 2.5 µm.
- Annual exceedance of the standard for respirable particles smaller than 10 µm (PM_{10}) in a number of cities and transportation stations in the Tel Aviv metropolitan area.
- Annual exceedances of the NO_x standard in all of Israel's transportation stations and isolated exceedances of the World Health Organization 1-h standard for NO_2 in limited locations.
- Increased O_3 concentrations in a limited number of cities while decreased O_3 concentrations were observed in other cities. Isolated exceedances of the O_3 standard.
- Low concentrations of SO_2.
- Low 30-min and 8-h averages of CO.

The major urban conglomerate closest to the area of interest and identified as the likely shorebase location is Ashdod. While coastal cities and recreation areas contribute to air quality degradation by adding emissions from traffic, heating, and cooking, these emissions are not at critical amounts that can cause significant violations of air quality. Since the long-range component of air pollutant transport is considerable, local emissions can additively increase local concentrations, especially in coastal areas due to recirculation processes.

3.7.3.10 Ashdod Region

The Israel Ministry of Environmental Protection (2009) reported on a preliminary assessment of air quality in the northern industrial area of Ashdod and Nir Galim. Sampling was conducted during three consecutive days in September 2008 at six sampling points. Measurements were taken within the framework of efforts by the Environmental Protection Ministry to measure air pollutants which are not routinely measured in monitoring stations throughout the country. The pollutants included suspended dust, respirable particles smaller than 2.5 microns, metals, hydrogen sulfide, volatile organic compounds, polyaromatics (i.e., benzo(a)pyrene), dioxins, and furans. Findings which indicated exceedance of standards or annual and short-term guideline values included suspended dust, $PM_{2.5}$, metals (i.e., arsenic, manganese, lead), hydrogen sulfide, benzene (carcinogen), trichloroethylene, benzo(a)pyrene (carcinogen) and dioxins, and furans. Sampling conducted by the Ministry of Environmental Protection in cooperation with the Ashdod-Yavne Association of Towns for the Environment, determined high concentrations of pollutants, including carcinogens, which exceed health guideline values. More comprehensive surveys were slated for 2009 along with the initiation of emission controls, however, results of those efforts were not reviewed for this analysis due to availability.

Levy et al. (2008), in their characterization and modelling of land-sea breeze interactions, utilized a 5-year dataset (2000-2004) from 18 sites located within the Hadera, Tel Avia, and Ashdod airsheds. Air quality data were acquired from the National Air Quality Monitoring Center (Israel Ministry of the Environment), the Israeli Electric Corporation, the Association of Town Hadera, Association of Towns Ashdod, and the municipality of Petah Tikwa. All sites used represent air pollution monitoring stations that, in addition to the measurement of pollutants, provide data (30-min averages) for various meteorological parameters (i.e., wind speed, wind direction, air temperature, relative humidity). The authors also used sea surface temperature (SST) measurements for the same period acquired from buoys located offshore Ashdod and Haifa.

Urban and industrial plumes have the potential to travel long distances and retain their characteristics for some days, depending upon meteorological conditions. This is more obvious for sources near the coast and in cases where weather conditions favor the transport of emitted pollutants towards or over the sea. The transport from southern Europe towards the Eastern Mediterranean occurs during all seasons but mainly during summer. During summer, transport is increased as a result of stable conditions prevailing in the region (mainly due to large-scale subsidence), the absence of removal processes, the appearance of trade winds, and insolation. In general, the transport occurs from north-to-south, and air quality in Israel and the Middle East is adversely affected.

There are no publicly available air quality data for the offshore areas of Israel. There are no site- or block-specific offshore air quality measurements available for the Matan (Tamar) Block. Given the remote location of the offshore blocks of interest, air quality offshore likely reflects the long-range transport of natural and anthropogenic air pollutants, and produced and regional sources. It is therefore expected that air quality in the project area will be good compared to coastal areas of Israel.

Emissions from the Mari-B Platform have been compiled by Noble. Projected emissions for the Mari-B Platform and the Tamar Platform are provided in **Table 22**.

Table 22. Projected emissions for the Mari-B Platform and Tamar Platform. Allowable emission levels are noted.

Year	Pollutant (tons/year)				
	Particulate Matter	Sulfur Oxides	Nitrogen Oxides	Volatile Organic Compounds	Carbon Monoxide
2012	1.23	5.43	278.25	14.23	436.22
2013	3.97	4.17	346.27	32.37	497.93
2014-2044 (annual)	4.83	4.25	370.33	37.96	517.63
Allowable	486.18	486.18	486.18	486.18	20,310.20

3.8 FLORA AND FAUNA

The following resource-specific discussions present summaries of pertinent, available information on both a regional (i.e., Eastern Mediterranean Sea, Levantine Basin) and site-specific basis (i.e., Tamar Gas Field, Matan concession area, pipeline corridor to shore, Mari-B Platform area and immediate environs).

3.8.1 Plankton

Marine plankton are organisms with limited swimming capabilities that drift with the prevailing currents. Plankton range in size from <0.2 µm (marine viruses) to >600 mm (large jellyfish) and may derive energy from sunlight (i.e., plant plankton [phytoplankton]), from the consumption of organic material (i.e., animal plankton [zooplankton]) or, in several unique deep-sea habitats, from chemosynthesis of inorganic molecules. In marine systems, phytoplankton form the base of the food web, while zooplankton link phytoplankton up the foodweb, to upper trophic level production. Zooplankton also mediate the transfer of organic material from the surface ocean to the deep sea and thus are indirectly responsible for maintaining benthic community production in most deep ocean ecosystems.

3.8.1.1 Phytoplankton

Phytoplankton productivity in the Mediterranean Sea is nutrient-limited (Longhurst, 1998). In contrast to other marine systems, Mediterranean phytoplankton production is co-limited by phosphorus and nitrogen (Krom et al., 1991; Thingstad et al., 2005). A west-to-east decrease in nutrient concentrations in the Mediterranean Sea results in extremely nutrient-poor (ultra-oligotrophic) surface waters in the eastern Levantine Basin and correspondingly low phytoplankton biomass and productivity relative to the western Mediterranean (Tanaka et al., 2007).

Primary productivity is thus significantly lower in the eastern basin compared with the central and western parts of the Mediterranean. Average chlorophyll concentrations for the euphotic zone in the oceanic region (depth <100 m) off the Mediterranean coast of Israel are 0.06 to 0.12 mg m^{-3} (Berman et al., 1986). Recent primary production studies (Moutin and Raimbault, 2002) indicated levels of 350 to 450 mg C m^{-2} d^{-1} around the Strait of Sicily vs. <150 mg C m^{-2} d^{-1} in the Levant Basin. Nitrate and phosphate concentrations in the surface layer (0 to 100 m) were 1.2 ± 1.4 and 0.05 ± 0.05 µM in the western basin and 0.3 ± 0.7 and 0.01 ± 0.02 µM in the eastern basin, respectively. Herut et al. (2000) reported chlorophyll *a* concentrations at two fixed stations across the southeastern Mediterranean continental shelf and slope (120 and 400 m) ranging between 0.003 and 0.415 mg/m^3.

Phytoplankton in the Levantine Basin, including in the vicinity of the study area, are primarily found in the surface ocean (0 to 150 m) where light levels are sufficient for growth (the euphotic zone, **Table 23**). However, phytoplankton pigments (chlorophyl *a*) have been found to 500 m in the deep mixed layer of a warm-core eddy to the south of Cyprus (Krom et al., 1991). On average, the vertical distribution of phytoplankton pigment concentrations (chlorophyll *a*) in the eastern Levantine Basin reaches a maximum at 90 to 110 m, just above the nutricline (**Table 23**) (Yacobi et al., 1995; Krom et al., 2005). Phytoplankton productivity is greatest in the surface mixed layer, typically at a depth of 0 to 50 m (Tanaka et al., 2007). Coccolithophorids (<20 µm) and monads constituted the most abundant components of the phytoplankton at the deep chlorophyll maximum (DCM) and near surface layer (Kimor et al., 1987). Certain individual species, mainly pennate diatoms and smaller dinoflagellates, seemed to adapt to the DCM to form a characteristic association.

Table 23. Inventories and concentrations of chlorophyll *a* (Chl *a*), a phytoplankton pigment, during autumn (October-November) in the Eastern Mediterranean region, including sampling near the Tamar Gas Field (bold entries). The depth of the deep chlorophyll maximum layer is also given (From: Yacobi et al., 1995).

Latitude (°N)	Longitude (°E)	Chl *a* Integrated (mg/m^2)	Surface Chl *a* (ng/L)	DCM Depth (m)	DCM Chl *a* (ng/L)
30.51	33.49	17.4	63	90	235
31.00	33.48	20.7	57	90	250
31.49	33.48	21.5	55	110	274
31.98	33.48	21.0	59	90	229
32.50	**33.49**	**31.3**	**71**	**100**	**253**
33.54	**33.48**	**30.8**	**85**	**100**	**248**

DCM = deep chlorophyll maximum.

Phytoplankton dynamics in the eastern Levantine Basin, including the region of the Matan and Michal concessions, vary on a seasonal cycle. Phytoplankton bloom in the winter and early spring (November to March) because deep winter mixing brings nutrients to surface waters (Vidussi et al., 2001). Phytoplankton growth during this season rapidly depletes phosphorus, and nutrient levels remain low during the summer when the surface ocean stratifies. Thus, the summer phytoplankton biomass is low (i.e., pigment concentrations [chlorophyll *a*]) in the surface mixed layer and up to an order of magnitude lower than observed during the winter (Krom et al., 1991). Occasionally, after storms in the Levant Basin, nutrients on the shallow continental shelf reach the euphotic zone and temporarily increase primary productivity and influence the food web (Azov, 1986). Also, Herut et al. (2000) reported distinct biomass phytoplankton peaks (~30 mg/ m^3 of chlorophyll *a* in the upper 120 m) following autumn and winter storms.

The dominant phytoplankton in Eastern Mediterranean assemblages is *Synechococcus* spp. (Pitta et al., 2005), a small (<2 µm) cell that outcompetes larger plankton for the limited amount of available nutrients. Analysis of phytoplankton accessory pigments in the eastern Levantine Basin also indicates the importance of prymnesiophyte nanoplankton (2 to 20 µm) and the presence of coccolithophorids, diatoms, and dinoflagellates (Psarra et al., 2005). Diatom populations in the study by Psarra et al. (2005) were dominated by *Thalassionema frauenfeldii*.

Studies of phytoplankton in the Eastern Mediterranean region, including those cited above, have primarily focused on the warm-core eddy to the south of Cyprus (e.g., Krom et al., 1991; Pitta et al., 2005; Psarra et al., 2005; Tanaka et al., 2007). Two of 28 stations occupied by Tanaka et al. (2007) fall within or immediately adjacent to the Matan Block (i.e., bold entries of **Table 23**), and are considered to be representative, site-specific phytoplankton data sources.

Dugdale and Wilkerson (1988) historically documented the basin-wide cyclonic circulation of nutrient-depleted water in the Eastern Mediterranean. Low nutrient levels, coupled with regional climatic conditions (i.e., hot, dry seasons; low annual rainfall) producing low land run-off levels contribute to the low productivity of the Eastern Mediterranean region.

3.8.1.2 Nearshore

A study being carried out by Bat-Shachar Dorfman at Tel Aviv University involves a detailed examination of the phytoplankton populations opposite the Tel Aviv coast in an attempt to develop efficient and reliable molecular tools to track and characterize these populations. Bat-Shachar has been conducting seasonal tracking of phytoplankton populations simultaneously with the tracking of other environmental parameters (e.g., temperature, salinity, strength of illumination, and chlorophyll concentrations in the water column). Research is being conducted at the mouth of the Yarkon River and at a reference site north of Herzlia. However, as the Yarkon station is located in a eutrophic effluent, its results will be less applicable to the study area, while measurements from the control station may better represent generic coastal waters. In a study by Azov (1986), the picoplankton size fraction (<3 µm) dominated at a neritic station located 2 km off Haifa during summer and fall, while the nanoplankton fraction (3 to 20 µm) dominated during spring. At a station located 10 km offshore, the picoplankton fraction dominated almost all year-round, but it is suspected that some portion of it was photosynthetically inactive.

3.8.1.3 Zooplankton

Zooplankton in the Eastern Mediterranean can be categorized by size into microzooplankton (20 to 200 µm), mesozooplankton (>200 µm), and macrozooplankton (>2 mm). Zooplankton in surface waters rely on a phytoplankton-based food web, whereas zooplankton in the deep sea rely on a food web based on organic particulate material sinking out of the surface ocean.

Microzooplankton in the study area a diverse assemblage of small cells that consume bacteria and small phytoplankton such as *Synechococcus* spp. The microzooplankton community includes heterotrophic nanoflagellates (2 to 10 µm) and ciliates (10 to 350 µm), as well as autotrophic nanoflagellates (2- to 10-µm microzooplankton that have chloroplasts and can derive energy from sunlight, and are thus "mixotrophic") (Pitta et al., 2005). Both ciliates and autotrophic nanoflagellates are found in surface waters. Ciliate abundances are maximal in the surface mixed layer (0 to 50 m) where phytoplankton production is highest, while autotrophic nanoflagellate abundances are maximal just above the nutricline, at approximately 100-m depth (Tanaka et al., 2007). In contrast, no consistent pattern is found for heterotrophic nanoflagellates in surface and deep waters of the eastern Levantine Basin, although their abundance and bacterial abundances decrease with depth (Tanaka et al., 2007). Koppelmann et al. (2003) suggested that *Synechococcus* spp. is one of the primary mechanisms for nitrogen fixation in the Levantine Sea. This species is common in this basin (Li et al., 1993; Detmer, 1995) under oligotrophic conditions (e.g., Kress, 2000; Struck et al., 2001).

Mesozooplankton and macrozooplankton in the eastern Levantine Basin are extremely diverse. In surface waters between Sicily and Cyprus, for example, zooplankton communities are dominated by copepods (**Table 24**; Mazzocchi et al., 1997), specifically the small copepods *Clausocalanus furcatus*, *C. paululus, Oithona plumifera*, and *Farranula rostrata* (Siokou-Frangou et al., 1997). Lakkis and Sabour

(2006) also comment on 12 copepod species of Indo-Pacific origin that established permanent populations in Syro-Lebanese waters. Among them they point out *Calanopia elliptica*, *C. media*, *Labidocera pavo*, *L. madurae*, and *Centropages furcatus*. None of these dominant species have been found to contribute more than 22% of total copepod numbers, and another 91 copepod species were also enumerated in this region (Siokou-Frangou et al., 1997). In addition to copepods, at least 21 other zooplankton taxa are found in the eastern Levantine Basin, including medusae, siphonophores, ctenophores, heteropods, pteropods, molluscan larvae, polychaetes, cladocerans, ostracods, euphausiids, decapod larvae, isopods, amphipods, echinoderm larvae, chaetognaths, appendicularians, pyrosomes, doliolids, salps, and fish eggs and larvae (**Table 24**; Mazzocchi et al., 1997). Signs of seasonality have also been documented at depth (Weikert, 1995).

Table 24. Distribution of the main zooplankton taxonomic groups (%) and total zooplankton abundance in the eastern Levantine Basin (From: Mazzocchi et al., 1997).

Taxa	Percent Contribution and Total Zooplankton Abundance
Copepoda	82.91
Ostracoda	5.57
Appendicularia	4.17
Chaetognatha	1.52
Pteropoda	1.37
Salpida	1.06
Medusae	0.86
Polychaeta	0.82
Total zooplankton (individuals/m^3)	**114**
Total zooplankton (individuals/m^2)	**23,097**

Per Koppelmann et al. (2003) and Koppelmann and Weikert (2003; cited in CIESM, 2003), zooplankton investigations in the Eastern Mediterranean are largely restricted to the epipelagic and upper mesopelagic zones (Scotto di Carlo et al., 1991; Mazzocchi et al., 1997; Siokou-Frangou et al., 1997; Kovalev et al., 2001). Quantitative investigations of the deep-water column were done by Delalo (1966), Kimor and Wood (1975), and Pancucci-Papadopoulou et al. (1992), which focused on mesozooplankton (Weikert and Trinkaus, 1990; Weikert et al., 2001; Koppelmann et al., 2003) and microzooplankton (Böttger-Schnack, 1997). Information on the ecology of protozooplankton mainly refers to the upper layers (Pitta and Giannakourou, 2000; Pitta et al., 2001).

Koppelmann et al. (2009) recently characterized the trophic relationships of Eastern Mediterranean zooplankton based on isotope analysis; their findings confirmed the oligotrophic character of the region, identified atmospheric nitrogen as a source for the nitrogen pool of the Eastern Mediterranean, and noted that at least one deep-sea zooplankton species can utilize suspended particulates as a nitrogen source. This, however, does not negate the significant role that riverine input of allochthonous particulate material plays in contributing to secondary production in nearshore waters.

Only one study describes qualitative and quantitative aspects of the pelagic and benthic occurrence of heterotrophic nanoflagellates (Arndt et al., 2003). Microbial respiration in the deep Eastern Mediterranean was measured in 1995 by La Ferla and Azzaro (2001).

Mesozooplankton abundance in the Eastern Mediterranean is highest in the surface mixed layer (0 to 50 m) where phytoplankton are most productive. Abundance values decrease within mid-water depths (Böttger-Schnack, 1997; Mazzocchi et al., 1997).

In the Eastern Mediterranean, zooplankton abundance has been characterized to water depths of 450 m by Mazzocchi et al. (1997), Siokou-Frangou et al. (1997) and Lakkis and Sabour (2006). Copepods dominate the samples to water depths of at least 300 m. Cladocerans and appendicularians are found primarily in surface waters (0 to 100 m), and ostracods and chaetognaths are more abundant at depth (100 to 300 m). At the species level, the copepods *C. furcatus*, *C. paululus*, and *F. rostrata* were most abundant in the surface mixed layer (0 to 50 m), while *Haloptilus longicornis*, *Spinocalanus* spp., *Mormonilla minor*, and *Oithona setigera* became relatively more important with depth.

Lakkis and Sabour (2006), working in Lebanon, found macrozooplankton comprised the following groups, in descending order by species diversity: diverse planktonic larvae (200 species), Crustacea and crustacean larvae (150 species), Hydromedusae (75 species), Ctenophora (33 species), pelagic mollusks (15 species), Appendicularia (15 species), Chaetognatha (10), Thalicea (6) ichthyoplankton, Siphonophora, and Copepoda.

Smaller mesozooplankton were collected by Böttger-Schnack (1997) using a fine mesh (0.055-µm) plankton net during the *Meteor* Cruise 5 (MINDIK), with several stations to the south and west of the Michal and Matan Blocks (~25 km south of Matan; ~25 km west of Michal). Copepods again dominated the smaller mesozooplankton, but the dominant species were small *Oncaea* spp., especially *O. zernovi*. Biomass values at stations off Israel averaged 2.1, 1.0, 0.7, and 0.45 g (wet weight)/m^2 in the 0- to 100-m, 100- to 250-m, 250- to 450-m, and 450- to 1,050-m depth intervals, respectively, for day and night samples.

Mesozooplankton in the deep Levantine Basin (>500 m) have been sampled primarily near Crete (Böttger-Schnack, 1997; Weikert et al., 2001). These studies indicate the presence of a secondary maximum in mesozooplankton abundance in the deep-sea abyssopelagic zone (>2,250 m) that comprises primarily *Eucalanus monachus*. It is unknown whether this secondary maximum is present in the Michal or Matan Blocks, although one study found a reduction in *E. monachus* numbers in mid-water depths (500 to 1,000 m) near Cyprus (Trinkhaus, 1988, in Böttger-Schnack, 1997). Deep-sea fine mesh (0.055-µm) plankton net samples have been collected only near Crete and Israel, and these indicate that the community of deep smaller mesozooplankton are dominated by multiple *Oncaea* species in Levantine Basin waters (Böttger-Schnack, 1997).

Zooplankton biodiversity data specific to the Tamar Gas Field area are lacking, with the possible exception of the data acquired by Böttger-Schnack (1997) several tens of kilometers south and east of the gas field and the study by Galil (2004) which deals with near benthic plankton and features one station several tens of kilometers to the east of Tamar block and another station west of Hadera, which is located adjacent to the pipeline deployment corridor. However, based on sampling throughout the Levantine Basin, zooplankton diversity at the offshore gas field is expected to be high. Based on a review of research efforts in the Levantine Basin, the composition and variability present in microzooplankton and mesozooplankton communities is beginning to be properly characterized within the study area.

Nearshore plankton in the Eastern Mediterranean, especially prominent macrozooplankton, is characterized by the presence of gelatinous swarms of scyphomedusan jellyfish and ctenophores. Each summer since the mid-1980s, huge swarms of the invading jellyfish *Rhopilema nomadica* have appeared along the Levantine coast (Galil and Zenetos, 2002). In the last 3 years, however, a phase shift has occurred, presumably due to rising sea temperatures (Fuentes et al., 2010). Jellyfish swarms now appear year-round with an unwelcome addition – the comb jelly *Mnemiopsis leidyi* (Fuentes et al. 2009), which has invaded the Black Sea via ballast water and caused a massive commercial collapse of its pelagic fisheries. These massive swarms of voracious planktotrophs, some stretching 100 km long, draw nearer to shore, with the potential to adversely affect tourism, fisheries, and coastal installations. Local municipalities have reported a decrease in holiday makers frequenting the beaches because of the public's concern over the painful stings inflicted by the jellyfish. Coastal trawling and purse-seine fishing are disrupted for the duration of the swarming. Water intake pipes blocked with jellyfish pose a threat to cooling systems of port-bound vessels and coastal power plants; for example, Israel Electric Corporation has removed tonnes of jellyfish from its seawater intake pipes, at estimated costs of US$50,000 per year (Galil and Zenetos, 2002). The migrant *R. nomadica* are estimated to consist of hundreds of thousands of individuals per square nautical mile. Many of these medusae are large, with bells up to 80 cm in diameter, weighing as much as 40 kg (Lotan et al., 1992). In general, such high densities and biomass of jellyfish should affect the abundance of zooplankton and ichthyoplankton (medusan prey) in the surrounding waters. In addition, the fish populations are expected to suffer as a result of competition over food between the fish and jellyfish or by direct predation of the jellyfish on fish eggs and larvae (Purcell, 1997). Swarms are usually poly-specific and although *R. nomadica* is the most prominent species, jellyfish of Atlanto-Mediterranean origin such as *Rhizostoma pulmo* and *Aurelia aurita* are also commonly found in them. Another common migrant jellyfish species which co-occurs with these swarms in ever-growing numbers in recent years is the Lessepsian scyphomedusa *Phyllorhiza punctata* (Edelist et al., 2011c).

3.8.2 Seabed Communities

The benthos refers to animals (benthic fauna) and plants (benthic flora) that are found on (epifauna), in (infauna), or near the seabed. Benthic fauna are often sorted according to size into meiobenthos (<1 mm) and macrobenthos (>1 mm). Specific data on composition and ecology of benthic ecosystems specific to the study area are scarce, however, there is a growing data base for the Eastern Mediterranean and its continental shelf, slope, and deep-sea habitats.

3.8.2.1 Continental Shelf

Continental shelf environments (i.e., from the shallow subtidal to a water depth of ~100 m; Sade et al., 2007) are not found within the Tamar Gas Field but do occur between Mari-B and Ashdod. Benthic ecosystems along the continental shelf of Israel remain an area of research interest, with survey results and summaries occurring more frequently in the recent scientific literature. What is known concerning benthos along Eastern Mediterranean continental shelves is derived from regional studies or local surveys off the Israeli coast.

The nearshore coastal zone of the Mediterranean Sea is characterized by high species diversity due to variable climatic and hydrological conditions, the existence of specific biotopes, and the geological history of the basin. Exotic species also contribute to the observed species richness due to migration from the Red Sea through the Suez Canal (Fishelson, 2000; Rilov and Crooks, 2009), and Fuentes et al. (2010) has found that the soft sediment shallow (<83 m) benthos of the Israeli coast is inhabited by more migrants than indigenous fishes. A total of 10,000 to 12,000 marine species, encompassing approximately 8,500 macroscopic faunal species and 1,300 floral species, has been identified and recorded from the Mediterranean, representing 8% to 9% of the total number of species in the world's seas (European Environment Agency, 2006). As new areas are explored and new technological developments are used, additional species are continuously added to the list.

3.8.2.2 Macrofauna

Regional macrofaunal characterizations in the Eastern Mediterranean have provided some insight into the potential benthic community structure off the Israeli coast, particularly in the absence of site-specific benthic studies. For example, within the Eastern Mediterranean, Tselepides et al. (2000) determined macrobenthic faunal composition, abundance, biomass, and diversity together with a suite of sedimentary environmental parameters from seasonal sampling conducted over the oligotrophic continental margin of the island of Crete. It is noteworthy that these results represent a benthic community which is a considerable distance from the study area. Macrofaunal species composition was similar to that of the western Mediterranean and the neighboring Atlantic Ocean, with the identification of several common dominant species. Mean benthic biomass, abundance, and diversity decreased with depth, with a major transition zone occurring at 540 m, beyond which values declined sharply. At comparable depths, biomass and abundance values were considerably lower to those found in the Atlantic, highlighting the extreme oligotrophy of the area. The continental margin of Crete was characterized by a high diversity upper continental shelf environment dominated by surface deposit feeding polychaetes, and a very low diversity slope and deep-basin environment dominated by carnivorous and filter feeding polychaetes. Faunal boundaries were evident between 200 and 540 m, as well as beyond 940-m depth. Significant correlations between macrofauna and sediment parameters led to the conclusion that besides depth, food availability is the primary factor regulating the benthic community. Prevailing hydrographic features that structure the pelagic food web (and are directly responsible for the flux of organic matter to the benthos) also affect benthic community structure.

Lakkis and Sabour (2009) describe the groups of zoobenthos recorded on the Syro-Lebanese continental shelf to 200 m. Groups included sponges (26 species), Cnidaria (5), Polycheta (130), Mollusca (150), Crustacea (87), Echinodermata (12), Ascidia (6), and others (**Figure 46**). About 35% of the marine species occurring in Lebanese waters were common with the fauna of the Red Sea, and 75% of the species were also present in the western Mediterranean.

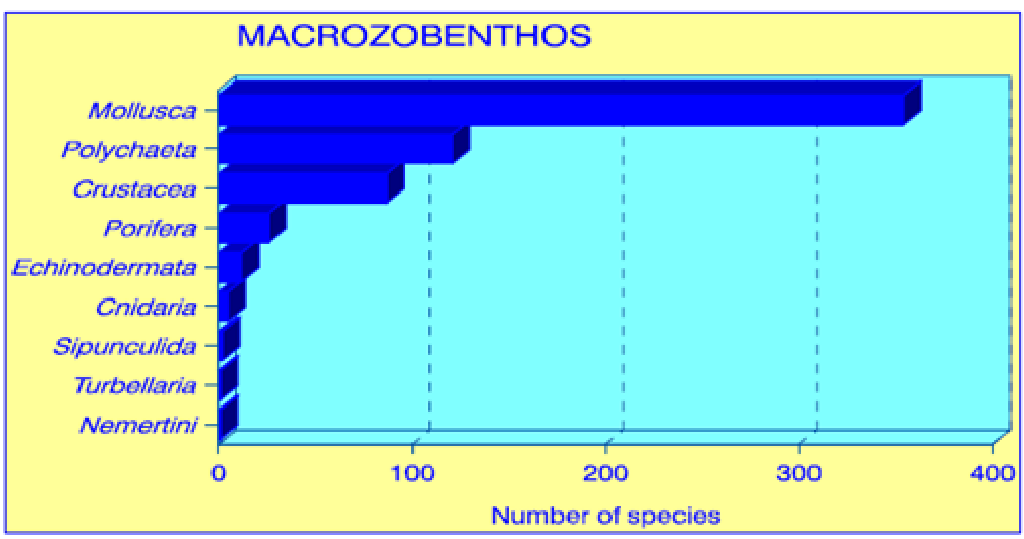


Figure 46. Major benthic faunal groups on the Syro-Lebanese continental shelf to 200-m water depth (From: Lakkis and Sabour, 2009).

Galil and Lewinsohn (1981), sampled and characterized the communities of the Israel continental shelf (i.e., 18- to 80-m water depths along an east-west transect off of Palmachim) using beam trawls and dredges. In general, they found macrofaunal species composition to be similar to that of the western Mediterranean and neighboring Atlantic Ocean environments with one exception – the sandy-mud associations encountered within the 35- to 50-m depth range had no parallels outside of the Israeli coast; this was attributed to the absence of typical Atlantic-Mediterranean species and the presence of Indo-Pacific species that had arrived via the Suez Canal. Of the 245 species identified, 26 taxa were of Indo-Pacific origin. Benthic communities of the Israeli shelf were dominated by mollusks (66 species), crustaceans (61 species), and polychaetes (50 species).

Ben-Eliahu and Fiege (1996), sampling within the central and Eastern Mediterranean, summarized a series of dredge and trawl samples acquired in the Levantine Basin as part of the R/V *Meteor* 5 and 25 surveys, as well as shallow water samples collected by the R/V *Shikmona* on the Israeli shelf. Their analysis concentrated on serpulid polychaetes found in association with hard bottom or rocky outcrops. "Biogenic concretions" and rocky outcrops were observed to be sporadic along the Israeli coast from the intertidal to 120 m. These are sandstone or 'Kurkar' ridges, which are also ancient shoreline markers. Along the northern coast of Israel, in particular, a series of these outcrops runs parallel to the coast at water depths of 7, 15, 20 to 30, 40 to 60, and 110 to 120 m (Mart and Belknap, 1991), with associated epifauna. Within these ridges, migrants outcompete indigenous fauna, with many hard surfaces covered by the invasive bivalve *Spondilus spinosus*, which is well established off the northern coast of Israel and forms dense populations of up to 15 specimens/m^2. Diverse serpulid polychaete assemblages are found in these topographically complex and stable biogenic substrates, including intertidal vermetid reefs (Ben-Eliahu, 1976; Ben-Eliahu and Safriel, 1982) and the *Cladocora cespitosa* and coralligenous conglomerates found between 12 and 30 m. Opportunistic settlement is also evident – where biogenic debris (e.g., decapod shells, sea urchin tests, gastropod, and bivalve shells), pumice, hardened clay, and anthropogenic debris is utilized by hardbottom species. Their analysis of nearly 500 samples from the R/V *Meteor* 5 and 25 and R/V *Shikmona* cruises covered water depths between the intertidal to 4,770 m. Their analysis also provided a summary of serpulid polychaetes recorded to date within the Levantine Basin, including shallow and deep-water hard bottom benthic environments off Israel; results indicated the presence of 47 polychaete taxa belonging to 20 genera in this region.

The R/V *Meteor* cruises have provided a significant source of benthic data, particularly in terms of characterizing polychaete species. Ben-Eliahu and Fiege (1995) characterized the polychaete fauna from the continental shelf and slope of Israel, as collected by the R/V *Meteor* 5 expedition completed in 1987. Fiege et al. (1999) characterized the macrobenthos of the Israel shelf based on analysis of the R/V *Meteor* 40 cruise from 1997 and 1998.

Galil and Goren (1994), working predominantly in deepwater but also sampling near the shelf break off Israel (west of Atlit), identified several species of crustaceans and echiurid worms. No differentiation was made regarding deep and shallow water fauna.

Overall, benthic faunal biomass and abundance determinations can be expected to be higher on the continental shelf than on the continental slope or in the deep sea in this region, due in part to the extreme oligotrophy of the Eastern Mediterranean and the limited number of surveys conducted beyond the shelf break. Expanded survey activity off Israel has resulted in further identification and an increase in the number of known species.

From both a commercial and ecological perspective, an important group of soft sediment burrowing crustaceans includes several very common macrouran shrimps. The habitat of the high priced invasive prawn *Marsupenaeus japonicus* is in shallow, sandy bottoms normally between 15- and 40-m depths. These prawns emerge from their dens to forage at night and are often targeted by local trawlers. Other very common, noncommercial crustaceans in this habitat include the prawn *Metapenaeopsys aegyptia*, the stomatopod *Erugosquilla massavensis*, and the brachyuran crab *Charybdis longicollis*. In deeper waters, only indigenous shrimps are found inhabiting the muddy substrate. At 80 to 200 m, rose shrimp *Parapenaeus longirostris* are found in great numbers and biomass during both daytime and nighttime. Even deeper, at 200 to 800 m, red shrimps *Aristeomorpha foliacea* and *Aristeus antennatus* dominate the assemblages, performing vertical migrations to the upper limits of their bathymetric distribution at night. Red and rose shrimps are caught primarily in the north of Israel. Fishermen of south Israel have not developed the rose and red shrimp deepwater fishery due to a combination of circumstances: lower prices for these species than for *M. japonicus,* higher costs of extracting them (rising fuel prices and the greater distance from shore of the deeper grounds), and recent declines in hake (*M. merluccius)* – the main commercial fish species of the deeper shelf and upper slope, have discouraged southern trawlers from venturing into deeper grounds.

Of the shallow sandy habitat mollusks, one species stands out – the invasive gastropod *Conomurex persicus*. Mutlu (2004) estimated that *C. persicus* produces as much as 58% of the total community respiration and 75% to 93% of the total biomass along the shallow (20 m) Syrian coasts, exhibiting density levels of tens of individuals/m^2. Meinis (2004) found *C. persicus* to occur in very dense numbers in sandy habitats at depths of 5 to 25 m along the Israeli coast, where it forms a major competitor of any herbivorous species. Another prominent benthic mollusk group includes the cephalopods – cuttlefish, octopi, and squids. Of these, the longfin squid *Loligo vulgaris* is the most common, representing 5% to 6% of the catch of Israeli bottom trawlers on the continental shelf (Snovsky and Shapiro, 2003; Shapiro, 2007). On the deeper slope, this species is replaced by deepwater squids such as *Illex coindetti* and even deeper by *Neorossia caroli* (Goren, 2006).

3.8.2.3 Meiofauna

For foraminiferan communities of the Eastern Mediterranean, the shallow continental shelf off Israel constitutes the distal part of the siliciclastic Nile littoral cell. Foraminiferal faunas were collected from a north-south transect parallel to the coast at ~40-m depth and characterized by Hyams et al. (2001). Living and dead benthic foraminifera were examined at intervals of 0.5 or 1.0 cm, from the surface down to 5 cm. Abundance, diversity, and composition of living and dead assemblages of benthic foraminifera vary according to substrate and location. Assemblages of the carbonate substrate north of Haifa grade into the more siliciclastic substrate of the southern shelf, controlled by Nilotic factors. Vertical distribution of living foraminifera in the top 5 cm of sediment is controlled by oxygen concentration, substrate, and seasonal changes. Sandy-silty sediments of the northern shelf are more carbonate-rich, seagrass dominated, are better ventilated, and have a more abundant and diverse fauna than do the equivalent sediments from south of Haifa. Living foraminifera are found through the upper 5 cm of sediment, with hyaline plano-convex species prominent.

Based on box core samples collected along bathymetric transects spanning the length of the Mediterranean, De Rijk et al. (2000) reported a broad peak in species richness between 200 m and 1,000 m, below which richness decreased to 4,000 m, the maximum depth sampled. When the bathymetric distributions of individual species are considered, the upper and lower depth limits are usually found to be shallower in the more oligotrophic eastern basins than in the more eutrophic western basins.

To the south, Nile-derived silty-clayey sediments bear an assemblage dominated by thin, smooth-tested forms with rounded periphery, mostly planispiral to low trochospiral. More dysoxic, clayey sediments here had living benthic forams limited mostly to the uppermost 2 cm, although a few were found deeper, mimicking deep infaunal species. Some species known to be epiphytes were found free in clayey sediment between 4 and 5 cm, and appear highly tolerant to a variety of oxygen levels.

Taphonomy significantly affected assemblages of agglutinated foraminifera with organic cements. Some very abundant living species were absent or rare in the dead assemblages due to post-mortem disintegration of their delicate tests. Alternatively, some miliolids showing high abundances in the dead assemblage were rarely found alive, indicating seasonality or high rates of turnover.

Recent work by Edelman-Furstenberg (2008) identified meiofaunal differences between the area of the sewage outlet of the Tel-Aviv metropolitan area (Shafdan) and a control area. Data show that species richness and number of specimens per gram sediment are considerably lower in the impacted area than those from the control stations. Unexpectedly, there is a considerable difference in species richness and total abundance per gram sediment between summer and winter in death assemblages from the treated sewage outlet station, similar to that seen in the live benthic foraminifera data. This may point to extremely high sedimentation rates for this station, on the one hand, and extremely strong impact of the sewage on the fauna, on the other hand.

3.8.2.4 Slope and Deep-sea Habitats

Benthic fauna in continental slope and deep-sea habitats in the Mediterranean Sea are characterized by the fact that 1) they live across a wide range of water depths (are eurybathic), 2) they comprise very few true deepwater species, and 3) the number of endemisms generally declines with increasing depth (Cartes et al., 2004). The first two characteristics are the result of extinctions of deepwater fauna in the Quaternary Period during recurring stagnant (dysoxic and anoxic) episodes (Van Harten, 1987). Stagnation would have precluded colonization by fauna until less than 6,000 years ago (Galil and Goren, 1994), although the eastern deep basins formed approximately 2 million years ago (Por and Dimentman, 1989). Deep-sea fauna now found in the eastern Levantine Basin have historically been considered to be extremely impoverished in terms of species number, in part because the deep eastern basin is separated from the western Mediterranean by the Siculo-Tunisian sill (approximately 400 m; Pérès, 1985). The low diversity and species richness are also due to differences in temperature, salinity, and food supply between Atlantic and Mediterranean waters. More recent surveys, however, indicate a different interpretation. Results of the R/V *Nautilus* survey conducted off the Israeli slope between 5 and 14 September 2010, a portion of which occurred on the Matan Block (which includes the Tamar gas field), suggest that deep-sea species diversity in the Levantine Basin is not as low as originally thought.

The abyssal basins of the Eastern Mediterranean are extremely unusual deep-sea systems. With water temperatures at 4,000 m in excess of 14°C (rather than <4°C for other deep oceanic basins), the entire benthic environment is as hot as the water around a hydrothermal vent system, but lacks the vents' rich chemical energy supply. The Mediterranean also differs from other deep-sea ecosystems in terms of its species composition, notably the absence of the near-ubiquitous deepwater grenadier fish *Coryphaenoides armatus* and the amphipod *Eurythenes gryllus*. Instead, *Acanthephhyra eximia* appears to have functionally replaced *E. gryllus*, the dominant deep-sea scavenging crustacean throughout most of the world's oceans (Christiansen, 1989). There are, however, grenadier fish in Levantine deep waters, the most common of which is *Coelorinchus coelorinchus*, observed by R/V *Nautilus* in its survey near the Tamar Field.

Other notable finds in the R/V *Nautilus* survey of the Palmachim disturbance geological feature include the first-time discovery of heterotrophic cold-water coral reefs in Israel. These corals are anthipatharians, such as these found by Zibrowius and Taviani (2005) in the straits of Sicily. While no corals of the genus *Lophelia* or *Madrepora* were found, the area scanned is small and their presence cannot be ruled out. These unique habitats, observed in the R/V *Nautilus* survey at 650-m depth west of Tel-Aviv, were shown to provide habitat to a diverse fauna of deepwater cephalopods, crustaceans, and fishes.

Danovaro et al. (2010) have summarized all available information on benthic biodiversity (i.e., prokaryotes, foraminifera, meiofauna, macrofauna, and megafauna) in different deep-sea ecosystems of the Mediterranean Sea (i.e., from 200- to >4,000-m water depths), including open slopes, deep basins, canyons, cold seeps, seamounts, deep-water corals, and deep-hypersaline anoxic basins and analyzed overall longitudinal and bathymetric patterns. Results indicate that, in contrast to what was expected from the sharp decrease in organic carbon fluxes and reduced faunal abundance, the deep-sea biodiversity of both the eastern and the western basins of the Mediterranean Sea is similarly high. All of the biodiversity components, except Bacteria and Archaea, displayed a decreasing pattern with increasing water depth, but to a different extent for each component. Unlike patterns observed for faunal abundance, highest negative values of the slopes of the biodiversity patterns were observed for meiofauna, followed by macrofauna and megafauna (**Figure 47**).

Details on the estimates of area per bathymetric range and the average abundance of each component, as presented in **Figure 47**, are summarized in Costello et al. (2010).

3.8.2.5 Macrofauna

Overall, mean benthic biomass, abundance, and diversity decrease drastically with depth in the Eastern Mediterranean, with major faunal transitions occurring at 200, 500, and 1,000 m (Tselepides et al., 2000). It remains to be determined if these major faunal transitions are present within Israeli shelf, slope, and basin environments. As these transitions are a product of the area and methodology of sampling, they are rather lithe in nature and may shift in as much as hundreds of meters in different environments, measuring resolution and methodology and site-specific bathymetric properties. However, given the bathymetric macrofaunal surveys of the Levant (Kröncke et al., 2003; Jones et al., 2003; Galil, 2004) and its bathymetric nature, it is generally accepted that faunal shifts occur at 100 to 120 m (i.e., shelf-slope break) and at 650 to 1,000 m (i.e., slope-rise breaks).

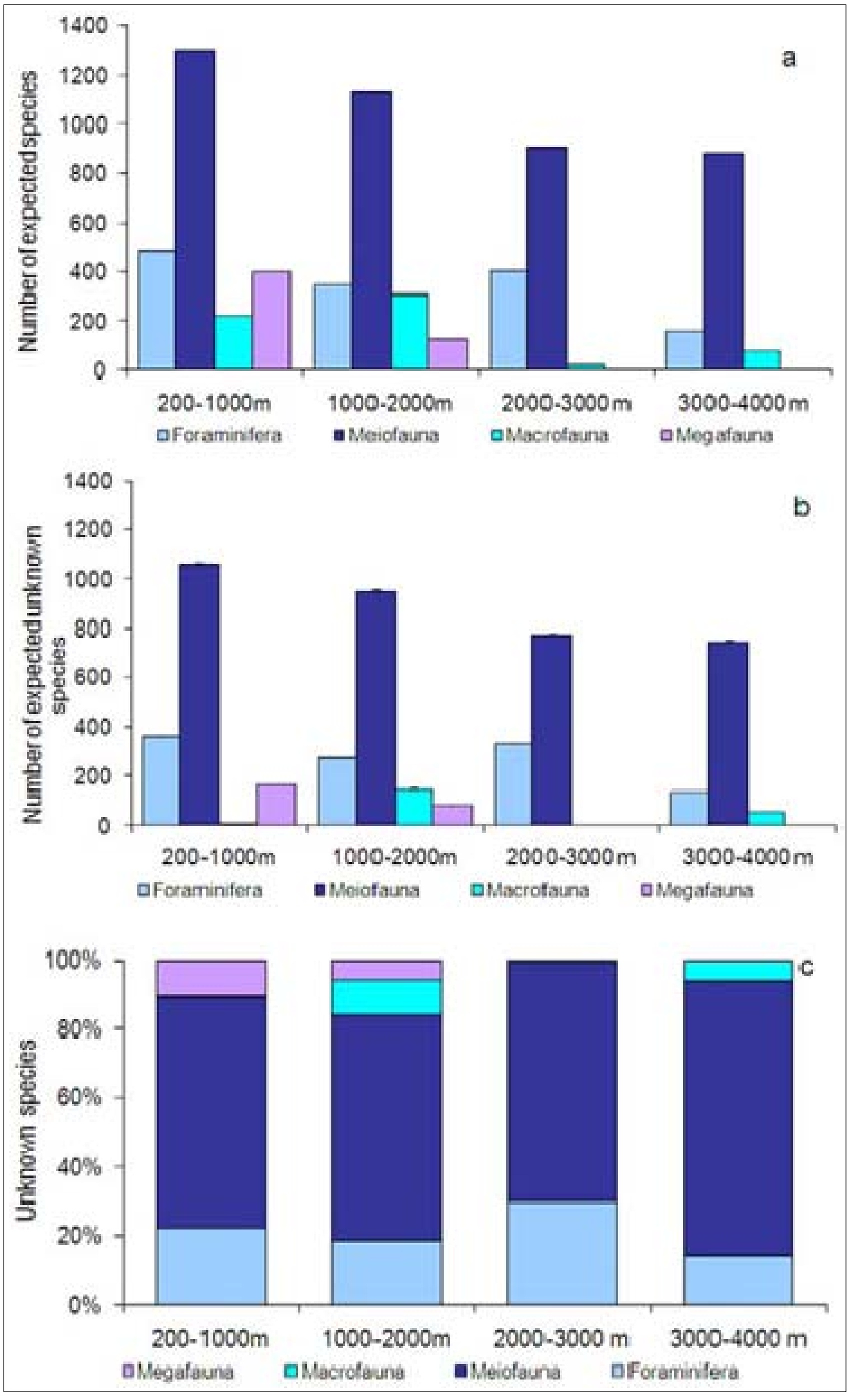


Figure 47. Expected number of species for each deep-fauna component within the sea bottom extension of each depth interval. Reported are a) total number of expected species, b) total number of unknown expected species, and c) the relative contribution of unknown expected species on total diversity for foraminifera, meiofauna (as Nematoda), macrofauna, and megafauna (From: Costello et al., 2010).

Kröncke et al. (2003) summarized two surveys conducted by the R/V *Meteor* in summer 1993 and winter 1997-1998 during which the structural and functional diversity of the benthic system of the highly oligotrophic Eastern Mediterranean deep sea was investigated. Macrofauna communities were dominated by polychaetes even at the deepest stations. The fauna at shallow stations was dominated by surface deposit feeders, whereas subsurface deposit feeders and predators generally increased with depth. A high percentage of suspension-feeding sponges (Porifera) was noted within the Levantine Basin. Mean abundance and number of taxa of both expeditions were significantly negatively correlated to depth (i.e., diversity and abundance decreased with increases in depth) and distance from shore (i.e., diversity and abundance decreased with increasing distance from shore). Mean abundance and diversity were positively correlated with sediment TOC content. While numbers of taxa and abundance generally decreased with depth, lowest numbers were not found at the deepest stations but in the extremely oligotrophic Levantine Basin. The significant correlations found for TOC content and distance from shore reflected the role of hydrographically governed transport of organic matter produced in coastal regions into greater and extreme depths of the Mediterranean Sea. Seasonal differences in macrofauna communities due to seasonal differences in food supply were not found. However, recent large-scale hydrographic changes (e.g., Eastern Mediterranean Transient [EMT]) might change the oligotrophy and, thus, the structure of the benthic communities in the Eastern Mediterranean deep sea. The origin and evolution of the EMT has been summarized by the CIESM (2000).

One station (Station 36) summarized by Kröncke et al. (2003) was located several kilometers from the Michal and Matan Blocks in 1,500 m of water. Predominant macrofaunal species from this site, summarized in **Table 25**, included echiurid worms, polychaete worms, nematodes, and holothuroids. Mean abundance at this station was ~50 individuals/0.25 m^2.

Table 25. Predominant macrofauna of the Israel slope sampled during the R/V *Meteor* cruise (Adapted from: Kröncke et al., 2003). Taxa entries represent multiple species.

Taxa	Common Name	Mean Abundance (Number of Taxa/0.25 m^2)
Echiurida	Echiurans (spoon worms)	16
Spionidae	Polychaetes (segmented worms)	12
Nematoda	Nematodes (worms)	6
Holothuroidea	Echinoderms, sea cucumbers	6
Scyphozoa	Benthic jellyfish (Stauromedusae)	3
Capitellidae	Polychaetes (segmented worms)	2
Syllidae	Polychaetes (segmented worms)	1
Paraonidae	Polychaetes (segmented worms)	1
Cirratulidae	Polychaetes (segmented worms)	1
Maldanidae	Polychaetes (segmented worms)	1
Isopoda	Crustacean, isopods	1

Per Basso et al. (2004), the benthic macrofauna of the deep Eastern Mediterranean appears to be sparse or depauperate with few exceptions (Fredj et al., 1992; Fiege et al., 2000). The available data for the deep-sea environments of the Eastern Mediterranean are extremely scarce. In the oligotrophic south Aegean Sea, over the continental slope of Crete, the macrobenthos distribution sharply decreases with depth and is limited by food availability, which in turn depends on the pelagic food web and its hydrological framework (Tselepides and Eleftheriou, 1992). Similar characteristics are expected off the coast of Israel. The macrobenthic activity in the eastern basin at sites far from the continental shelves is expected to depend mainly on primary production from surface waters; therefore, its intensity should mirror the trophic quality of the seawater (Basso et al., 2004).

Sampling at several deepwater dumpsites off the Israeli coast by Goren et al. (2006) encountered four species of interest, including the bobtail squid, *Neorossia caroli caroli*; the deep-sea asteroid, *Brisingella coronata*; and the tonguesole, *Symphurus ligulatus*, all of which were new records for the Levant Sea. A fourth species of interest, the four-horned octopus, *Pteroctopus tetracirrhus*, was a new record for the Israeli coast. As noted by Goren et al. (2006), there is a growing list of bathybenthic species, which has resulted from expanded research efforts into slope and basin environments of the Levantine, challenging the conventional view of diminished Levant deep-sea biodiversity.

Per Tyler (2005), quantitative analyses of macrofauna in deep water of the Eastern Mediterranean are limited. Tselepides and Eleftheriou (1992) quantified macrofaunal distribution between 200 and 985 m, assessing the importance of environmental variables. Biomass, abundance, and species diversity decreased with depth, particularly below 500 m. Dominant macrofauna were polychaetes, with surface deposit feeders and carnivores dominating at the shallowest (200 m) and deepest (985 m) sites, respectively.

As described in Galil (2004) and Jones et al. (2003), the major macrofaunal species recorded in the deep Levantine Sea (1,000 to 4,264 m), including the region of the Tamar Gas Field, were characterized as follows:

- Decapod Crustaceans – A total of 2,819 specimens was collected representing 19 decapod crustacean species. The Mediterranean endemic geryonid crab *Chaceon mediterraneus* was photographed southwest of Cyprus at a depth of 2,900 m. Eight species were new records for the Israeli coast. *Polycheles typhlops*, *Acanthephyra eximia*, *Aristeus antennatus*, and *Geryon longipes* were the most common decapod species, accounting for 48%, 25%, 14%, and 7% of the specimens, respectively. *Polycheles typhlops* was the most common decapod in the Levantine samples.
- Amphipod Crustaceans – A total of 673 specimens was collected representing 22 species of amphipod crustaceans. Four species were newly recorded for the Israeli coast. Four of the 22 deep-sea amphipod species collected were Mediterranean endemics, two of which (*Ileraustroe ilergetes* and *Pseudotiron bouvieri*) represented 40% and 15% of the specimens, respectively. The next most common species were *Rhachotropis rostrata* and *Stegophaloides christianiensis*, representing nearly 11% of the specimens. *Ileraustroe ilergetes* is the most common amphipod in the Levantine Basin.
- Cumaceans – A total of 575 specimens was collected representing 12 cumacean species. *Procampylaspis bonnieri* was the most frequently collected, representing 33% of the specimens. *Campylaspis glabra* was the next most common species with nearly 13%, followed by *Makrokylindrus longipes*, *Platysympus typicus*, and *Procampylaspis armata*, each accounting for nearly 11% of the specimens. The most common and abundant species in the Levantine samples was *Procampylaspis bonnieri*.
- Molluscs – A total of 4,580 specimens was collected representing 42 mollusc species. In depths greater than 1,000 m off the Israeli coast, the most common benthic mollusks were *Benthonella tenella*, *Kelliella abyssicola*, *Yoldia micrometrica*, *Cardyomia costellata*, *Entalina tetragona*, *Benthomangelia macra*, and *Bathyarca pectunculoides*. The same species were identified by Janssen (1989; as cited by Galil, 2004) in material sampled by box core at a station off the Israeli coast at 1,217 m.

- Echinoderms – A total of 16 specimens of a single synallactid holothurian species, *Mesothuria intestinalis*, was collected.

Galil and Goren (1994) summarized the results from a series of 12 cruises conducted between 1988 and 1991, sampling predominantly within the bathyal regions (i.e., generally between 1,240 and 1,550 m) off the coast of Israel. Sampling sites included several locations just inshore of the Tamar Gas Field. New records for the Levantine Basin were noted, including crustaceans (*Eryonekus kempi, Munidopsis marionis, Bathynectes maravigna, Geryon longipes*) and echiurids (*Echiurus abyssalis*, *Bonellia viridis*). The distribution of 18 more species was also extended to the easternmost boundary of the Mediterranean.

Recent benthic literature for Israeli deepwater environments has focused on specific taxonomic groups. Bogi and Galil (2003), sampling between 1994 and 1999 at four stations (off the northern coast of Israel) in water depths between 734 and 1558 m, characterized the bathypelagic and pelagic molluscan fauna. Results included the identification of 43 molluscan species, nearly half of which were dead specimens. The most common benthic mollusks in waters >1,000 m off the Israeli coast were the Atlantic-Mediterranean and Boreal species *Yoldia micrometrica* (83 of 90 samples), *Kelliella abyssicola* (77 of 90 samples), *Cardyomia costellata* (76 of 90 samples), *Entalina tetragona* (63 of 90 samples), *Benthomangelia macra* (59 of 90 samples), *Benthonella tenella* (50 of 90 samples), and *Bathyarca pectunculoides* (33 of 90 samples). The same species were identified by Janssen (1989) in box core samples from 1,217 m water depths off the Israeli coast. Bogi and Galil (2003) noted that *K. abyssicola*, *C. costellata*, *E. tetragona*, and *B. pectunculoides* are eurybenthic species with upper bathymetric ranges well within the circalittoral (i.e., <150 m), while *B. macra* and *B. tenella* are stenobathic.

Kress et al. (1993) reported the results of a monitoring study of the disposal of coal fly ash in the Eastern Mediterranean. The coal fly ash was dumped 70 km offshore from the coast of Israel, at 1,400-m depth, approximately 40 km from the Tamar site. A comparison of the benthic fauna at the center of the disposal site with that of a control area indicated a severe impoverishment of the benthos in the affected area.

While Galil and Goren (1994) suggest that the extreme poverty of the deep Levantine fauna is due, in part, to recurrence of anoxic conditions at bathyal depths during the Quaternary, and the general consensus is that deepwater fauna of the Levantine Basin are depauperate when compared to the shallower continental shelf environment, increased survey activity in the Levant suggests that benthic species diversity in this region is not as low as previously thought (Goren et al., 2006, Danovaro et al., 2010).

3.8.2.6 Meiofauna

Few studies have examined deepwater benthic fauna in the study area region off Israel, but, based on existing evidence, Galil (2004) has characterized these communities as diverse but scarce, consisting of "autochthonous, self-sustaining populations of opportunistic, eurybathic species." Results from Cruise 25/1 of the R/V *Meteor* in 1993 revealed a strong dependence of meiofaunal abundance on depth, distance from the coast, and food (labile organic carbon) availability (Tselepides and Lampadariou, 2004). The meiofaunal community was dominated by nematodes, harpacticoid copepods, and polychaetes (**Table 26**).

Table 26. Relative abundance (%) of nematodes and the less abundant meiofaunal taxa (individuals/10 cm^2) collected in the Eastern Mediterranean region (From: Tselepides and Lampadariou, 2004).

Taxa	Relative Abundance (%)		
	33°19.94' N, 33°24.92' E[1]	34°26.06' N, 32°36.83' E[2]	33°59.89' N, 32°10.70' E[3]
Nematoda	64.4	41.4	50.5
Copepoda	13.3	24.3	25.2
Copepoda nauplii	15.3	29.0	10.4
Polychaeta	2.8	4.2	11.7
Gastrotricha	0.3	--	0.5
Ostracoda	0.1	0.2	--
Tardigrada	0.3	--	--
Turbellaria	3.3	0.7	1.4
Tanaidacea	--	--	0.5
Sipuncula	0.1	--	--

[1] ~60 NW of Matan Block.
[2] ~150 km NW of Matan Block.
[3] ~180 km NW of Matan Block.

Tselepides and Lampadariou (2004) noted highest total meiofaunal abundance values near the Israeli coast and over the shallow continental shelf off the Nile delta (i.e., 435 and 304 individuals/10 cm^2, respectively). In the Mediterranean, meiofauna abundance and community composition change with water depth and distance from shore and are influenced by food availability (i.e., sedimentary chlorophyll pigment, organic carbon).

In general, measured meiofaunal abundances were very low, as was the case for macrofaunal abundances inferred from bioturbation proxies during a different study (Basso et al., 2004). These facts, as well as microbial enzyme activity data obtained during Cruise 25/1 of the R/V *Meteor* (Boetius et al., 1996), point directly to the ultra-oligotrophic nature of the eastern Levantine Basin.

Danovaro et al. (1995) also characterized deep-sea meiofauna of the Eastern Mediterranean, however, their stations were not near the Tamar Gas Field. Danovaro et al. (2001), citing significant changes in the physico-chemical characteristics of deep waters in the Eastern Mediterranean during the 1990s, documented the accumulation of organic matter on the deep seafloor, alteration in the carbon and nitrogen cycles of the benthic ecosystem, and negative effects on deep-sea bacteria and benthic fauna. Evidence from a miniature ocean model provided by Danovaro et al. (2001) provided a unique method for interpreting signals from the deep sea and indicated that deep-sea ecosystems respond quickly to climate change.

Danovaro et al. (2004), sampling the deep waters of the Eastern Mediterranean, further evaluated nematode populations to investigate the response of deep-sea biodiversity to the climate anomaly that modified the region's physico-chemical characteristics. Using data from 1989-1998, the authors provided evidence that deep-sea nematode diversity can be strongly and rapidly affected by temperature shifts. Abrupt decreases in temperature (i.e., ~0.4°C) and modified physico-chemical conditions that occurred between 1992 and 1994 caused a significant decrease in nematode abundance and a significant increase in diversity.

3.8.2.7 Chemosynthetic Communities

Another habitat – chemosynthetic benthic communities, driven by the biological oxidation of sedimentary methane – has not yet been fully documented in this region but reports from the Hotspot Ecosystems Research on the Margins of European Seas (HERMES) project map such habitats several tens of kilometers to the northwest of the Tamar Gas Field (Weaver et al., 2004). Surveys designed to locate chemosynthetic communities in the Eastern Mediterranean (via remote identification of small depressions or surficial pockmarks) have been described in various locations by Dimitrov and Woodside (2003) and Bayon et al. (2009). Verification of the absence of chemosynthetic communities along the pipeline corridor was determined during the geohazards survey.

In the southeastern Mediterranean, communities of polychaetes and bivalves were found associated with cold seeps and carbonates near Egypt and the Gaza Strip at depths of 500 to 800 m, but no living fauna was collected (Coleman and Ballard, 2001). During submersible dives, communities comprising large fields of small bivalves (dead and alive), large siboglinid tube worms (either isolated or forming dense aggregations), large sponges, and associated endemic fauna were observed in various cold seep habitats associated with carbonate crusts at depths of 1,700 to 2,000 m. Several provinces of the Nile deep-sea fan have been explored recently (Danovaro et al., 2010), including the very active Menes Caldera brine seepage in the eastern province between 2,500 and 3,000 m and the pockmarks in the central area along mid- and lower slopes (Bayon et al., 2009). As many as five bivalve species harboring bacterial symbionts are known to colonize these methane- and sulfide-rich environments. A new species of Siboglinidae polychaete, the tubeworm colonizing cold seeps from the Mediterranean ridge to the Nile deep-sea fan, has just been described. Moreover, the study of symbioses has revealed associations with chemoautotrophic bacteria, including sulfur oxidizers in Vesicomyidae and Lucinidae bivalves and Siboglinidae tubeworms, and has highlighted the exceptional diversity of bacteria living in symbiosis with small mytilid bivalves. Mediterranean seeps appear to represent a rich habitat characterized by megafaunal species richness (e.g., gastropods) or the exceptional size of some species such as sponges (*Rhizaxinella pyrifera*) and crabs (*Chaceon mediterraneus*). This contrasts with the perceived nonseep characteristics of low macrofaunal and megafaunal abundance and diversity of the deep Eastern Mediterranean (Danovaro et al., 2010). Seep communities in the Mediterranean that include endemic chemosynthetic species and associated fauna differ from the other known seep communities in the world both at the species level and by the notable absence of the large size bivalve genera *Calyptogena* or *Bathymodiolus*. The isolation of the Mediterranean seeps from the Atlantic Ocean after the Messinian crisis led to the development of unique communities, which are likely to differ in composition and structure from those in the Atlantic Ocean.

3.8.3 Fish and Other Nekton

The distribution and abundance of nekton of the Levantine Basin are determined, to a large extent, by the mesoscale oceanographic features of the Mediterranean Sea. The Mediterranean gets most of its nutrient salts from surface layers of the Central Atlantic, where nutrient levels are moderate. The Atlantic Water that enters the Mediterranean through the Strait of Gibraltar follows the northern coast of Africa, with various branches from circulation eddies on the way, and reaches the Eastern Mediterranean, where water travels mainly in an anticlockwise rotation in the Shiqmona Gyre. On the way to the Eastern Mediterranean, nutrients enter into various life cycles and are either landed as fish or sink to the lower layers of the sea, with the Eastern Mediterranean receiving whatever nutrients are left.

On its way through the Mediterranean, seawater becomes not only oligotrophic but also warmer and very salty, hence denser. In the area offshore Israel, this water (known as Mediterranean Surface Water) sinks in a downwelling pattern to the intermediate layer and moves west during the winter. Ultimately, these waters (i.e., LIW) flow out of the Mediterranean and into the Atlantic through the lower strata of the Strait of Gibraltar. Levantine Intermediate Water has been tracked all the way to the Caribbean based, in part, on the nutrients that have dropped into it as organic debris.

With this general pattern, the productivity of the sea offshore of Israel is estimated to be even lower than productivity of the rest of the Eastern Mediterranean and is termed ultra-oligotrophic. The presence of a strong seasonal thermocline may also have a significant effect on the vertical distribution of marine life, as it limits vertical mixing and the provision from more nutrient rich deep layers.

The Mediterranean has its own specific fauna and flora as a result of its origins and peculiar hydrography. The marine fishes of the eastern Levant have been studied by several authors. A historical account of these studies was developed by Golani (1996). The first general study of the Israeli marine ichthyofauna was by Ben-Tuvia (1953), who later revised this list (Ben-Tuvia, 1971). Another comprehensive study of the ichthyofauna of this region (Golani, 1996) included species from adjacent countries, such as Cyprus, southern Turkey, and Egypt (Golani, 2005).

3.8.3.1 Nearshore Environment

Fishes of the nearshore environment of Israel have not been thoroughly characterized. Some information regarding nearshore fishes off Israel have been derived from peripheral studies. Walline (1987) studied the abundant clupeoids of the Israeli coastal zone – *Engraulis encrasicolus*, *Sardina pilchardus*, and *Sardinella aurita* – in his analysis of growth and ingestion rates of larval fishes in pelagic waters of coastal Israel. Due to the extremely oligotrophic marine environment, species richness and fish biomass and abundance along Israeli coasts is low. When the base of a food web is limited, the upper levels (in this case, piscivore fish) are expected to be accordingly narrow. Another main limiting resource is thought to be lack of habitat, which stems from shortage in vertical relief and structural complexity (Edelist and Spanier, 2009). The natural rocky outcrops of the Israeli coast are mostly submerged sandstone (Kurkar) ridges – these are aeolinite sand dunes lithified with time by mostly calcium-sand deposits. They are markers of ancient shorelines that form sets of ridges parallel to shore. Underwater, only their uppermost structure (1 to 2 m) endures the harsh wave and sand erosion. These outcrops, along with the rocky coralligenous extension of the Carmel range, account for less than 10% of the Israeli continental shelf area (Adler, 1985) whereas the rest of the nearshore shelf is comprised of vast sand and mud flats (approximately 3,500 km^2 in area) which are strewn with a few random sunken shipwrecks and other man-made reefs.

Edelist (unpublished data) has been quantifying the shelf fauna of Israel via trawl surveys as part of his doctoral research at the University of Haifa for the past 3 years. He describes (**Table 27**) the most dominant fish species contributing to the Levantine sandy (<37 m) and muddy (>38 m) habitats.

Table 27. Contribution of the 10 most common fish species to 208 trawl hauls carried out in three depth strata along the Israeli coast in 2008-2011 (From: Edelist, unpublished data).

Depth	Origin	Species	Contribution (%)
Shallow Stratum 15-37 m	Lessepsian	*Nemipterus randali*	11.77
	Lessepsian	*Plotosus lineatus*	11.75
	Lessepsian	*Callionymus fillamentosus*	9.55
	Lessepsian	*Lagocephalus suezensis*	7.57
	Lessepsian	*Saurida undosquamis*	7.5
	Lessepsian	*Upeneus pori*	5.94
	Lessepsian	*Leiognathus kluzingeri*	5.73
	Indigenous	*Lithognathus mormyrus*	5.67
	Lessepsian	*Decapterus russelli*	5.32
	Indigenous	*Boops boops*	4.28
Medium Stratum 38-83 m	Lessepsian	*Nemipterus randali*	11.46
	Lessepsian	*Saurida undosquamis*	10.36
	Indigenous	*Boops boops*	8.85
	Indigenous	*Pagellus erythrinus*	8.42
	Lessepsian	*Upeneus moluccensis*	8.12
	Lessepsian	*Leiognathus kluzingeri*	4.91
	Indigenous	*Citharus linguatula*	4.36
	Indigenous	*Pagellus acarne*	4.11
	Indigenous	*Trachurus trachurus*	3.73
	Lessepsian	*Apogon smithi*	3.10
Deep Stratum 84-150 m	Indigenous	*Pagellus erythrinus*	12.07
	Indigenous	*Citharus linguatula*	11.97
	Indigenous	*Boops boops*	9.72
	Indigenous	*Trachurus trachurus*	7.63
	Indigenous	*Mullus barbatus*	7.42
	Indigenous	*Lepidotrigla cavillone*	5.79
	Indigenous	*Dentex macrophthalmus*	5.28
	Lessepsian	*Nemipterus randali*	4.18
	Indigenous	*Macrohamphosus scolopax*	4.12
	Lessepsian	*Saurida undosquamis*	4.02

These results highlight the dominance of fishes of Indo-Pacific origin (e.g., Lessepsian migrants) on the shelf below 83 m. Both purely benthic species (such as goatfishes, dragonets, and flatfishes) and several bento-pelagic species (i.e., mackerels, sea-breams) appear to dominate the benthic shelf and upper slope ichthyofauna. A similar analysis was performed for invertebrates; similarly, significant differences were found between the strata, mainly in the benthic crustacean composition, as shallow communities were comprised almost solely of migrants. Chief among these was the commercial tiger prawn *M. japonicus* and others including the noncommercial prawn *M. aegyptia*, the stomatopod *E. massavensis*, and the brachyuran crab *C. longicollis*. Medium stratum communities featured mostly the indigenous rose shrimp *Parapenaeus longirostris*, which was joined on the deeper shelf and upper slope by the red shrimps *A. antennatus* and *A. foliacea*. Of the cephalopods present in benthic shelf and slope environments, the most common species was the longfin squid *Loligo vulgaris*. Other cephalopods included several octopus species, as well as the cuttlefish *Sepia officinalis.* In greater depths, beyond 100 m, these species were joined by the squid *Illex coindetti* and the cuttlefish

Sepia orbignyana. Of the soft sediment echinoderms, several sea stars (mostly *Astropecten* sp.) and sea urchins (*Cidaris cidaris* and *Centrostephanus* spp.) were prominent.

Among the most commercially important fish species on the shelf and upper slope are several migrants including: the goatfish *U. moluccensis,* the sea bream *N. randall,* and the lizardfish *S. undosquamis*. Pelagic migrants include the sardine *E. teres*, the jack *A. djedaba,* the barracuda *S. chrysotaenia*, and the mackerels *S. commerson* and *D. russelli*. Notable benthic indigenous species in the catch, most of which were displaced by the migrants, include several groupers, the goatfishes *M. barbatus* and *M. surmuletus,* and the breams *P. erythrinus* and *P. coeruleostictus*. In the mesopelagic realm, common indigenous commercial fishes include the jack *S. dumerili*, the tuna *E. aletteratus*, and the sardine *Sardinella aurita.*

3.8.3.2 Natural and Artificial Reefs

Diamant et al. (1986), documenting fish fauna associated with natural reefs and shipwrecks, including predominant groupers and sea breams, found 42% more species on wrecks than adjacent, less structurally complex natural rock patch reefs. Spanier (1989, 2000) and Spanier et al. (1990), summarizing artificial reef research off Israel, noted 43 fish species associated with natural and man-made reefs. The most common fishes on artificial reefs included Atlantic-Mediterranean species *Epinephelus alexandrinus*, *E. marginatus* (*guaza*), *Diplodus sargus*, *D. vulgaris*, and *Pagrus coeruleostictus*; and Lessepsian migrants *Siganus rivulatus*, *S. luridus*, and *Sargocentron rubrum*.

Hard bottom-associated fishes have also been documented in nearshore waters off Israel. Edelist (2006) and Edelist and Spanier (2009) assessed four artificial reefs in 20 m water depths west of Haifa for a year. They determined that artificial reefs supported 20 times the biomass of control quadrats (i.e., natural hard bottom adjacent to the reefs). Predominant fish species included constant reef residents like the groupers *Epinephelus costae* and *E. marginatus*, which are rare and commercially important species. The most common fishes recruited to this reef, however, were damselfish (*Chromis chromis*), wrasses (*Thallasoma pavo* and *Coris julis*) and sea breams (*Pagrus coeruleostictus* and *Diplodus vulgaris*). The migrant herbivore *Siganus rivulatus* was also common, while the most consistent occupant of the inner artificial reef units was the crevice dwelling, nocturnal migrant *Sargocentron rubrum*. The six species of migrants accounted for 65% of commercially exploitable biomass and 25% of specimens observed on artificial reefs.

Edelist (2006) also assessed the ichthyofauna of the Ashdod to Dor gas pipeline deployed in 2005, between Tel-Aviv and Ashdod. Significant differences were noted between pipeline segments covered by concrete mattresses and uncovered segments. The pipeline fish assemblage mostly comprised transient, pelagic greater amberjack (*Seriola dumerili*). Immense adult shoals of this species visit the Israeli shore every winter and spring and are fished by trawl, longline, and purse seine. Amberjack diet is composed mainly of pelagic fish (e.g., sardines or bouge), but also zoobenthic fish and macroinvertebrates (Froese and Pauly, 2006). Potential prey abundance may be the main attractive trait for these fishes. Due to the larger amounts of *S. dumerili* observed, the concrete mattress covered sections held 11 times the abundance and 13 times the biomass of the exposed pipeline. As a general rule, Edelist (2006) suggests the enhanced complexity offered by the concrete mattress cover facilitate more diversity and richness whereas its high vertical relief serves to attract abundance and biomass of organisms (namely amberjacks). Other fishes noted included common sea breams *Diplodus vulgaris*, *Lythognathus mormirus*, and *Diplodus sargus* as well as the round stingray *Taeniura grabata* and several grouper species. The pipeline was laid 6 months prior to the Edelist survey, however, relatively few sessile fauna were evident. Epibiota found either attached to the pipeline or concrete mattresses included hydrozoans and sponges with small amounts of algae. Several factors were suggested for limited epibiotal growth, including pipeline depth (i.e., 30 m) and the possibility of marginal light penetration for algal cover; the distance from natural reefs and the corresponding lack of settling larvae; and abrasion due to storms. Trenching operations employed during pipeline burial may also have eroded delicate biofilm organisms. This temporary lack of biological interaction of fish with the substrate is less substantial in this classic case of attraction; as sessile epifaunal colonization increases, so does production within the fish assemblage. It is also noteworthy that only one Lessepsian migrant species was observed – the carnivore *S. rubrum*. The absence of herbivorous siganids is consistent with the low levels of algal cover.

3.8.3.3 Offshore Environment

As described in Galil (2004) and Jones et al. (2003), the major species recorded in the deep Levantine Sea (1,000 to 4,264 m), including the region of the Tamar Gas Field, were characterized as follows:

- Fishes – A total of 566 specimens from 31 fish species was collected. *Bathypterois mediterraneus* and *Nezumia sclerorhynchus* were the most common, representing 38% and 27% of the specimens, respectively. *Cataetyx laticeps*, *Chauliodus sloani*, and the ubiquitous *Bathypterois mediterraneus* were photographed at a depth of 2,900 m.
- Sharks – Sharks found in the Eastern Mediterranean at depths of ≤2,300 m were *Hexanchus griseus*, *Galeus melastomus*, *Centrophorus* spp., *Centroscymnus coelolepis*, and *Etmopterus spinax*.

Photographic investigations have collected valuable qualitative information on the Levantine bathyal ichthyofauna. In the general study area, a survey summarized by Gilat and Gelman (1984) utilized bait, thus attracting facultative or obligate scavengers. Employing a free-fall camera positioned on top of a bait holder, still photographs taken at 5-minute intervals for 18 hours were acquired at six sites between Israel and Cyprus. Off the Israeli coast in relatively shallow water (i.e., 280 m water depth), Triglidae formed >90% of the population, with minor contributions from *Epinephelus* (4%) and *Centrophorus* (<5%). At 510 m, only *Centrophorus* was observed. In deeper water (880 m), *Centrophorus* was predominant (>98%) and *Etmopterus* contributed <2%. At the deepest station sampled (1,080 m) off Haifa, species observed included *Etmopterus* (39%), *Echelus* (38%), and *Centrophorus* (23%).

Deepwater biota, including fishes in deep waters of the Levantine Basin region, have not been studied extensively. A series of twelve cruises 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) produced a wealth of new data (Galil and Goren, 1994), including new records for the shark *Etmopterus spinax* and the fish *Coelorbyncbus labiatus* and *Nezumia sclerorbynchus*. Results also extended the distribution of 18 more species to the easternmost boundary of the Mediterranean; results suggest that the extreme poverty of the deep Levantine fauna is due, in part, to recurrence of anoxic conditions at bathyal depths during the Quaternary (Galil and Goren, 1994). A study of the benthos of the area by Galil (2004) recorded three fish species – *B. mediterraneous*, *Cataetyx latipes*, and *Chauliodes sloani*. The study confirmed “the ichthyofauna scarcity of the Levantine Basin compared not only with the adjacent Atlantic Ocean (Haedrich and Merrett, 1988) but also with the western Mediterranean.”

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

The pelagic offshore environment includes both small and large pelagic 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 to spawn in the spring. Specimens caught in Israeli waters are almost always observed with ripe gonads. Other large offshore pelagic fishes in the Levant include albacore tuna and other scombrids (e.g., *Euthynnus alletteratus*), dolphinfish, swordfish, sailfish, and pelagic sharks (e.g., hammerhead, blue shark, *Priona glauca*).

Of the deepwater ichthyofauna, hake (*M. merluccius)* is worthy of a 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 grouper *E. haifensis*.

3.8.3.4 Anthropogenic Effects

The Levantine Basin is a relatively isolated ocean basin, separated from the western basin by a submarine sill between Sicily and North Africa. The eastern continental shelf is very narrow (i.e., <9 km wide), except off the Nile Delta where the 200-m depth contour lies 60 km offshore. Before construction of the High Dam at Aswan, 50% of the Nile flow drained into the Mediterranean. During an average flood, the total discharge of nutrient salts was estimated to be approximately 5,500 tons of phosphate and 280,000 tons of silicate. The nutrient-rich floodwater, or Nile Stream, was approximately 15 km wide and had sharp boundaries, extending along the Egyptian coast and detectable off the Israeli coast and occasionally farther north (southern Turkey).

Construction of the High Dam has had far-reaching effects on the transport of fertile silt and sediments into the southeastern Mediterranean. Sediments trapped behind the dam have resulted in severe erosion along the Egyptian coast, and affected the fertility of coastal waters in the region. The fertilizing effect of the inflow of the nutrient-rich water during the flood season once resulted in exceptionally dense blooms of phytoplankton off the Nile Delta. This "Nile bloom" provided sustenance to sardines and other pelagic fishes. It also constituted a large source of detritus for the food chain, including providing a source of food for commercially valuable organisms (e.g., shrimp). The highly productive coastal Mediterranean fishery off the Nile River delta collapsed after the completion of the Aswan High Dam in 1965. However, the fishery has been recovering dramatically since the mid-1980s, coincident with large increases in fertilizer application and sewage discharge in Egypt. Oczkowski et al. (2008) used stable isotopes of nitrogen ($\delta^{15}N$) to demonstrate that 60% to 100% of the current fishery production may be from primary production stimulated by nutrients from fertilizer and sewage runoff. Although the High Dam put Egypt in an ideal position to observe the impact of rapid increases in nutrient loading on coastal productivity in an extremely oligotrophic sea, the Egyptian situation is not unique. Such anthropogenically enhanced fisheries also may occur along the northern rim of the Mediterranean and offshore of some rapidly developing tropical countries, where nutrient concentrations in the coastal waters were previously very low. Since the completion of the dam, Egypt's population has more than doubled, which translates to a higher sewage production and increases in nitrogen (N) and phosphorus (P) discharge. Public water and sewer systems have expanded greatly and annual fertilizer consumption has increased almost four-fold, from 3.4×10^5 tons to 13×10^5 tons. Before 1965, the Nile flood delivered about 7 × 10^3 tons/year of N and 7 to 11 × 10^3 tons/year of P to the Mediterranean coast. Today, the Rosetta Branch of the Nile River alone discharges almost three times more inorganic N (dissolved organic nitrogen, [DIN]) per year (2 × 10^4 tons) and about half as much bioavailable P (4 × 10^3 tons) into this oligotrophic region (Oczkowski et al., 2008).

There are also seven other major discharges and numerous minor drainage points along the coast. Tile-drained fields release water into more than 13,000 km of drainage canals in Egypt, which eventually discharge offshore. Off the coast of Israel, cessation of the Nile has had only a minor effect on the catch of the coastal fisheries, although pelagic landings have decreased 10-fold over the past three decades (Shapiro, 2007). However, the size of the fish catch in Israel is determined primarily by socioeconomic factors and fluctuations in landings may not be directly related to primary productivity of Israeli waters (El-Sayed and van Dijken, 1995). Although several studies have been conducted on the effects of the Nile discharge on the biological oceanography and marine fisheries off the Egyptian and Israeli coasts, the dramatic changes in the physical, chemical, and biological conditions in the Levantine Basin have not yet been fully assessed. Data are lacking or deficient in several areas to fully characterize seasonal fluctuations of primary productivity in this region and determine the hydrographic and chemical factors that regulate this productivity. Furthermore, it remains to be determined whether reduced river outflow has caused changes in the species composition of planktonic communities, with potential changes to the nearshore marine food chain. Migratory patterns may also have been affected. For example, sardines historically migrated into the Nile Delta region to feed on the fall phytoplankton blooms; following construction of the dam, sardines have altered their migration patterns (El-Sayed and van Dijken, 1995).

Another main detrimental effect of damming the Nile is the increased erosion of the sand from Israeli beaches. Prior to dam construction, some 35 million m^3 of sand were transported and deposited along Israel's beaches on an annual basis, whereas post-dam sand budgets are less than 3.5 million m^3, substantially eroding beaches all along the coast. This also results in differences in grain size and alteration of the sandy habitat.

In the 20th century, the population of Israel increased 15-fold; during the last three decades, it has more than doubled (Israel Central Bureau of Statistics, 2011). As a consequence, a variety of effluents – sewage, chemicals, brine, or other pollutants – are currently discharged along the Israeli coast. While these effluents may serve to enrich a nutrient poor marine environment, the concentrated and site-specific effects of such eutrophication may be adverse. Furthermore, large doses of heavy metals and various chemicals are being discharged. The most prominent land-based pollution sources include:

- The Kishon River, among the 16 primary Israeli rivers flowing into the Mediterranean, has been labeled the most polluted (State of Israel, Ministry of Environmental Protection, 2010) due to heavy loads of industrial chemicals. In recent years, a comprehensive legislation, monitoring, and enforcement program has substantially reduced the amount of toxic chemicals released into the river and improvements in the water quality of the Bay of Haifa have already been recorded (State of Israel, Ministry of Environmental Protection, 2010). While there is a growing awareness of the harmful effects of transporting urban and agricultural effluents into the marine environment via rivers, they are still widely used.

- The Shafdan, or Dan Region Association of Towns for Sewage and Environment, is the largest of the municipal pipelines discharging organic sludge into Israeli waters. Located approximately 2 nmi offshore Palmachim, this discharge releases up to 15,000 m^3 of treated sludge daily. Effects on the environment include intense pollution of both sediments and the water column near the outfall. The most notable effect is on the benthic environment, where elevated crustacean and polychaete abundance has been documented. Other sewage outfalls also exist along the Israeli coast, including offshore of Acco, Atlit, Herzeliya, and Ashdod.
- Several major desalination plants have been releasing brine into coastal waters since 2008. While this is a new development, an extensive five-year monitoring program was initiated at Michmoret Maritime College (Ruppin) to examine the effects of this brine and associated chemicals (e.g., ferrous sulfate) on the coastal ecosystem.
- Several major power plants exist along the Israeli coast, all of which utilize seawater for cooling purposes. While no extensive studies have been performed on cooling water discharge effects, a localized temperature increase in receiving water is expected within several hundreds of meters from the outfall. Warm water effluents, including the discharge just south of Hadera's Orot Rabin power plant, are well known to local fishermen as hotspots where sharks come to bask in the shallow warm effluent during winter, where they are easily caught. Another notable effect of power plant cooling water effluent is the transport of atmospheric pollutants, most notably CO_2 and SO_2, into surface waters, with potential for increased ocean acidification.

Increases in sludge discharges may have also resulted in, or contributed to, the proliferation of jellyfish. Given the oligotrophy of the Levant, the food source necessary to support such blooms and growth remains unknown. A positive correlation between pollution and swarming of jellyfish was found for *Rhizostoma pulmo* in the coastal waters of Mersine Bay, Turkey (Bingel et al., 1991) and for *Aurelia aurita* in the Aegean Sea (Wilkerson and Dugdale, 1984). These findings for indigenous jellyfish, which usually co-occur with *R. nomadica* swarms in Israel, suggest that jellyfish blooms may be caused by the ability of medusae to utilize eutrophication-induced plankton blooms (Legovic, 1987), or their ability to utilize pollutants directly as food (Muscatine and Matian, 1982).

3.8.4 Alien or Non-native and Nuisance Species – the Lessepsian Migration

The opening of the Suez Canal in 1869 led to the connection of the Mediterranean with the Red Sea. For the first time, the Mediterranean's pure Atlantic-origin fauna faced competition from invading Indo-Pacific flora and fauna that established themselves first in the Suez Canal and later in the Mediterranean Sea. Several hundred species have since established themselves in the Eastern Mediterranean. This migration, which has been named the Lessepsian Migration, after Ferdinand De Lesseps, the Frenchman that built the canal, has been the subject of many studies during the last half of the 20th century (e.g., Steinitz, 1967). As of the early 1990s, these Indo-Pacific species formed over 12% of the marine fauna of the Eastern Mediterranean and 5% of the entire Mediterranean marine fauna (Fredj et al., 1990, 1992; Bellan-Santini et al., 1992). A detailed species by species comparison of the data presented in **Table 27** to similar trawl hauls from the early 1990s (Fuentes et al., 2010) reveals that the migration rate is increasing and its effects are much more pronounced than previously thought, with a rise in migrant fish proportion in the deep, medium, and shallow strata from 5%, 15%, and 39% to 21%, 50%, and 76%, respectively. Fuentes et al. (2010) has suggested that migrants along the Levantine shelf have now surpassed their indigenous counterparts.

Many species, such as red soldierfish and two siganids (rabbitfish), are now common in the commercial fish catches of Eastern Mediterranean fishermen. Whereas the soldierfish, along with migrant sweepers, compete for sheltered habitat with indigenous groupers, the siganids are unique in that they are the only migrant herbivores and have been nearly eradicated; the only existing herbivorous siganid is *Sarpa salpa*, which is an indigenous species. Bariche et al. (2004) noted that migrants have a significant detrimental effect on the Levantine algae community. A recent study by Golani et al. (2007) has found that Lessepsian migrants remain poorly established in the rocky littoral.

Several other species of commercial value are common in the catches of fishermen off the Levant coast, such as *Upeneus moluccensis*, which displaced the more valuable local red and striped mullets into deeper waters (Golani and Ben-Tuvia, 1995). Along with migrant prawns, breams, mackerels, scads and lizardfish, migrants now provide the majority of landings in Israel (Fuentes et al., 2010). The spread of Indo-Pacific species in the Levantine Basin seems to follow an anticlockwise pattern following the prevailing coastal currents. Many nuisance species are now well-established in the Eastern Mediterranean. Several jellyfish and ctenophore species (Fuentes et al., 2009) and some invasive algae (e.g., *Caulerpa racemosa*; Rilov and Galil, 2009) have been reported to have deleterious effects on both humans and biotic resources.

Three pufferfish species of the genus *Lagocephalus* have colonized the Levant in great numbers in recent years. The population explosion of *L. sceleratus* into the Eastern Mediterranean (i.e., as far west as the Aegean) has caused problems due to the toxicity of the fish and damage to fishing gear (i.e., longlines). Its wider impact on the ecosystem is not yet clear. Another pufferfish, *L. spadiceus*, that entered the Mediterranean earlier, is found in moderate numbers. The third pufferfish species, *L. suezensis*, has also recently exploded in population (see **Table 27**).

Fish toxicity reports in Israel are increasing. Several severe poisoning cases resulting from pufferfish consumption have already been reported by the Israel Poison Information Center in Rambam Health Care Campus, Haifa (Y. Bentur, personal communication, 2011). Similar reports are noted from human contact. Dozens of incidents have been reported where fishermen handling fish or people walking on the beach were stung by *Plotosus lineatus* – a poisonous eel catfish that invaded the Levant in 2002. This species has established a sizable population along the shores of the Eastern Mediterranean (Edelist et al., 2011a; see **Table 27**).

Golani et al. (2011) recently reported on a second collection of two Lessepsian migrant fish in the Eastern Mediterranean – the arrow bulleye, *Priacanthus sagittarius*, and the spotbelly batfish, *Platax teira* – and suggest the establishment of new populations. The record of another Lessepsian migrant, the spiny blaasop, *Tylerius spinosissimus* from Israel, constitutes a considerable extension of its distribution range in the Mediterranean.

The last reported alien, which represents the 79th Lessepsian migrant fish species in the Mediterranean, is the most poisonous fish known to man – the stonefish *Synanceia verrucosa*. A single specimen was recently caught by fishermen at a depth of 3 m off the coast of Palmachim and reported by Edelist et al. (2011b). This species is solitary and is not expected to colonize the Levant in great numbers.

Other recent immigrants to the Mediterranean that have established themselves include the algae *Caulerpa racemosa* and *Stypopodium shimperi*. Both algae, especially *C. racemosa*, have spread extensively since about 1990 (Argyrou et al., 1999). *C. racemosa* covers the seabed (especially soft substrates) in a mat a few centimeters thick, competing very successfully with other floral species such as *C. prolifera* and *Cymodocea nodosa*, which it may replace. Apparently this species has no enemies as yet in the Mediterranean; if its proliferation continues, it is likely to revolutionize the entire Eastern Mediterranean shallow-water ecosystem, with far-reaching effects on the native marine flora and, perhaps more significantly, on the marine fauna of the area. The reduction, for example, of *C. nodosa* in key feeding areas of the green turtle (*Chelonia mydas*) in the Levantine Basin will inevitably have an effect on the survival of this species in the Mediterranean. This marine turtle feeds almost exclusively on this seagrass in the Mediterranean, at least up to its subadult stage (Demetropoulos and Hadjichristophorou, 1995). At present, *Caulerpa racemosa* appears to have lost vigor and is apparently proliferating more slowly, with some indications that it is retreating from the areas that it previously covered.

Goren and Galil (2005) reviewed changes in the fish assemblages of the Levantine marine region following introduction of non-native fishes. Indo-Pacific and Erythrean biota entering the Mediterranean (through the Suez Canal) have produced significant changes to nearshore ichthyofauna – non-native migrants now dominate community structure (i.e., 50% to 90% of fish biomass) and function (i.e., via alteration of the native food web) of the Levantine littoral and infra-littoral zones. The process has accelerated in recent years concurrent with the global warming trend. Record numbers of newly discovered non-native species is leading to the creation of a human-assisted Erythrean biotic province in the Eastern Mediterranean (Galil and Zenetos, 2002; Goren and Galil, 2005; Galil, 2006, 2007).

The Lessepsian Migration includes a variety of marine invertebrate and algal species. The peer-reviewed literature contains numerous citations documenting the presence of Indo-Pacific and Erythrean invertebrate and algal species – new species records for species in the Eastern Mediterranean – across a diverse variety of taxonomic groups (e.g., cumaceans: Corbera and Galil, 2007; mollusks: Lubinevsky and Mienis, 2005; algae: Hoffman et al., 2007).

Goren (2007), offering a recent analysis of the Lessepsian Migration, indicates that a total of 296 metazoan species have been identified to date as alien off the Israeli coast; Rilov and Galil (2009) estimate that there are more than 320 Lessepsian migrants. The list is limited to multicellular organisms because the identity of many unicellular organisms is still in doubt, as well as their native range and distribution. Taxonomic classification of alien species shows that the alien phyla most frequently recorded are Mollusca (43%), Chordata (22%), Arthropoda (16%), and Annelida (7%). Phyla not represented in the list include those that are either very cryptic or have received little study include Porifera, Nemertea, Priapula, Nematoda, Entoprocta, Pogonophora, Sipuncula, Echiura, Brachiopoda, and Phoronida. The data are presumably most accurate for large and conspicuous species, which are easily distinguished from the native biota.

3.8.5 Seabirds

The Mediterranean is home to several hundred bird species, a portion of which occur exclusively in this climatic zone. Seabirds may be found along the coastal zone and offshore islands throughout the Mediterranean. Pelagic bird species in the Mediterranean are relatively few, but several breeding colonies of Cory's Shearwater (*Calonectris diomedea*), Levantin Shearwater (*Puffinus yelkouan*), Balearic Shearwater (*Puffinus mauretanicus*), and European Storm-petrel (*Hydrobates pelagicus*) may be found along sea cliffs or on small isolated rocky islands and islets. Coastal seabirds, such as terns, occur in river deltas and on inland saltwater lagoons. Many coastal species are also found breeding in man-made habitats.

The Mediterranean lies along seasonal migratory pathways for several species moving between Europe and Africa (Shamoun-Baranes et al., 2003); several species that breed in Europe over-winter in the Mediterranean Basin (United Nations Environment Programme, Mediterranean Action Plan, Regional Activity Centre for Specially Protected Areas [UNEP MAP RAC/SPA], 2003). **Table 28** summarizes bird species listed in Annex II of the Barcelona Convention, representing endangered or threatened avifauna of the Mediterranean region. Israel is well known as one of two major migratory pathways in the Mediterranean region, with the other being Gibraltar. Frumkin et al. (1995) note that 185 bird species migrate regularly from Europe and Asia to sub-Sahara Africa, with many migratory routes over and adjacent to Israel. Safriel (2008) notes that migrants occur year-round, but are most numerous in March-April and September. Only a few of the 185 species recorded pass the winter in Israel; about 25 bird species are recorded in autumn, whereas about 50 species are more common in the spring. More than 40% of birds migrating between Africa, the Middle East, and Europe have declined in the last three decades. Of these, 10% are classified by BirdLife as Globally Threatened or Near Threatened on the Union for the Conservation of Nature (IUCN) Red List. In addition to the transient avifauna species, more than 270 other species are native to Israel.

Most species cited in **Table 28** occur as rare migrants or as vagrants in or near Israeli nearshore or offshore waters. White Pelicans, Sandwich Terns, and Little Terns are common migrants and the Pygmy Cormorant (*Phalacrocorax pygmeus*) is known to breed in Israel.

Shirihai (1996) identified 511 bird species in Israel. Israbirding (2009) has updated the current species list to include 532 bird species present in Israel representing 23 separate orders (**Table 29**). Avibase (2011) identifies a total of 547 bird species in Israel, including 14 globally threatened species and 18 introduced species; the Avibase database was last updated in February 2002. While these listings include species that are strictly terrestrial or found in association with freshwater, species noted within the Procellariiformes (petrels, shearwaters, storm-petrels), Pelecaniformes (pelicans, cormorants, boobies) and Charadriiformes (plovers, sandpipers, phalaropes, skuas, gulls, terns, and skimmers) typically utilize the maritime coast, nearshore, and/or offshore waters for foraging and/or nesting, as indicated in **Table 28**.

A complete listing of Israel birds, including those species which are likely to be found along the coast or over nearshore or offshore waters, is provided in **Appendix B** (Israbirding, 2009). Monthly presence (e.g., common, uncommon, rare) for each species is also provided.

No systematic surveys of seabird populations within the Levantine Basin have been conducted to date. The oligotrophic nature of the region suggests that offshore seabird concentrations might be low relative to more productive regions within other regions of the Mediterranean or in Atlantic waters.

In May 2010, UNEP MAP RAC/SPA (2010) issued a report which contained a georeferenced compilation of bird important areas in the Mediterranean open seas. While the central and western portions of the Mediterranean were the predominant areas of interest, the southeastern Mediterranean (including the Levant coast and Nile River delta regions) were evaluated. **Figure 48** depicts the relative distribution of important bird species offshore of Israel. UNEP MAP RAC/SPA (2010) indicated that, due to low productivity in the region attributed to diminished Nile output, high evaporation, elevated sea surface temperatures and salinities, and low nutrients, the offshore waters of this region do not exhibit high bird diversity. Additionally, the absence of offshore islands suitable for nesting and breeding colonies, and the limited number of suitable coastal nesting sites, serves to further limit bird populations in the region. Only two species – *Puffinus yelkouan* and *Larus melanocephalus* – are noteworthy. A few coastal sites were noted for nesting Sternidae (terns) and Laridae (gulls).

Table 28. Bird species listed in Annex II (Barcelona Convention) – endangered or threatened species of the Mediterranean region (Adapted from: United Nations Environment Programme, Mediterranean Action Plan, Regional Activity Centre for Specially Protected Areas [UNEP MAP RAC/SPA], 2003; Perlman and Meyrav, 2009).

Species	Population Characteristics	Presence in Israel
Cory's Shearwater (*Calonectris diomedea*)	The nominate subspecies *Calonectris d. diomedea* is restricted to the Mediterranean. It breeds in sea cliffs, and on rocky islands, and islets. The population has been estimated at less than 76,000 pairs, but surveys in the eastern part of the Mediterranean and in the Adriatic are lacking. There has been a considerable decline of the species throughout the Mediterranean.	Uncommon visitor year round to Mediterranean coast and Gulf of Aqaba
Mediterranean Shearwaters Balearics Shearwater (*Puffinus mauretanicus*) and Levantin Shearwater (*Puffinus yelkouan*)	The two subspecies of the endemic Mediterranean Shearwater have recently been given specific status and are now considered as two separate species, Balearic Shearwater (*Puffinus mauretanicus*) and Levantin Shearwater (*Puffinus yelkouan*). Because both species still appear in the Protocol as one species they are treated jointly. The Balearic Shearwater breeds in the Balearic Islands and the Levantin Shearwater breeds in the Tirrenian, Adriatic, and Aegean Seas. Both are pelagic species, which breed on rocky islands and islets. The population of the Balearic Shearwater has been estimated at about 1,750 pairs (2002 figures by Spanish Working Group on Balearic Shearwater), with that of the Levantin Shearwater at probably less than 16,500 pairs. Some pairs probably breed along the North African coast. The Balearic Shearwater is classed as a critically threatened species by BirdLife International because of extreme risk of extinction in three generations (current decline over 7% annually).	Uncommon visitor (August–April) to Mediterranean coast, vagrant to Gulf of Aqaba
European Storm Petrel (*Hydrobates pelagicus*)	Pelagic species breeding in small to very large colonies mainly on islets and in caves along the coast. Subspecies *melitensis* is endemic to the Mediterranean. Important breeding colonies are found in Malta, Sardinia, and Sicily. Breeding surveys are totally lacking for the Adriatic and Eastern Mediterranean. A general decline has been recorded.	Vagrant
Shag (*Phalacrocorax aristotelis*)	The Mediterranean subspecies of the European Shag (*Phalacrocorax aristotelis desmarestii*) is an endemic subspecies, present in the western Mediterranean (Balearic Islands, Corsica and Sardinia), and the Adriatic, Aegean and Black Seas, breeding along the coast on rocky islands and islets. The Mediterranean population numbers less than 10,000 pairs.	Vagrant
Pygmy Cormorant (*Phalacrocorax pygmeus*)	The main breeding populations in the Mediterranean of this globally threatened species are found in Albania, Serbia, Greece, Turkey, with some pairs in Israel and Italy. It is restricted to lowland freshwater and brackish habitats, and in winter frequents coastal lagoons, deltas, rivers, and riparian forests. The whole population of the Mediterranean countries probably numbers less than 2,500 pairs.	Common resident in Hula, Kinneret, and Bet She'an Valley

Table 28. (Continued).

Species	Population Characteristics	Presence in Israel
White Pelican (*Pelecanus onocrotalus*)	In the Mediterranean, the white pelican breeds in Turkey and Greece. Numbers have declined in the last 30 years. Nests on the ground in large reedbeds, bare earth, or rocky islands, in isolation from the mainland to be safe from mammalian predators.	Large numbers on migration through North and West (April, October–December), uncommon in winter mainly in the north, rare in summer
Dalmatian Pelican (*Pelecanus crispus*)	Vulnerable and globally threatened. In the Mediterranean, small populations (totaling 1,000 pairs) breed mainly in Albania, Greece, and Turkey. Breeds on inland and coastal wetlands and nests on floating islands of reeds and on bare ground on islands, isolated from mainland to be safe from mammalian predators. Up to about 3,000 birds winter in Albania, Greece, Syria, and Turkey.	Vagrant
Greater Flamingo (*Phoenicopterus rubber*)	In the Mediterranean, it breeds in localized sites in suitable wetlands, mainly in Spain, France, and Turkey, as well as in Italy. Breeding colonies are established at sites free from human disturbance and secure from terrestrial predators. Breeding is irregular with numbers fluctuating from one season to another. Substantial numbers also occur in Greece and Cyprus but do not breed. Mediterranean population seems to be separated from Asiatic populations, with minimal exchange and overlap in Libya and Egypt.	Absent
Osprey (*Pandion haliaetus*)	A cosmopolitan species, which is vulnerable in several regions. Less than 70 pairs have been known to breed regularly in the last 15 years in the Mediterranean (Balearic Islands, Corsica, Morocco, and Algeria). Some local small populations have disappeared from other islands (e.g., Ibiza, Sicily, and Sardinia).	Uncommon on migration and in winter, mainly in north and Eilat
Eleonora's Falcon (*Falco eleonorae*)	Breeds in colonies along the coast of the mainland or on rocky islands, which are often uninhabited. The total world population is estimated at 6,200 pairs but no comprehensive census has been carried out. Almost all the entire population breeds on rocky Mediterranean islands. The Aegean islands and Crete hold about 70% of the whole population, but other substantial colonies are also found in Spain, Italy, and Tunisia.	Rare migrant (September–October, April–May)
Slender-billed Curlew (*Numenius tenuirostris*)	Globally threatened, once described as common in the Mediterranean region, it is now one of the rarest and least known species in the Western Palearctic. Migrates from Siberia across eastern and southern Europe to winter in North Africa. On passage, occurs in a wide range of habitats: salt marshes, saltpans, brackish lagoons, dry fishponds, steppe, and freshwater marshes.	Vagrant
Audouin's Gull (*Larus audouini*)	Endemic species to the Mediterranean. Its main breeding populations occur in the western Mediterranean in coastal and island sites in Spain and in Corsica. Other colonies occur in other parts of the Mediterranean including Greece, Turkey, Tunisia, and Sardinia. It was close to extinction in the 1970s, but better enforcement of protection measures has resulted in an increase in the breeding population.	Very rare migrant and winter visitor, mainly to the Mediterranean coast and Gulf of Aqaba

Table 28. (Continued).

Species	Population Characteristics	Presence in Israel
Lesser Crested Tern (*Sterna bengalensis*)	In the Mediterranean, a small localized population (exact breeding population unknown but probably less than 4,000 pairs) of the endemic subspecies *Sterna bengalensis emigrata* breeds on two Libyan offshore islands. Occasional breeding has also been recorded in France, Greece, Italy, and Spain.	Absent
Sandwich Tern (*Sterna sandvicensis*)	In the Mediterranean, a population of probably less than 3,000 pairs nests in colonies mainly in river deltas, on sandbanks, and in salinas. Also migrates from elsewhere into the Mediterranean for wintering.	Common migrant, summer and winter visitor mainly to the Mediterranean coast and Gulf of Aqaba
Little Tern (*Sterna albifrons*)	Mediterranean population mainly along southern coastline and western basin, where the actual size is unknown. Quantitative data from the eastern Adriatic and Eastern Mediterranean countries are lacking. Breeds in rivers and deltas, estuaries, lagoons, and salinas.	Common migrant along the Mediterranean coast and Gulf of Aqaba, rare summer visitor to north Mediterranean coast and Hula Valley

Table 29. Avifauna orders and families of Israel (Adapted from: Shirihai, 1996; Israbirding, 2009).

Order	Family
Struthioniformes	Struthionidae
Gaviiformes	Gaviidae
Podicipediformes	Podicipedidae
Procellariiformes	Diomedeidae
	Hydrobatidae
	Procellariidae
Pelecaniformes	Anhingidae
	Fregatidae
	Pelecanidae
	Phaethontida
	Phalacrocoracidae
	Sulidae
Ciconiformes	Ardeidae
	Ciconiidae
Phoenicopteriformes	Phoenicopteridae
Anseriformes	Anatidae
Accipitriformes	Accipitridae
	Pandionidae
Falconiformes	Falconidae
Galliformes	Phasianidae
Gruiformes	Gruidae
	Otididae
	Rallidae
Charadriiformes	Burhinidae
	Charadriidae
	Dromadidae
	Glareolidae
	Haematopodidae
	Laridae
	Recurvirostridae
	Rostratulidae
	Rynchopidae
	Scolopacidae
	Stercorariidae
	Sternidae
Pteroclidiformes	Pteroclididae
Columbiformes	Columbidae
Cuculiformes	Cuculidae
Strigiformes	Strigidae
	Tytonidae
Caprimulgiformes	Caprimulgidae
Apodiformes	Apodidae
Coraciiformes	Alcedinidae
	Meropidae
Psittaciformes	Psittacidae
Coraciiformes	Coraciidae
	Upopidae

Table 29. (Continued).

Order	Family
Passeriformes	Alaudidae
	Bombycillidae
	Corvidae
	Emberizidae
	Estrildidae
	Fringillidae
	Hirundinidae
	Laniidae
	Motacillidae
	Muscicapidae
	Nectariniidae
	Oriolidae
	Paridae
	Passeridae
	Prunellidae
	Pycnonotidae
	Remizidae
	Sittidae
	Sturnidae
	Sylviidae
	Tichodromadidae
	Timaliidae
	Troglodytidae
	Turdidae

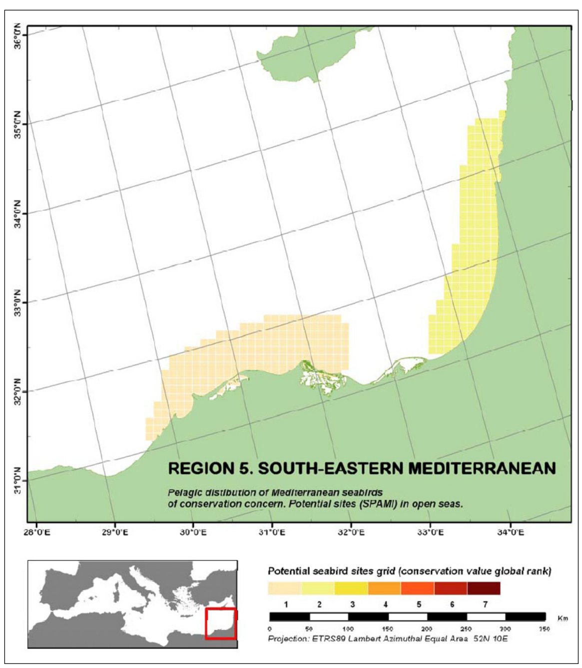


Figure 48. Pelagic distribution of seabirds in the southeastern Mediterranean Sea (From: United Nations Environment Programme, Mediterranean Action Plan, Regional Activity Centre for Specially Protected Areas [UNEP MAP RAC/SPA], 2010).

Areas of specific ornithological importance included:

- Nile River system – the river delta and associated wetlands supports numerous waterbirds (i.e., gull and tern species) throughout the year, most notably during winter and during migration periods. Of the species present in the system, only *Larus melanocephalus* is truly pelagic.
- Levantine coast – representing a homogenous stretch of coastline, offshore waters and adjacent coast are known to support a wintering population of *Puffinus yelkouan*.

A nationwide yearly census has been conducted for water birds wintering in Israel since 1965. **Table 30** lists the latest available censuses in the southern coast of Israel dated 2005-2008 (Hatzofe, 2005; 2006; 2008). While none of these species are recognized as endangered or threatened by the Barcelona Convention, eight of them are listed as locally endangered (Dolev and Perevolotzky, 2004), and one, *Oxyura leucocephala*, is listed as globally endangered the IUCN Red List.

Table 30. Water birds counted in the Israeli southern coastline (From: Hatzofe, 2005, 2006, 2008).

Species	2005	2006	2008	Endangered?
Fulica atra	1,301	1,305	1,880	N
Anser spp.	0	0	13	N
Anser albifrons	0	0	12	N
Ardea cinerea	17	0	7	Y
Bubulcus ibis	0	0	49	N
Tringa erythropus	5	20	1	N
Actitis hypoleucos	10	1	15	N
Tringa tetanus	34	6	47	N
Tringa glareola	2	0	4	N
Tringa stagnatilis	1	1	4	N
Tringa ochropus	2	1	5	N
Tringa spp.	0	0	3	N
Anas strepera	27	4	23	N
Anas acuta	5	2	3	N
Anas angustirostris	0	0	1	Y
Anas penelope	0	1	28	N
Anas platyrhynchos	1,036	867	1,678	N
Circus spp.	1	0	0	N
Circus aeruginosus	13	0	0	Y
Pluvialis squatarola	0	0	1	N
Calidris spp.	0	30	0	N
Calidris alpina	0	0	3	N
Calidris temminckii	0	2	1	N
Calidris minuta	2	0	236	N
Charadrius alexandrinus	0	0	28	Y
Charadrius dubius	0	1	32	Y
Charadrius leschenaultii	0	0	45	N
Charadrius hiaticula	0	0	45	N
Ciconia ciconia	2	0	1	N
Gallinago gallinago	14	4	28	N
Lymnocryptes minimus	0	0	4	N
Podiceps nigricollis	13	40	23	N

Table 30. (Continued).

Species	2005	2006	2008	Endangered?
Podiceps nigricollis	323	428	371	N
Alopochen spp.	5	0	15	N
Platalea leucordia	0	0	3	N
Halcyon smyrnensis	2	1	0	N
Egretta alba	0	0	2	N
Egretta garzetta	42	19	4	N
Philomachus pugnax	42	0	107	N
Threskiornithinae	447	249	601	N
Anas lypeata	1,332	1,388	4,265	N
Gallinula chloropus	21	52	31	N
Vanellus spinosus	291	192	222	N
Ceryle rudis	5	0	0	N
Aythya spp.	15	0	0	N
Aythya nyroca	4	0	7	Y
Aythya ferina	16	8	198	N
Aythya fuligula	61	1	9	N
Oxyura leucocephala	0	174	229	Y
Anas querquedula	0	0	6	N
Phalacrocrax carbo	7	0	0	N
Vanellus vanellus	98	15	0	N
Larus ridibundus	78	3	193	N
Larus michahellis	0	3	113	Y
Larus armenicus	336	234	7	N
Larus fuscus	15	65	61	N
Peoecanus onocrotalus	0	0	6	N
Anas crecca	1,330	1,061	1,815	N
Himantopus himantopus	13	28	18	N

Due to its climatic diversity and location as a land bridge connecting Asia and Europe with Africa, Israel is a globally important biodiversity hotspot for birds. While the southern Mediterranean coast and offshore waters are not locally important within this context, there are a large number of bird species that migrate and nest in the area, a small portion of which are endangered.

3.8.6 Marine Mammals

3.8.6.1 Marine Mammals of the Mediterranean

The Mediterranean Sea supports a diverse marine mammal fauna, including several species listed by the IUCN as critically endangered (e.g., Mediterranean monk seal), endangered (e.g., fin whale, sei whale), or vulnerable (e.g., sperm whale, humpback whale, common porpoise) as outlined in **Table 31**. Common species that may be present either in or near the offshore blocks or along transit corridors to shore are expected to include mostly the bottlenose dolphin, common dolphin, Risso's dolphin, and striped dolphin.

Twenty years ago, UNEP developed an Action Plan for the conservation of cetaceans in the Mediterranean (UNEP MAP RAC/SPA, 1991). The Action Plan calls for implementation of concrete protection measures and a coordinated program for scientific research and public awareness.

Table 31. Marine mammals potentially occurring in the Mediterranean Sea, their status according to the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List, and their expected presence offshore Israel. Species of greatest concern are shaded (From: IUCN, 2008).

Marine Mammal Species	IUCN Category[1]	Presence in Israeli Waters[2]
Mysticetes		
Minke whale (*Balaenoptera acutorostrata*)	LR/NT	Likely
Fin whale (*Balaenoptera physalus*)	EN	Likely
Sei whale (*Balaenoptera borealis*)	EN	Possible
Humpback whale (*Megaptera novaeangliae*)	VU	Possible
Odontocetes		
Sperm whale (*Physeter macrocephalus*)	VU	Likely
Blainville's beaked whale (*Mesoplodon densirostris*)	DD	Possible
Cuvier's beaked whale (*Ziphius cavirostris*)	DD	Likely
Short-beaked common dolphin (*Delphinus delphis*)	LR/LC	Likely
Striped dolphin (*Stenella coeruleoalba*)	LR/CD	Likely
Pygmy killer whale (*Feresa attenuata*)	DD	Possible
Short-finned pilot whale (*Globicephala macrorhynchus*)	LR/CD	Possible
Long-finned pilot whale (*Globicephala melas*)	LR/LC	Possible
Killer whale (*Orcinus orca*)	LR/CD	Possible
Common porpoise (*Phocoena phocoena*)	VU	Possible
False killer whale (*Pseudorca crassidens*)	LR/LC	Likely
Rough-toothed dolphin (*Steno bredanensis*)	DD	Likely
Bottlenose dolphin (*Tursiops truncatus*)	DD	Likely
Risso's dolphin (*Grampus griseus*)	LR/LC	Likely
Indo-Pacific humpback dolphin (*Sousa chinensis*)	LR/NT	Likely
Pinnipeds		
Mediterranean monk seal (*Monachus monachus*)	CR	Possible to very unlikely

[1] IUCN categories: DD = data deficient; EN = endangered; LR/CD = lower risk/conservation dependent; LR/LC = lower risk/least concern; LR/NT = lower risk/near threatened; VU = vulnerable.

[2] Presence: Likely designation based on sightings or strandings data; Goffman et al. (2006).

The Action Plan further notes that effective and durable cetacean protections in the Mediterranean Sea require the cooperation with existing programs and plans, such as

- Global conventions regarding the protection of the marine environment – 1973/78 MARPOL Convention and London Dumping Convention; conventions on endangered species, including UNEP Global Plan of Action for Conservation of Marine Mammals (adopted in 198, and the Bonn Convention on the Conservation of Migratory Species of Wild Animals, and the Convention on International Trade in Endangered Species (CITES) (Washington Convention); and fisheries management plans;
- Working within the framework of the International Whaling Commission (IWC), to address an appeal to the IWC to designate the Mediterranean Sea Area as a whale sanctuary; and

- At the regional level, compliance with all relevant regional agreements (e.g., Food and Agriculture Organization [FAO] General Fishery Council for the Mediterranean, FAO/GFCM and the Bern Convention on the Conservation of European Wildlife and Natural Habitats).

The following general priorities were recommended as part of the Action Plan:

- Prohibition of deliberate taking;
- Prevention and elimination of pollution;
- Elimination of incidental catches in fishing gear;
- Prevention of over-exploitation of fishery resources;
- Protection of feeding, breeding and calving grounds;
- Monitoring, research and data collection, and dissemination with regard to biology, behavior, range, and habitats of cetaceans; and
- Implementation of educational activities aimed at the public at large and fishermen.

Gannier (2005) described regional delphinid populations in the major basins of the Mediterranean; however, no work was conducted in Israel waters. Based on nearly 400 sightings acquired along nearly 14,000 km of survey lines, with only a few sightings in the Levantine Basin region, the following determinations were made:

- All species had fairly consistent habitat across the Mediterranean;
- Delphinid diversity is dependent upon habitat, in terms of both production and topographic features;
- Striped dolphin is a wide ranging, opportunistic, pelagic species;
- Common dolphin are typically found in association with moderate water depths and slope habitat;
- Pilot whale distribution is dependent upon prey availability; and
- Relative abundance of delphinids was high in the northwestern basin, with decreases in abundance evident as one moves southward and eastward, in agreement with lower primary biomass in the Eastern Mediterranean.

3.8.6.2 Marine Mammals of the Eastern Mediterranean and Israeli Waters

The Mediterranean Sea supports a diverse marine mammal fauna, including several species listed by the IUCN as critically endangered (Mediterranean monk seal), endangered (fin whale, Sei whale), or vulnerable (sperm whale, humpback whale, common porpoise) as outlined in **Table 31**. Of the marine mammal species listed, monk seals are unlikely to occur in offshore Israeli waters, however due to its rarity, there is unsufficient information regarding the Israeli population and its ecology to eliminate the possibility of its presence in Israel waters. Other marine mammal species listed have variable likelihood of occurrence in either nearshore or offshore waters, including the Tamar Gas Field, as discussed below.

Mysticetes and Odontocetes

Few studies have been undertaken in the Eastern Mediterranean that address questions of cetacean abundance, either relative or absolute. Marine mammals (i.e., cetaceans) known to be present on the Israel continental shelf or slope, based on sightings or stranding reports compiled by the Israel Marine Mammal Research and Assistance Center (IMMRAC) and/or summarized by Goffman et al. (2006), include

- sperm whale (*Physeter macrocephalus*);
- minke whale (*Balaenoptera acutorostrata*);
- fin whale (*Balaenoptera physalus*);
- Cuvier's beaked whale (*Ziphius cavirostris*);
- false killer whale (*Pseudorca crassidens*);
- Risso's dolphin (*Grampus griseus*);
- common bottlenose dolphin (*Tursiops truncatus*);
- rough-toothed dolphin (*Steno bredanensis*);
- Indo-Pacific humpback dolphin (*Sousa chinensis*);
- short-beaked common dolphin (*Delphinus delphis*); and
- striped dolphin (*Stenella coeruleoalba*).

The main species of dolphin found in Israeli waters is the common bottlenose dolphin (*Tursiops truncatus*), which is found both in coastal waters in small groups (2 to 10 individuals) and in offshore waters in larger groups. The mean detectability rate (effort spent from initiation of a half day survey until first sighting of dolphins) for 26 sightings of coastal bottlenose dolphins unassociated with trawlers was 1.13 groups per 100 km of effort in 2007. Mean group size of bottlenose dolphins in Israel is 5 animals, giving a density of 5.5 animals per 25 km^2. It is believed that trawlers and dolphins frequent the same area, mainly beyond the 40-m isobath; under this scenario, the overall residency area would comprise approximately 1,400 km^2 and a population size of 360 animals (Kerem and Edelist, 2008; Scheinin, 2010). This estimate, however, may be high judging from the annual mortality rate, in spite of the fact that not all dead animals beach (i.e., all beachings are reported to and attended by IMMRAC).

Scheinin (2010) gives a detailed account of the Israel bottlenose dolphin population characteristics, as well as its relationships with trawlers. The association has been found to be very strong – dolphins were found to be present off the stern of trawlers working on the Israeli shelf >10% of the time. However, Scheinin (2010) did not determine that trawl landings matched gut contents of stranded dolphins, concluding that dolphins feed mostly on fish that either escape the nets or are discarded from onboard sorting. Edelist et al. (2011c) confirms this estimate based on the observation of 20 out of 208 trawl hauls examined in 2008-2011, where dolphins approached the stern of the trawler when nets were hauled onboard. Sighted groups were mainly engaged in foraging behavior, a series of long dives interrupted by short periods of ventilation at the surface, either while following bottom trawlers or without much horizontal movement (Scheinin, 2010). Of 23 dolphins sighted four times or more, all were observed at least once foraging behind a bottom trawler, suggesting behavior common to all members of the resident population, rather than a specialty of some members, as described in other parts of the world.

Goffman et al. (2009) recently summarized the distribution of rough-toothed dolphin (*Steno bredanensis*) in Israeli Mediterranean waters for the period 1993-2008. Goffman et al. (2006) also reported on the first sighting of a minke whale (*Balaenoptera acutorostrata*) in the Eastern Mediterranean.

Both the striped and the short-beaked common dolphins are also found in more open waters, seldom approaching coastal waters. Rough-toothed dolphins appear to be regular springtime visitors to Israeli waters as a result of their migrations the eastern edge of the Mediterranean Sea. Strandings of some other species of cetaceans denote the presence of these species in the area, although the lack of historic systematic marine mammal surveys precludes a definitive statement regarding their occurrence offshore Israel. These include Risso’s dolphin and Cuvier's beaked whale, with the occasional stranding of juveniles of the latter. Risso’s dolphin (*Grampus griseus*) has also stranded along the coast of Israel (Shoham-Frider et al., 2002).

All but two resident Mediterranean cetacean species have been sighted or have stranded in seemingly good nutritional state off or on the Israeli shoreline, respectively (Goffman et al., 2000, Feingold et al., 2005). The eastern Levantine Basin also holds special interest given its location north of the Suez Canal, a possible corridor for potential Lessepsian migrants from the Red Sea, including cetacean species (Kerem et al., 2001). These authors also noted the sighting of a single hump-backed dolphin (*Sousa* sp.) along the Israeli coast.

The cetacean populations of the eastern Levantine Basin have not been studied systematically. Most of the knowledge has been gathered in the last decade by IMMRAC. Information is based on stranded animals and opportunistic sightings collected since 1993 and on dedicated nearshore half-day coastal surveys being performed since 1999. The latter involved considerable survey effort, but one that is mainly confined to a limited survey area (i.e., 180 mi^2, 6 mi wide, 30 mi long) extending from nearshore waters offshore. Initiated in September 2005, it resulted in 14 cetacean sightings totalling 53 animals, including the first sighting by IMMRAC of striped dolphins in Israeli waters, the first offshore sightings of bottlenose dolphins (i.e., 10 to 18 nmi from shore in water depths of 180 to >1,000 m), and resighting of Risso's dolphins. The low sighting rate (0.088 animals per nmi) is consistent with the extreme regional oligotrophicity of the Eastern Mediterranean (Kent et al., 2006). A thorough coastal and offshore cetacean survey has never been attempted in the region.

There are approximately 300 to 400 individuals in the IMMRAC photo-identification dolphin catalog and the cumulative curve of new sightings continues to rise. The paucity of sightings with adequate photoidentification precludes estimation via mark-recapture models. Since the vast majority of surveying and photoidentification effort is invested on the shelf, in the center of Israel (roughly one-third of the coastline length), it is not certain whether the rise of the curve is due to the fact that dolphins from the south and north only occasionally move into the center (not all animals in the population have been marked), or that the population is "open" with exchange of individuals from outside the region, although the latter is more probable.

Several marine mammal researchers have presented sightings and strandings data at scientific conferences (e.g., European Cetacean Society annual conferences). Feingold et al. (2005) summarized cetacean strandings along the Mediterranean Israeli coast during the period 1993 to 2004 and to date more than 170 such strandings were recorded along the Israeli coast since 1993. Scheinin et al. (2005) summarized results from the first coastal sea surveys conducted off the Mediterranean coast of Israel between 1999 and 2004. Goffman et al. (2006) updated cetacean sightings information in Israeli waters for the period 2000-2006. Nir et al. (2008) more recently summarized cetacean sightings along the Israeli Mediterranean coast for the period 1993 to 2005. All of these works have found an increase in the rate of cetacean occurrence, concurrent with the increase in research efforts.

IMMRAC is a volunteer-based program established in 1994 in the University of Haifa to monitor research and assist marine mammals in Israel (Kerem and Edelist, 2008). IMMRAC's activities include:

- Updating the list of Mediterranean cetacean species that range into the inadequately-studied Eastern Basin.
- Conducting near-shore surveys with the goal of studying the habitat use, site fidelity, home-range extent, trends in population size and genetic profiles of coastal bottlenose dolphins, the most common local species.

- Manning a nationwide, 24-hour alert net which responds to real-time reports of distressed-at-sea, floating, beached and stranded dolphins, as well as a modest rehabilitation facility for sick/injured animals.
- Conducting post mortem examinations to determine age, feeding habits through stomach contents, possible cause of death, general state of health and level of tissue contaminants. Tissue samples are also sent to laboratories abroad for analyses unavailable locally at present.
- Pursuing a multi-year longitudinal study of dolphin-human relations expressed by a solitary sociable female bottlenose dolphin in the gulf of Aqaba/Eilat.
- Devising means of reducing by-catch, specifically of bottlenose dolphins, which have a close and costly association with the local trawl-boat fleet.
- Launching public awareness campaigns to draw attention to important ecological issues affecting dolphins in the Middle East, as well as the marine bio-diversity of our whole planet. This is accomplished by media interviews, press releases, public lectures, information stands and activity centers at various “green” exhibitions, as well as by offering educational programs at all age levels, from kindergarten to university.
- Lobbying for legislation aimed at conservation of the marine environment at large, and specifically marine mammals.

As only a few live cetaceans have stranded along the coast, most of the work entails research. In a limited number opportunities, however, attempts to assist live (but dying) beached cetaceans were made (i.e., two bottlenose dolphins, two Risso's dolphins, and one beaked whale). These efforts, however, met with little success and no specimens survived.

Of the less sighted species whose range apparently extends to the Israeli coastline (i.e., bottlenose, striped, common, Risso’s and rough-toothed dolphins, and Cuvier’s beaked whale), the IMMRAC database currently includes the Indo-Pacific humpback dolphin (one live individual, most probably a Lessepsian migrant, sighted at several locations along the coast), the minke whale (two calves found on separate occasions, entangled in gill-nets off Acre and Haifa, respectively), and false killer whale (one sighting of a 20-member pod and the beached remains of one adult, collected 30 km south of Haifa).

IMMRAC sighting and stranding data for the period 2005-2009 are summarized in **Table 32**. Sightings include short-beaked common dolphins, common bottlenose dolphins, rough-toothed dolphins, and several large whales (possibly minke or fin whale, sperm whale). Strandings include striped dolphins, common bottlenose dolphin, and rough-toothed dolphins.

Table 32. Summary of recent sightings and strandings, coastal Israel (Adapted from: Israel Marine Mammal Research & Assistance Center [IMMRAC], 2009).

Date	Location	Species and Comment
8 May 2009	1.5 mi offshore Ashdod	Sighting; short-beaked common dolphin; sightings included 6 calves
22 May 2009	Offshore Ashdod	Sighting; 50 short-beaked common dolphin
22 May 2009	600 m offshore Lachish River Beach	Sighting; 3 short-beaked common dolphins
28 May 2009	Offshore Tel-Aviv	Sighting; Several tens of short-beaked common dolphins
26 July 2008	Haifa Port	Sighting: unidentified large whale, possibly an adult minke whale (*Balaenoptera acutorostrata*) or a young fin whale (*Balaenoptera physalus*)
25 July 2008	Giv'at Olga Beach	Stranding: striped dolphin (*Stenella coeruleoalba*)

Table 32. (Continued).

Date	Location	Species and Comment
4 July 2008	Ne'urim Beach	Stranding: common bottlenose dolphin
4 July 2008	one km south of Beit-Yanay	Stranding: common bottlenose dolphin
4 May 2008	Sironit Beach	Stranding: rough-toothed dolphin calf
3 February 2008	Eilat-Ashkelon Pipeline Company anchorage	Sighting: 14-m long fin whale
23 January 2008	Offshore	Sighting: two adult dolphins
14 January 2008	Herzliya Beach	Sighting: 7-10 dolphins
27 November 2007	3 km off Ahziv	Sighting: common bottlenose dolphin
11 November 2007	Cliff Beach, Tel Aviv	Stranding: female bottlenose dolphin
29 October 2007	Hadera	Stranding: male dolphin
5 July 2007	3 mi off Ashdod	Sighting: sperm whale; 4 rough-toothed dolphins
21 June 2007	Ashdod Port	Stranding: 2 common bottlenose dolphins
28 April 2007	Eliat to Akko	Sighting: several bottlenose dolphins
March 2007	HaBonim Beach Nature Reserve	Stranding: fin whale
September 2006	Ma'ayan Zvi	Stranding: striped dolphin
March 2006	Sironit Beach	Stranding: bottlenose dolphin
March 2005	Haifa Port	Sighting: several tens of rough-toothed dolphins

Limited information regarding species presence in Israeli waters is also available from peripheral studies. For example, Roditi-Elasar et al. (2003) summarized heavy metal body burden levels in bottlenose and striped dolphins found off the Israeli coast. Sheinin et al (2009) evaluated the social ecology of common bottlenose dolphin (*Tursiops truncatus*) in Israeli waters. Goffman et al. (1996) reported on the herding of wild bottlenose dolphins out of Haifa Port using acoustic deterrents. A recent summary of environmental regulations in Israel, compiled from various published and unpublished sources, identified the following data for marine mammals present in Israeli waters:

- Bottlenose dolphin (*Tursiops truncatus*) – by far the most common marine mammal, accounting for numerous live sightings, and for which a detailed individual-level identification catalogue based on photographs is available (Goffman et al., 2000).
- Only 20 sightings of any species other than *T. truncatus* were documented, primarily the striped dolphin (*Stenella coeruleoalba*), however several more recent sightings other than *T. truncatus* were made in the last several years (Scheinin, pers. comm., 2011).
- Two species, Cuvier's beaked whale (*Ziphius cavirostris*) and fin whale (*Balaenoptera physalus*) were sighted only once but also stranded, indicating possible presence with low detectability rates.
- Twenty percent of all marine mammal sightings between 1993 and 1998 were of live animals at sea, the rest being of stranded (live) or beached (dead) individuals.

Several reasons for cetacean mortality in Israeli waters were identified by IMMRAC:

- Natural – mostly old and juvenile specimens;
- Disease – potentially exacerbated by anthropogenic toxic chemicals, as the fatty layers of most stranded cetaceans were found to contain elevated levels of heavy metals;
- Inadvertent capture by fishermen (roughly 30% of mortality) either by trawl or gillnets; and
- Hunger or dehydration by stomach and gut blockage from solid waste – almost solely plastic bags.

While collision with ships was not identified as a major reason for mortality in Israel, cases were recorded of juvenile whales following ships into port and subsequently dying there from hunger.

Notarbartolo di Sciara and Birkun (2010) recently prepared a status report specific to the conservation of cetaceans in the Mediterranean and Black Seas. The report provides information concerning regional distribution of the various resident and visitor cetaceans found in the Mediterranean Sea.

Pinnipeds

The Mediterranean Monk Seal is a pinniped belonging to the Phocidae family. With a worldwide population estimated to be 350 to 450 individuals, this species is believed to be the world's second rarest pinniped, second only to the Saimaa Ringed Seal. It is one of the most endangered mammals in the world. 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 these events were 50 and 60 years ago, at which time neighboring Lebanon reported an estimated population of 10 to 20 of the critically endangered species in its waters. Up until the 20th century, Mediterranean Monk Seals had been known to congregate, give birth, and seek refuge on open beaches. In more recent times, they use only sea caves for such purposes, which are inaccessible to humans. This is a recent adaptation, most likely due to the rapid increase in human population, tourism, and industry, which have caused the destruction of animals' open beach habitat. Because of these seals' shy nature and sensitivity to human disturbance, they have slowly adapted to avoid contact with humans completely within the last century. The coastal caves are dangerous for newborns, and are causes of major mortality among pups.

This earless seal's former range extended throughout the Mediterranean Sea and Black Sea coastlines including all offshore islands of the Mediterranean, and into the Atlantic and its islands as far West as the Azores. The population has been reduced through commercial hunting (especially during the Roman Empire and Middle Ages) and, during the 20th century, eradication by fishermen who used to consider it a pest due to the damage the seal causes to nets. Coastal urbanization and pollution are also recognized factors in the reduction in monk seal numbers. The species is extinct in the Sea of Marmara due to pollution and heavy ship traffic from the Dardanelles and the Bosphorus. The last report of a seal in the Black Sea dates to the late 1990s. At present, the monk seal population is scattered throughout a wide distribution range with only two key sites which can be deemed viable – one is in the Aegean Sea (i.e., 150 to 200 individuals in Greece; approximately 100 individuals in Turkey), the other in the Western Saharan portion of Cabo Blanco (approximately 130 individuals). All of the other remaining subpopulations are composed of less than 50 mature individuals, many of them being only loose groups of extremely reduced size – often less than 5 individuals. Israel, with the recent rare sightings may be such a case.

3.8.7 Sea Turtles

Three sea turtle species occur in the Mediterranean Sea: green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and loggerhead (*Caretta caretta*). The loggerhead turtles are listed by the IUCN as endangered, and the leatherback is listed as critically endangered (IUCN, 2011; Tikochinski et al., 2012).

Gerosa and Casale (1999) summarized the interaction of marine turtles of the Mediterranean with the fisheries industry. The impact of accidental catch on Mediterranean sea turtle populations is an issue which has potentially significant impacts on turtle species survival. In the Mediterranean, all marine turtle species are affected by fishing activities, in particular loggerhead and green turtles, which are more common than the others and are the only ones breeding in the Mediterranean. Because Mediterranean loggerhead and green turtle populations appear to be genetically isolated from populations in the Atlantic Ocean (Bowen et al., 1992, 1993; Laurent et al., 1993), fishing-induced mortality cannot be counterbalanced by immigration. This implies that the survival of the Mediterranean populations of these species depends to a great extent on current and future conservation efforts by Mediterranean to reduce accidental mortality. Furthermore, since Israel's beaches are prominent nesting sites, conservation of turtles in Israel greatly depends on beach conservation.

Broderick et al. (2002) provide estimates of the number of green and loggerhead turtles nesting in the Mediterranean. The intensive use of beaches for tourism and recreational purposes is now threatening turtles in the Mediterranean by depriving them of their nesting grounds. Many turtles drown or are killed when caught in fishermen's nets or on long-lines. Caminas (2004) estimated that 60% of turtle mortalities are fishing related. Other threats include the use of explosives (damage to inner soft tissues) or direct hits from vessels; and the ingestion of plastic bags and other man-made debris, leading to suffocation and starvation. Natural threats to turtles include predation by foxes and inundation by seawater during summer storms. The main anthropogenic threat to turtle nests is the intensive traffic of four-wheel drive vehicles on the beaches. Another threat to successful nesting is coastal development, with its associated nighttime lighting, sand theft, and diminished undisturbed hatching habitat.

The United Nations Environment Programme recently developed the Mediterranean Action Plan for marine turtles (UNEP MAP RAC/SPA, 2007). For Israel, the action plan calls for the implementation of Israeli policies and procedures to 1) ensure long-term protection of major and potential nesting beaches; 2) promote the process of legal declaration of protected marine and coastal areas; and 3) eliminate both destructive human activities on nesting beaches and the disorientation of hatchlings caused by artificial light.

3.8.7.1 Species Presence and Israeli Management

The Israel National Nature and Parks Authority (INNPA) prepared a management plan for sea turtles since the 1980s. During more than 20 years, rangers survey potential nesting beaches along the Mediterranean coast, tracking, protecting and relocating loggerhead and green turtles nests into hatcheries in coastal nature reserves, where they are protected. Once hatched, the hatchlings are released; more than 72,590 and 12,091 hatchlings of loggerhead and green turtles have been released to date, respectively (INNPA, 2011). In 1999, INNPA established a sea turtle rescue center. Since 1999, 330 wounded turtles were rehabilitated to date, with >60% (182 specimens) released back to the wild. The rescue center also runs a green turtle breeding stock program, where hatchlings are grown in seawater ponds and are expected to reach a full-mature weight of approximately 100 kg by 2019 (INNPA, 2011). An additional activity of the INNPA is sampling stranded sea turtle carcasses in order to collect different data, such as genetic information, population size, and distribution.

A national management program was developed by Meir and Kuller (1992) and has been implemented since 1993. This program, based on collection and translocation of eggs to safe hatcheries, is currently applied throughout the Israeli coastline. There are currently five such hatcheries: west Galillee (Betzet), Carmel coast (Atlit), Sharon (Michmoret-Beit Yannay), Pleshet, and the southern coast.

From 2008 to date, 10 satellite transmitters were attached to adult sea turtles to monitor their migration patterns in the Eastern Mediterranean. These can be monitored online (seaturtle.org, 2011) and initial results indicate that after laying their eggs, females migrate to various locations for wintering (e.g., Tunisia, Lybia, Egypt, Syria, Israel, and Cyprus; **Figure 49**). Along with the migration of hatchlings, whose migration pattern is unknown, these data indicate that there is a large probability of sea turtles occurring offshore Israel, especially in June-July during the breeding season.

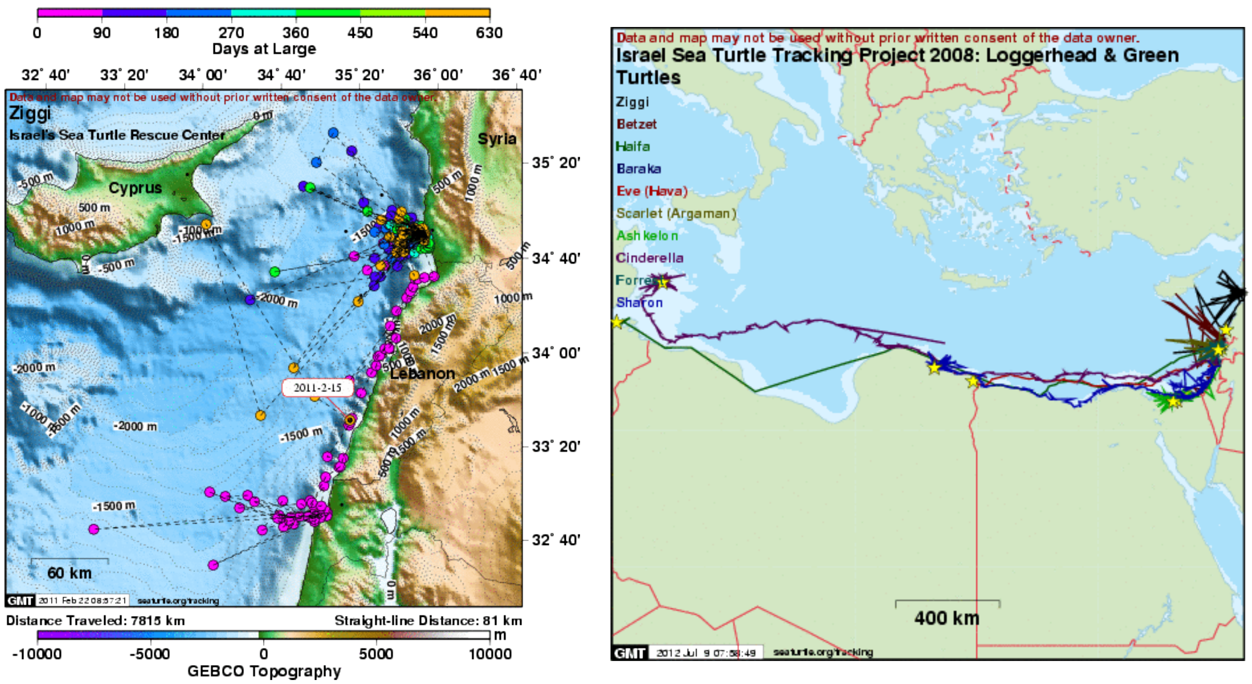


Figure 49. Tracked movements of sea turtles off Israel (From: SeaTurtle.org, 2011).

3.8.7.2 Nesting

The main nesting grounds for loggerheads in the Mediterranean are in Greece, Turkey, and Cyprus, with some nesting in other countries in the East Mediterranean (International Council for the Scientific Exploration of the Mediterranean [ICSEM], 1986). Nesting starts at the end of May for loggerhead turtles and in mid-June for green turtles. It continues until about the end of July and mid-August, respectively.

In Israel, both green turtles (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*) nest along the coast. Among the sea turtles of the Eastern Mediterranean, the loggerhead is the most common nesting species along Israeli shores. While the primary nesting grounds for the Mediterranean loggerhead population are located along the shores of Greece, Cyprus, and Turkey, the Israeli coast has historically provided habitat for hundreds of nests. In the 1950s, approximately 200 nests with a density of ~15 nests/km were recorded on 15 km of typical beach in the northern region of Israel (Sella, 1982). During the last few decades, however, concurrent with excessive coastal development, nesting activity in Israel has decreased significantly. Reports by the Israeli Nature Reserves Authority and other turtle researchers (Soffer, 1988; Kuller, 1990; Silberstein and Dmi'el, 1991) document decreased nest abundance and density. Along ~55 km of coastline, including the coastal region assessed by Sella (1982), only 10 nests were found in 1984, 14 in 1985, 16 in 1986, 16 in 1987, and 11 and 13 nests in the years 1988 and 1989, respectively (Silberstein and Dmi'el, 1991). These authors also cited diminished and variable hatching success ranging between 0% and 90% during 1986-1989. Hatch failure was attributed to the depth of the nest and to its location with respect to the water line.

Kuller (1999) reported on loggerhead and green turtle nesting and hatchling counts on Israel beaches during 1993-1998 (**Table 33**), indicating variable success in nesting and hatchlings over this 6-year period.

Table 33. Summary of loggerhead and green sea turtle nesting and hatchling numbers, coastal Israel, 1993-1998 (From: Kuller, 1999).

Year	Loggerhead Sea Turtle		Green Sea Turtle	
	Nests	Hatchlings	Nests	Hatchlings
1993	10	597	0	0
1994	26	1,552	8	593
1995	46	2,743	1	59
1996	34	1,946	0	0
1997	21	1,089	2	0
1998	40	2,523	13	993
Total	177	10,450	24	1,645

In contrast to the findings of Kuller (1999), INNPA (2010) have continued to monitor loggerhead and green sea turtle nesting along the Israeli coast, noting success in the rehabilitation and stabilization of nesting success during the last decade (see **Figures 50** and **51**,respectively). These recent efforts confirm that Israel is a major potential nesting site, and that conservation efforts are successfully moving loggerheads and green sea turtle nesting activity back towards natural pre-human interference levels. The trend of low hatching success reported by Silberstein and Dmi'el (1991) also seems to be reversed within the specialized hatcheries, with a 10-year average of 69.21% and 71.23% success rate (e.g., hatchlings which made it to sea) for loggerhead and green turtles, respectively.

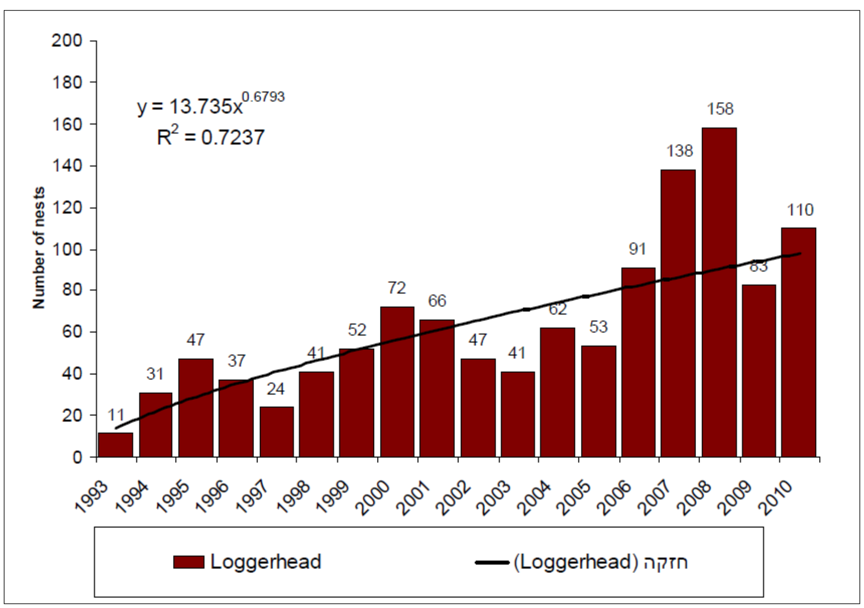


Figure 50. Number of sea turtle nests during the period 1993-2010 (From: Israel National Nature and Parks Authority, 2010).

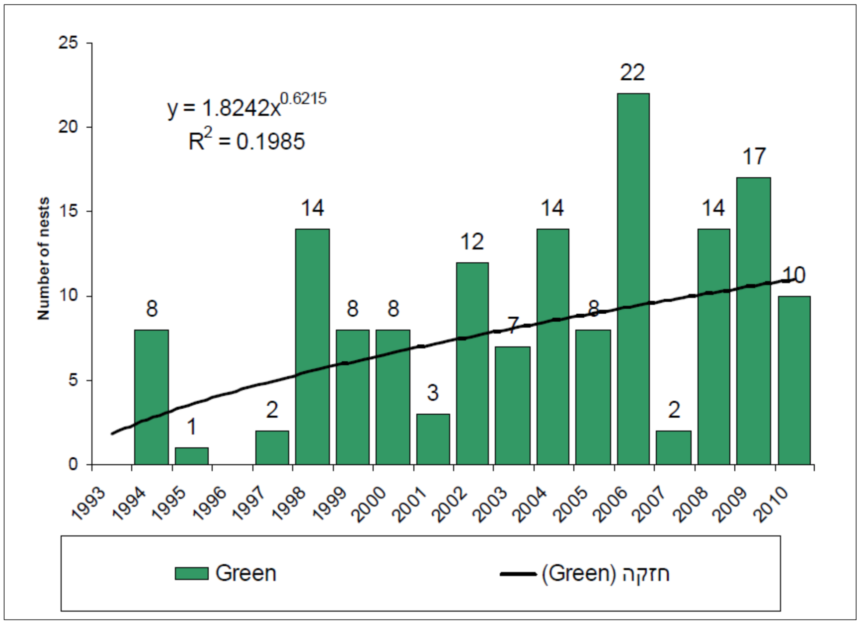


Figure 51. Number of green sea turtles nests in Israel during the period 1985-2010 (From: Israel National Nature and Parks Authority, 2010).

During the last decade, 1,082 turtles beached along Israeli shores (NNPA, 2011), and only 329 of these were alive. Whereas such numbers indicate the great threat to turtles, they may also indicate frequent human-turtle encounters as a result of a rebounding population.

To date, there have been no systematic marine sea turtle surveys in nearshore or offshore waters off Israel. However, the information presented in this summary indicates loggerhead and green sea turtles are expected to occur in offshore waters, particularly in the nesting season (early summer), during their approach and departure from Israel nesting beaches.

3.9 CONSERVATION

3.9.1 Categories for Israel Conservation Areas

National Parks. National parks are defined as areas meant for "the public enjoyment of nature or for the preservation of areas of historic, archaeological, or architectural importance." An area designated as a national park may not be changed, or its designation as such revoked, unless the Interior Minister cancels his declaration. A National Parks Authority, appointed by the Minister of the Environment, manages the national parks and reports to the Minister on matters relating to national parks. The Authority is composed of "government officials, local officials, members of scientific organizations, and members of the public concerned with improvement and preservation of the Israeli landscape, development of vacation and natural sites, and the preservation of areas of historical and national importance." No building work or other activity will be permitted unless approved by the National Parks Authority. The Minister may not cancel the declaration of a national park without the approval of the Minister of the Environment, the Local Council, in which the park is located, and the Interior and Environmental Committees of the Knesset.

Nature Reserves. Following consultation with the Minister of the Agriculture, the Minister of the Interior may declare an area of scientific or educational interest to be a Nature Reserve. A nature reserve is "an area in which animals, plants, inanimate objects, soil, caves, water, and landscape are protected from changes in their appearance, biological makeup, and natural development." The Minister of the Agriculture appoints a Nature Reserves Authority to manage the affairs of nature reserves. The 11-member authority is to be made up of government officials, members of scientific and public bodies, and representatives of the public. Initiating and planning the establishment of nature reserves, managing and developing the reserves and protecting natural assets are among the responsibilities of the Nature Reserves Authority. Following consultation with the Israel Academy of Science, the Minister of Agriculture appoints a professional committee of zoologists, botanists, geographers, ecologists, and planners to advise the Nature Reserves Authority. The Nature Reserves Authority sets rules for the use of nature reserves, following consultation with the local authority in whose jurisdiction the reserve lies, and with the permission of the Minister of Agriculture.

Protected Natural Resources. A "protected natural resource," as defined by this Law, means "anything or class of things in nature, whether animal, vegetable or mineral, whose preservation, in the opinion of the Minister of Agriculture, is of value." The Minister of Agriculture may declare, after consultation with the National Reserves Council, any natural resource throughout Israel, or any specific part of it, to be a protected natural resource. It is forbidden to damage, destroy, pick, uproot, poison, or otherwise change a protected natural resource except with the permission of the Director of the Nature Reserves Authority. Selling protected natural resources is prohibited except with the permission of the Nature Reserves Authority. A person may not own a protected natural resource unless he receives permission from the Nature Reserves Authority.

National Sites and Memorial Sites. The Minister of the Interior, following consultation with the National Sites Council, may declare a place to be a "national site." As is the case with national parks, the Minister must also consult with those in whose jurisdiction the site lies. National sites are protected from damage or alteration. The Minister of the Environment may promulgate regulations delineating the means of preservation and protection of a national site. When a national site carries special local importance, the Minister of the Environment may give the local authority the authority to manage the site. The Government upon the recommendation of the Ministers of Defense, Labor, and Interior appoints “Memorial Sites Council.” The Council is authorized to advise the Ministers of Interior and Defense as to all issues concerning memorial sites. The Minister of Interior, following consultation with the local authority and the Memorial Sites Council, may declare an area a memorial site. Upkeep and maintenance of memorial sites is the responsibility of the local authority that has jurisdiction of the site. The Minister of the Interior, after consulting with the Minister of Defense, is authorized to promulgate regulations concerning memorial sites.

3.9.2 Marine Habitats and Areas of Special Concern

Designated and proposed parks and reserves in Israel are characterized in **Section 3.9.1**. The UNEP and IUCN have identified a series of marine habitats in Israel, including reserves, nature reserves, marine nature reserves, and national parks, as summarized in **Table 34**.

Table 34. Summary of designated protected marine or marine-terrestrial habitats along the Mediterranean coast of Israel, including those listed by the International Union for the Conservation of Nature (IUCN).

Site Name	Designation	IUCN or National	Marine or Terrestrial	Total Area (ha)	Total Marine Area (ha)
Hof Hasharon (Sharon Beach)	National Park; MPA	V	Both	ND	ND
Hof Palmachim	National Park	National	Both	ND	ND
Hof Dor HaBonim	Marine Nature Reserve; MPA	IV	Marine	ND	ND
Iyye Hof Rosh Ha-niqra	Nature Reserve	IV	Marine	31.0	31.0
Iyye Hof Dor U-Ma'agan Mikha'el	Nature Reserve	IV	Marine	ND	ND
Nahal Alexander	National Park, MPA	V	Marine	374.0	374.0
Nahal Poleg	Nature Reserve	IV	Both	ND	ND
Rosh HaNigra	Nature Reserve	IV	Both	440.0	--
Rosh Hanikra Sea and Shore	Nature Reserve; MPA	National	Marine	960.0	960.0
Sidney Ali	National Park	National	Both	ND	ND
Yam Dor HaBonim	Marine Nature Reserve; MPA	IV	Both	574.0	532.0
Yam Evtah	Marine Nature Reserve; MPA	National	Marine	137.0	137.0
Yam Gador	Marine Nature Reserve; MPA	National	Marine	138.0	65.0
Yam Maa'gan Mikeael	Nature Reserve	National	Both	450.0	--
Yam Shiqma	Nature Reserve; MPA	National	Marine	1,030.0	1,030.0

IV and V – IUCN marine habitat categories (see text); MPA – Marine Protected Area; ND – not determined.

Table 34 identifies several IUCN designations for marine habitats. Categories are defined as follows:

- **Category II** areas are typically large and conserve a functioning ecosystem, although to be able to achieve this, the protected area may need to be complemented by sympathetic management in surrounding areas. The area should contain representative examples of major natural regions, and biological and environmental features or scenery, where native plant and animal species, habitats, and geodiversity sites are of special spiritual, scientific, educational, recreational, or tourist significance. The area should be of sufficient size and ecological quality so as to maintain ecological functions and processes that will allow the native species and communities to persist for the long term with minimal management intervention. The composition, structure, and function of biodiversity should be to a great degree in a natural state or have the potential to be restored to such a state, with relatively low risk of successful invasions by non-native species.
- **Category IV** protected areas usually help to protect, or restore: 1) flora species of international, national, or local importance; 2) fauna species of international, national, or local importance including resident or migratory fauna; and/or 3) habitats. The size of the area varies but can often be relatively small; this is however not a distinguishing feature. Management will differ depending on need. Protection may be sufficient to maintain particular habitats and/or species. However, as category IV protected areas often include fragments of an ecosystem, these areas may not be self-sustaining and will require regular and active management interventions to ensure the survival of specific habitats and/or to meet the requirements of particular species.
- **Category V** protected areas result from biotic, abiotic, and human interaction and should have the following essential characteristics: 1) landscape and/or coastal and island seascape of high and/or distinct scenic quality and with significant associated habitats, flora and fauna and associated cultural features; 2) a balanced interaction between people and nature that has endured over time

and still has integrity, or where there is reasonable hope of restoring that integrity; and 3) unique or traditional land-use patterns, e.g., as evidenced in sustainable agricultural and forestry systems and human settlements that have evolved in balance with their landscape. The following are desirable characteristics: 1) opportunities for recreation and tourism consistent with life style and economic activities; 2) unique or traditional social organizations, as evidenced in local customs, livelihoods, and beliefs; 3) recognition by artists of all kinds and in cultural traditions (now and in the past); and 4) potential for ecological and/or landscape restoration.

Abdulla et al. (2008) describes 17.97 km^2 or 0.56% of Israel's coast as managed or protected areas (MPAs). The small-declared nature reserves of Achziv in the north and Dor-Habonim midway along the coast comprise the bulk of the protected and managed areas, holding a unique status as the only sites along the entire Levantine coast which conserve the coastal rocky and sandy ecosystem and their fishery resources in a near pristine state. The 0.56% of managed coast makes Israel the least advanced of the 16 Mediterranean countries surveyed by Abdulla et al. (2008).

In recent years, plans were implemented to enhance and develop at least three larger MPAs along the coast, in the north, south, and center of the country (**Figure 52**). These are expected to be an expansion of existing MPAs. Plans called for the establishment of four large nature reserves, stretching from the 12 nmi territorial water boundary; this will comprise approximately 600 km^2, or 20% of Israel's territorial sea. INNPA is currently negotiating this plan with the Department of Fisheries and other stakeholders, legislators, and relevant bodies. The plan is to implement several large scale MPAs in order to protect the environment and conserve biodiversity (Yahel, 2010). These MPAs are described below and shown in **Figure 52**.

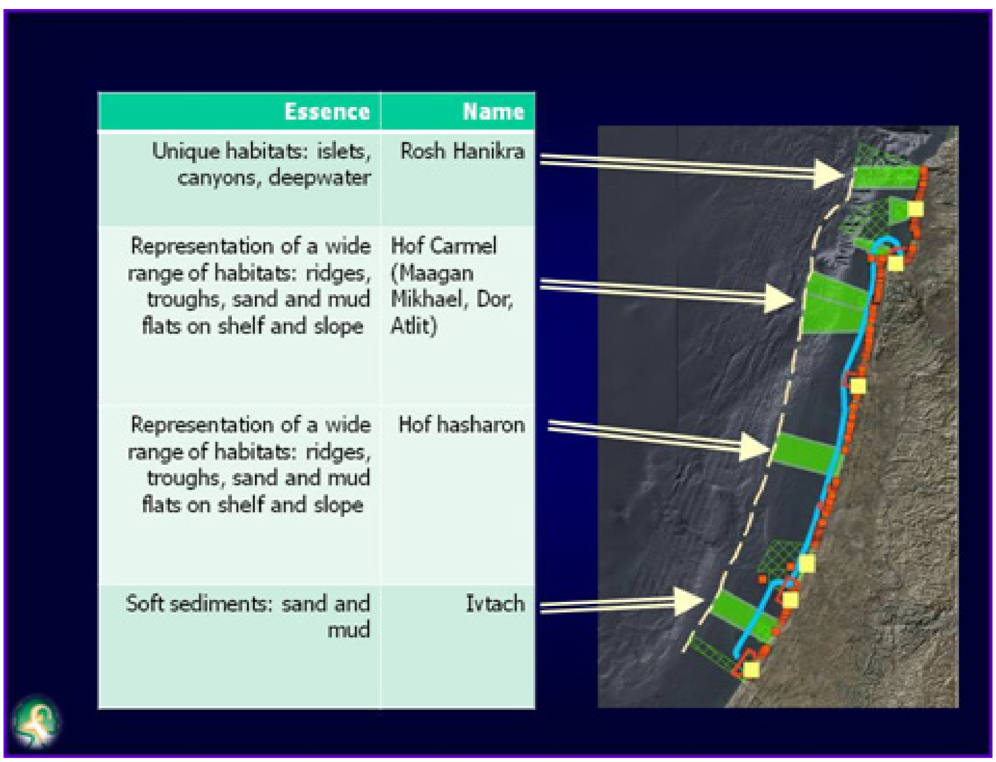


Figure 52. Proposed Marine Protected Areas in the Israeli marine environment (From: Yahel, 2010).

According to the European Commission (2011), based on MedPAN statistics, Israel presently has five established MPAs, including 1) Rosh Hanikra Nature Reserve (with 9.6 km^2 of marine surface area), 2) Yam Dor Habonim Marine Nature Reserve (5.3 km^2), 3) Yam Evtah Marine Nature Reserve (1.4 km^2), 4) Yam Gador Marine Nature Reserve (0.7 km^2), and 5) Shigma Nature Reserve (1.0 km^2).

According to the Israel Ministry of the Environment (1999), wetland conservation and development are integrated into the country's National Biodiversity Strategy. The general objectives of this strategy, as specified in Israel's report on implementation of the Convention on Biological Diversity (December 1997), include:

- Increasing efforts to preserve biological diversity and sustainable development of biological resources;
- Initiating an ecological approach to management which is based on an understanding of ecosystem functioning, biological inventory, reliable data, integrated planning and monitoring systems;
- Increasing public participation in planning, developing and implementing biological diversity policies;
- Striving to achieve an optimal balance between regulatory action and education in order to promote responsible public behavior; and
- Contributing to the international effort to preserve biological diversity.

Israel hopes to meet its goals through the implementation of a number of targets, including:

- Developing and implementing a comprehensive plan for preserving biodiversity and for sustainable use of its components;
- Establishing a network of protected areas for the preservation of ecosystems, species and genetic resources which are capable of functioning ecologically and which are related to other open spaces;
- Rehabilitating damaged ecosystems in order to promote biodiversity;
- Coordinating the implementation of the plan among all stakeholders including governmental and nongovernmental bodies, the private sector, community groups and other target populations;
- Utilizing legislation, rules and procedures, budgetary allocations and other regulatory measures to establish methodologies for conservation of biological diversity and sustainable use of resources;
- Advancing public awareness concerning the advantages of biodiversity conservation and sustainable development;
- Promoting knowledge and expertise through formal and nonformal education, ongoing research, and increased institutional capabilities;
- Harmonizing national action with international and regional conventions, activities and plans;
- Implementing the precautionary principle approach through measures intended to forecast, prevent and combat the causes for reduction or loss of biodiversity at source; and
- Integrating traditional knowledge on the conservation of biodiversity.

The central components of the strategy include the following:

- Declaration of at least 10% of each ecosystem as a nature reserve;
- Preservation of 20% of all open spaces as scrubland, half of which will be natural scrubland;
- Establishment of regulatory and other controls on the use of biological resources;
- Implementation of an environmental impact assessment system to control pollutants which threaten to damage ecosystems;
- Protection of the diversity of domesticated races;

- Monitoring and establishment of a database to assess the condition of species and ecosystems and to establish priorities for conservation;
- Incorporation of such considerations as natural resource conservation and ecological functioning of ecosystems in development decisions; and
- Promotion of regional and international cooperation.

An essential part of the national biodiversity strategy is the setting of priorities for action. In Israel, the following criteria have been set for selecting ecosystems for preservation:

- wealth of biodiversity;
- high level of endemism;
- representative value;
- undisturbed status;
- presence of important species; and
- critical ecological value (path of migration, nesting, food, hydrological significance to the ecosystem).

The following criteria have been set for selecting species for preservation:

- genetic importance;
- ecological importance;
- economic and social importance; and
- level of risk and damage.

Israel began preparing its national coastal strategy for sustainable development in 1996 within the framework of a Coastal Area Management Programme (CAMP) signed between Israel and the Mediterranean Action Plan. As part of the project, seven target groups were organized, one of which is specifically concerned with biodiversity and open space development. The groups are composed of a wide range of stakeholders including national government, local government, the private sector, academics, and NGOs.

3.9.3 Protected Marine Species and Habitats

Protected seabirds, marine mammals, and sea turtles of the Eastern Mediterranean region have been outlined previously in **Sections 3.8.5**, **3.8.6**, and **3.8.7**, respectively. In addition, there are several invertebrate and vertebrate species listed as endangered or threatened by CITES. Listed species of the Eastern Mediterranean that may occur in Israeli waters are noted in **Table 35**. **Table 36** lists species in the Eastern Mediterranean, including their preferred habitat, whose exploitation is regulated by the Barcelona Convention.

Table 35. Endangered or threatened species in the Eastern Mediterranean (Adapted from: Abdul Malak et al., 2011).

Higher Taxon	Species	Comments
Porifera (sponges)	*Tethya* spp.	Mostly below 15 m
Echinoderms	*Centrostephanus longispinus*	Within coralligenous crevices
Mollusca	*Dendropoma petraeum* (petraeum) *Erosaria spurca* (Mediterranean cowry) *Lithophaga lithophaga* (date mussel) *Pinna nobilis* (noble pen shell) *Tonna galea* (tun snail)	A builder of the biogenic reefs Sand dweller; shallow to ~40 m Hard substrate burrower; intertidal Sand dweller; shallow Soft bottom dweller; deep
Crustacea	*Ocypode cursor* (sand crab)	Above water level
Sharks	*Cetorhinus maximus* (basking shark) *Carcharodon carcharias* (great white shark)	Not dangerous to humans Dangerous to humans
Pisces	*Hippocampus hippocampus* (shortsnouted seahorse)	Soft bottom; 8 to 30 m
Reptilia	*Caretta caretta* (loggerhead) *Chelonia mydas* (green) *Dermochelys coriacea* (leatherback) *Eretmochelys imbricata* (hawksbill)	Predominant nester in Israel Critically Endangered. Minor nester in Israel Not a nester in Israel Not a nester in Israel
Aves	*Calonectris diomedea* (Cory's Shearwater) *Falco eleonorae* (Eleonora's Falcon) *Phalacrocorax aristotelis* (European Shag) *Pelecanus onocrotalus* (Great White Pelican) *Pelecanus crispus* (Dalmatian Pelican) *Phoenicopterus rubber (*American Flamingo) *Sterna albifrons* (Little Tern) *Sterna sandvicensis* (Sandwich Tern)	Rare Very rare Rare Common Very rare Rare Common (rare nester) Rare

Table 36. Species in the Eastern Mediterranean whose exploitation is regulated by the Barcelona Convention (Adapted from: Abdul Malak et al., 2011; SeaLifeBase, 2009).

Taxon	Species	Common Name	Habitat
Porifera	*Spongia officinalis*	Commercial sponge; Greek bathing sponge	Sessile, marine; depth range: 5 to 76 m
Echinodermata	*Paracentrotus lividus*	Sea urchin	Demersal, marine; depth range: not determined
Crustacea	*Maja squinado*	European spider crab; spinous spider crab	Demersal, marine; depth range: 0 to 75 m
	Scyllarides latus	Mediterranean slipper lobster	Demersal, marine; depth range: to 100 m
	Scyllarus pygmaeus	Pygmy locust lobster	Demersal, marine; depth range: 5 to 100 m
	Scyllarus arctus	Small European locust lobster	Demersal, marine; depth range: to 100 m
Pisces	*Anguilla anguilla*	European eel; Tzlofach	Freshwater, brackish, marine; depth range: 0 to 700 m
	Prionace glauca	Blue shark; Karish kakhol	Pelagic-oceanic, marine; depth range: 1 to 350 m

Table 36. (Continued).

Taxon	Species	Common Name	Habitat
	Squatina squatina	Angelshark; Mak'akh; Mal'ah	Demersal, marine; depth range: to 150 m
	Rhinobathos cemiculus	Guiterfish	Demersal, marine; depth rage: to 100 m
	Gymnura altavela	Butterfly ray	Demersal, marine; depth range: to 100 m
	Pristis spp.	Wide sawfish	Demersal, marine; depth range: to 100m
	Dipturus batis	Grey skate	Demersal, marine; depth range: 200 to 600 m
	Pagrus pagrus	Red porgy	Demersal, marine; depth range: to 100 m
	Rostroraja alba	Bottlenose raja	Demersal, marine; depth range: 40 to 400 m
	Epinephelus marginatus	Dusky grouper	Demersal, marine; depth range: to 60 m

The following protected species present along the Israeli coast, pursuant to requirements of the Parks and Nature Reserves Law (Natural Assets), 2005 are natural assets protected by law:

- Coelenterata – the entire phylum is protected, including eight hydrozoan species, five scyphozoan species (i.e., jellyfish), and eight anthozoan species (i.e., sea anemones, corals).
- Echinodermata – the entire phylum is protected, including nine urchin species, nine seastar species, eight brittlestar species, four sea cucumber species, and one featherstar species.
- Polychaeta – the entire order is protected, including 15 species.
- Mollusca – the entire phylum is protected, including 10 polyplacophoran species (i.e., chitons), 470 gastropod species (marine snails), 190 bivalve species (i.e., clams, mussels, etc.), and 12 cephalopod species (i.e., octopus).
- Pisces – 18 families of Teleostei (i.e., bony fishes) are protected, including the following fish families (number of species provided in parentheses): Apogonidae (1), Labridae (9), Pomacentridae (1), Balistidae (1), Scorpaenidae (6), Anthiidae (1), Gobiidae (15), Bleniidae (13), and Scaridae (1). In addition, sharks of the Order Selachii are also protected; the total number of shark species protected remains undetermined.
- Reptilia – four species of sea turtles are protected.
- Aves – Israeli law declares all bird species protected, with 18 specified exceptions. All shore and marine bird species are protected under this declaration.
- Mammalia – all but 10 species of mammals are protected under Israeli law.

3.10 SOCIOECONOMIC ENVIRONMENT

The following resource-specific discussions present summaries of pertinent, available information on the socioeconomic environment of Israel. Most of this information has been derived from the available literature and government sources.

3.10.1 Commercial and Recreational Fishing and Mariculture

3.10.1.1 Overview of Commercial Fishing

The Israeli commercial fish industry generates approximately US$100 million per annum in revenue and employs about 1,500 workers. The Mediterranean fish catch is roughly 3,000 tons, generating about US$40 million annually. Most of the fishing in the Mediterranean is in shallow water, in water depths up to 110 m, which 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.

In 2007, the population of Israel consumed 72,000 tons of fish or roughly 10 kg per person. About 25,000 tons are locally produced (including aquaculture) with only 3,000 tons (6% to 7% of the total consumption) of this caught in the Mediterranean. Approximately 70% of the fish consumed in Israel is imported (Shapiro, 2007). The following four domestic fish sources account for local production:

- Aquaculture – consisting of fish ponds, which account for the majority of production;
- Marine fishing in the Mediterranean and Gulf of Eilat (Red Sea);
- Mari-culture in Mediterranean and Gulf of Eilat; and
- Freshwater fishing from Lake Kinneret (Sea of Galilea).

The annual fish production in Israel in 2007 is detailed by source and value in **Table 37**.

Table 37. Fish production and catch in Israel, 2007 (From: Shapiro, 2007).

Source	Catch (tons)	Percent of Catch	Value	
			NIS 000	US$000
Aquaculture	19,168	77.1	252,475	61,458
Marine Fishing	2,607	10.5	101,200	24,114
Mariculture	2,251	9.1	67,720	16,484
Lake Kinneret Fishing	840	3.4	4,844	1,041
Total	**24,866**	**100**	**426,239**	**103,097**

USD = 4.1 NIS

Recent events have changed the relative contribution from various fish sources. In June 2008, the Gulf of Eilat mariculture operation was terminated, eliminating more than 60% of mariculture production in the country. Furthermore, Kinneret yields in 2008-2009 plummeted by more than half, prompting the Ministry of Agriculture to declare a two-year cessation of fishing in the lake, effective starting in the spring of 2010.

3.10.1.2 Commercial Fishing in the Mediterranean

The Israeli Mediterranean coastline has a length of 179 km, excluding the Gaza strip, with 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 about 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. Fishing areas are crossed by the offshore INGL marine natural gas transmission pipeline. Currently there is a lawsuit pending regarding compensation demanded by the fishermen for economic losses due to laying the pipeline in 2004-2005.

Fishing in the Eastern Mediterranean is influenced by many factors, the most important of which are outlined in the following discussion.

Naturally Poor Fishing: Levantine fishing fields are considered to be naturally poor due to the oligotrophic nature of the water (low amount of nutrients), high temperatures, and elevated salinity levels (Por and Dimentman, 1989). These factors, among others, have been postulated to contribute to the smaller size of Levant fishes. This phenomenon, called "Levantine Nanism," was shown, along with early sexual maturation, for ground fishes of the family Mullidae by Sonin et al. (2007).

Pollution: Certain types of pollution tend to negatively impact fish stocks. Two types in particular impact Israeli fisheries:

- Inorganic effluents, which tend to cause fish depletion and bio-accumulation of mercury and other heavy metals in marine organisms and sediments, especially in the Bay of Haifa but also in many river estuaries and factory outfalls.
- Some forms of organic pollution actually provide nutrient enrichment and contribute to overall marine production and yields, as is the case for the Tel-Aviv metropolitan urban sludge outfall, the Shafdan. Nevertheless, the deleterious influence of this outfall on surrounding water quality and health of adjacent benthic populations is still a matter of great environmental concern.

Overfishing of Coastal Waters: It has recently been demonstrated by Edelist et al. (2011c) that despite large-scale fluctuations in fishery yields since 1948, when combining catch with effort data (as Catch Per Unit Effort), trawlers now have to exert three times the effort they did in the 1950's to land the same amount of catch. It is postulated in the same study that this is due to the overfishing of the shelf resources. Other effects found were a decrease in mean length of some species (alluding to growth overfishing) and increases in the amounts of crustaceans in the catch (some of which are also high-priced tiger prawns, sold for up to US$30/kg), which is evidence of "fishing down the marine food web" (Pauly and Palomares, 2005).

Political Events: Political events can have negative short-term effects on fishing. For example, closure of fishing fields near the borders in order to serve as buffer zones against infiltration when conflicts within Gaza arise or in the Lebanese border (despite functioning as de-facto no-take zones). There are a few marine security zones. Most of them are closed 20 to 50 days a year and are fished quite often, while others are permanently closed to fishing. Upon closure, the Palmachim zone, for instance will be closed for all fishing 4 to 5 nmi from shore and the Israeli Defense Force will contact the fishermen on channel 67 very high frequency (VHF) to inform them of all closure activities. The army will also monitor their presence and inform or even consult with them on reopening conditions. Some of the military zones are known to contain large amounts of ammunition in the seabed and trawlers thus try to avoid them.

Over-development: Over development of coastal areas greatly affects fishing. Installation of marinas and port development has resulted in loss of fishing grounds. A submerged cage mariculture farm 5 mi from Ashdod also displaced fishermen from another muddy-bottom fishing field. Other fishing ground losses were incurred by deployment of the natural gas pipeline from Ashkelon to Dor. This pipeline was laid in 30 to 40-m water depths along the coast and closely demarcates the transition from sandy to muddy seafloor. Claims have been made that the high temperatures of pressurized gas in the pipe create a thermal barrier above the pipeline, which disturbs the migration of fishes such as groupers to and from deeper spawning areas. This claim is yet to be verified. Deployment of gas pipelines also involves trenching, which disturbs benthic habitats. Pipe crossing of sandstone ridges may altogether flatten these important rocky habitats. Some development, however, may actually contribute to fishery yields. Complex benthic structures, such as concrete mattresses laid over protruding pipeline fractions, were shown by Edelist (2006) to attract fishes. If located within a nature reserve and given sufficient design, size, and protection, artificial reefs may serve as a means of mitigating fishery losses.

Desalination: New desalinization plants along the coast in Palmachim, Hadera, and Ashkelon now discharge brine into Israeli coastal waters. Although this phenomenon has yet to be studied in depth, it is assumed to further degrade fish resources along the coast. It has been recently suggested by the Department of Fisheries that all of these operations must mitigate for these effects on fishermen livelihoods by various means, such as contributions to Artificial Reef projects in Marine Protected Areas or other means of augmenting for the losses incurred.

Lessepsian Migration: Migration of Red Sea fauna via the Suez Canal has been termed Lessepsian Migration (Spanier and Galil, 1991). More than 70 species of fish (Golani, 2010) and 430 species of invertebrates (Galil, 2007) have migrated to the Mediterranean since the canal first opened in 1865. The rate of this migration has increased in recent decades; in recent years, two to three new migrants per year have established significant populations along the Israeli coast. While some of these species are of great commercial importance (e.g., tiger prawns, bream [*Nemiptrus randalli*], lizardfish [*Saurida undosquamis*], or mackerel [*Scomberomorus commerson*]), other species such as the venomous catfish *Plotosus lineatus* and the jellyfish *Rhopilemma nomadic*, are a great nuisance and a hazard to fishermen and ocean goers. In the last 2 years, huge swarms of alien jellyfish and ctenophores appeared in Israeli coastal waters during winter, probably due to warmer winter minimum temperatures (Fuentes et al., 2010). The impacts of these intrusions include a decline in fish yields to decline and damages to mobile gear (e.g., trawls, purse seines).

Aswan High Dam: Erection of the Aswan High Dam on the Nile in Egypt is one of the reasons for the increase of Lessepsian (Red Sea) migration, due to the removal of a freshwater nodule which set a barrier to migrants before dam erection. The dam is also thought to have caused a collapse of both Israeli and Egyptian sardine fisheries in the early 1970's, but it was suggested recently (Oczkowski et al., 2009) that due to the rise in population and agriculture activities, the amounts of nutrients released by the Nile today exceed those of the pre-dam years and that Egyptian fishing now benefits from this increase.

Table 38 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. Note that Gaza is not included. 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.

Table 38. Characteristics of the Israel fishing fleet, including composition by vessel size, gear, and port (anchorage) (From: Shapiro, 2007).

Anchorage	Gear				Vessel size (LOA)		
	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 + 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**

3.10.1.3 Commercial Fishing Methods

Commercial vessel operations are closely monitored and controlled near existing offshore facilities (i.e., Mari-B); similar controls are expected to be put into effect around the Tamar Platform. As a result, commercial fishing activities are routinely restricted within a prescribed 500-m buffer zone. Further, the use of buffer or safety zones around pipelay vessels, barges, crane vessel, and other installation-related support vessels effectively precludes commercial fishing operations near these activities. However, transiting supply vessels and other activity-specific vessels (e.g., AHTS vessels) may create space use conflicts either during transit or while on stand-by.

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 devices, echo sounders, and hydraulic winches. Many vessels in the trawling fleet are more than 30 years old.

Bottom trawlers fish within the territorial waters at depths ranging from 15 to 400 m, however most of the fishing effort is concentrated in waters shallower than 50 m. Typical towing speeds are ~3 knots and haul duration is ~3 hours in the daytime and 5 hours at night. The entire fleet trawls ~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 over 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 (*Merluccius merluccius*) or red shrimp (*Aristeomorpha foliacea*). Fishing regulations forbid the trawl fleet from fishing at depths less than 15 m and other regulations concern minimum landing size of the commonest species but are rarely enforced.

The average trawl catch is about 1,500 tons a year. In 2007, trawl catch represented 5.9% of the total catch and was valued at US$13.5 million. About 180 families earn their living directly from the trawl fishing and 150 families indirectly (Sonin, Edelist, pers. comm., 2011). In recent years, revenues have increased due to elevated fish prices but net profits have declined due to soaring fuel prices, reduced fishing zones, costly maintenance, and reduction in catch.

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 *Marsupenaeus japonicus*), goatfishes (Family 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) also comprise a significant portion of the catch, as do bony fishes from the families Sparidae and Carangidae (**Figure 53**).

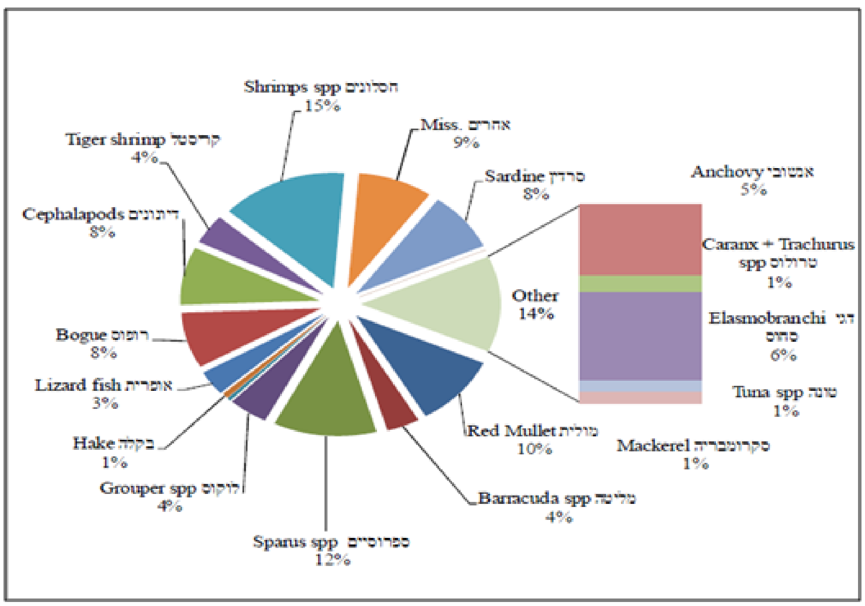


Figure 53. Major bottom trawl catch in 2007 (From: Shapiro, 2007).

Discards of this fishery are greater than those generated by other methods and recent findings indicated that they have increased in the last two decades, amounting to ~45% of the biomass (Edelist et al., 2011c). Trawlers usually fish for bottom fishes and cephalopods in the deeper strata during the daytime and then approach closer to shore to trawl for shrimps in shallow waters between 15 to 40 m at night. Until 2005, there was also 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.

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 fulltime 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 legal mesh size is 35 mm, and the fishermen can switch between gillnets and bottom or floating long-lines, depending on the availability of fish and the season (FAO, 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 lately are deepwater demersal groupers and wreckfish, 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, Herzelyia, Natanya, Olga, Caesarea, Jasser-A-Zarka, Dor, Shiqmona, Kishon, Acco, and Naharyia.

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 (FAO, 2007). The pelagic fishery reported a catch of 303 tons in 2007, valued at US$1.8 million, which is about 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.), as well as 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 (FAO, 2007). The main reason for the decline in pelagic fishery landings is installation of the Aswan High Dam on the Nile in 1969. The presence of the dam, while controlling flooding in the lower Nile delta, also ended the annual floods that enriched coastal waters of the Eastern Mediterranean with nutrients and supported a large pelagic fishery in Egypt and Israel. This fishery subsequently collapsed to its current level.

3.10.1.4 Commercial Catch Profile

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 cartilagenous fishes, and bony fishes (Sparidae, Carangidae) (**Figure 53**). 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 (FAO, 2007) and groupers, amberjacks, scombrids, and sparids are the main target species of bottom long-liners.

3.10.1.5 Mariculture

Fish production from mariculture operations has declined significantly in Israel over the last number of years, primarily as a result of the government suspension of Red Sea mariculture operations in June 2008. Consequently, the Mediterranean became the center of Israeli mariculture.

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 now become operational about 5 nmi west of Palmachim. Total capacity is about 1,500 tons per annum when fully operational. Another farm is located inside Ashdod port with capacity of 300 tons and was built as a temporary solution for the fish farms of Eilat. All fishes are being inspected at the farm gate by the veterinary services for pathogens and heavy metals and so far, no threats were detected. Mariculture production for 2007 was 2,251 tons valued at US$16.5 million (Shapiro, 2007). The main cultured fish species grown is gilthead sea-bream (*Sparus aurata*), with some sea-bass (*Dicentrarchus labrax*).

3.10.1.6 Recreational (Sport) Fishing

Along with the increase in population, as well as affluence, sport fishing in Israel has risen sharply in recent years (Kerem and Edelist, 2008). Although sporadic in nature and predominantly a hobby, 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 are estimated to 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 jig and troll along the Israeli coast; and
- Yacht and Small Craft Fishing: Several hundred small vessels engage in jigging and trolling along the coast.

3.10.2 Tourism and Recreation

Overview

Tourism and recreation are concentrated mainly along the coast. The main tourist attractions are bathing beaches, heritage sites, archaeological sites, nature reserves, and national parks. The MoEP Coastal Resources Management policy determines that

- any development along the coast, which is not for necessary coastal use, will be forbidden;
- tourism and recreation development should be concentrated, to protect the open areas, and ensure enough opportunities and area for day and night activities available for the public;
- development at currently undeveloped sites, with recreation potential is to be limited; and
- areas adjacent to a reserve or park should be designated for moderate activity.

These principles were assimilated in TAMA 12 for tourism (1992) and the Protection of the Coastal Environment Law (2004).

3.10.2.1 Main Tourist Attractions – Palmachim to Gaza

The southern part of the Israeli coastline has many unspoiled areas, several of which have been declared as national parks and nature reserves. These include

- Palmachim Nature Reserve and National Park;
- Ashkelon National Park; and
- Nizanim and Zikim sand dunes.

Along the section of coast between Palmachim to the border with Gaza (**Figure 54**), there are 12 declared bathing beaches. Of these bathing beaches, six are located within the boundaries of Ashdod Municipality, three are found within the Ashkelon Municipality, and three are located between Ashdod and Ashkelon. Water quality is tested once a year. All 12 bathing beaches are known to have good water quality (Israel Central Bureau of Statistics, 2008). Ashdod and Ashkelon are the main cities in the study area, and most facilities (e.g., hotels, restaurants) are concentrated nearby. Key tourist destinations include:

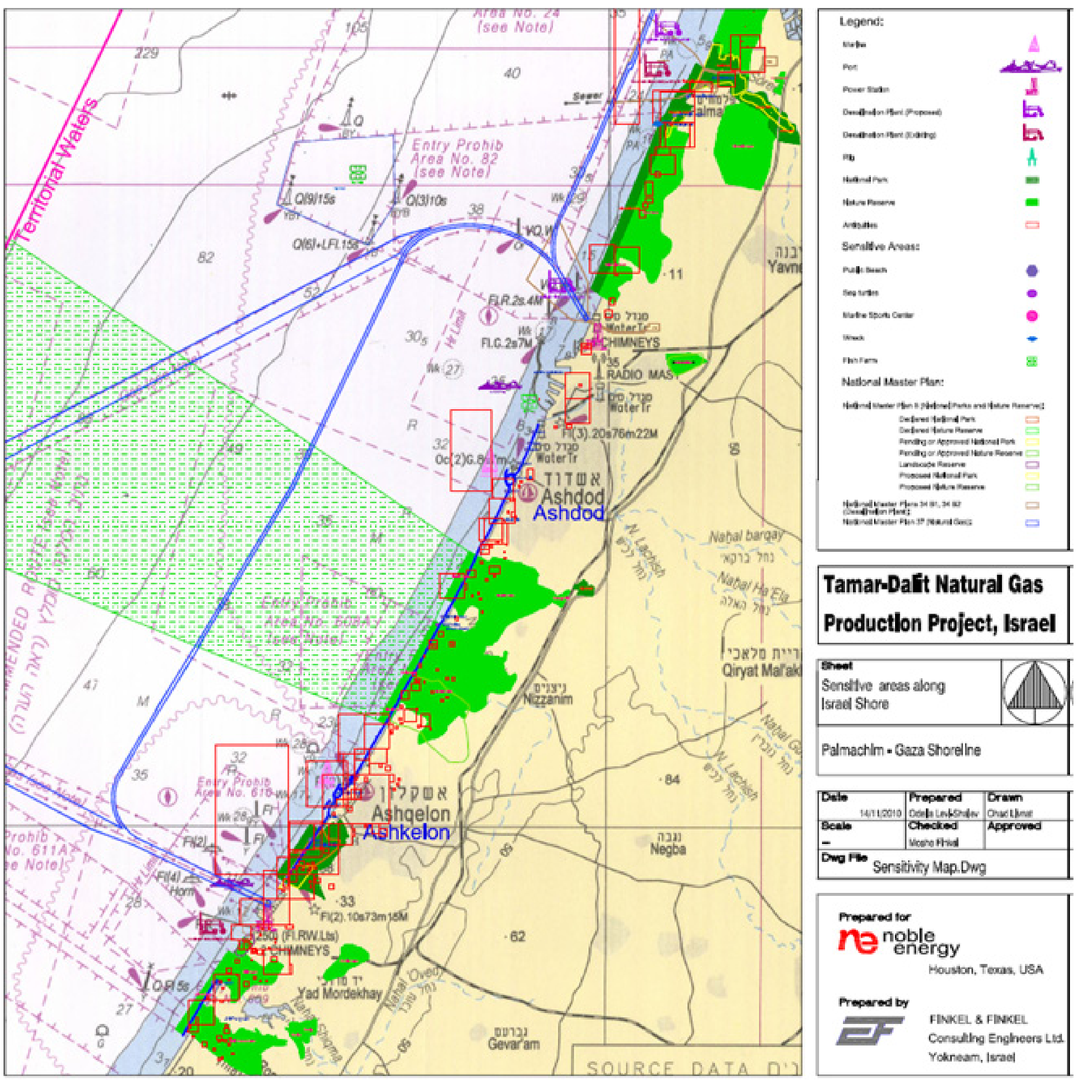


Figure 54. Sensitive coastal features, Palmachim to Gaza (From: Finkel and Finkel, 2010).

- **Ashkelon:** Declared a national tourist site. The coast of Ashkelon spreads over 12 km and plays an important role in the image of Ashkelon as a resort town. The main tourism is attracted by the coast, the national park, and the marina. There are eight hotels and bed and breakfast inns in the city. Most of the coastline is used for recreation and bathing beaches. All are located about 5 km north of the location of the planned receiving station.
- **Ashkelon Marina:** Functions as the southern yachting gate to Israel. It is known in the yachting community as a center for international rallies and regattas. The marina is located between two beaches: Delila and Bar-Kochba, in the center of tourist area of Ashkelon (31°41.19' N latitude, 34°33.26' E longitude), a few km north of the proposed location of the receiving station as defined by TAMA 37A/2/5. The marina was established in 1995. It spreads over 6.8 ha with maximum water depth of 4 to 6 m and total pier length of 1,550 m. It can accommodate up to 650 anchorage points.
- **Ashdod:** The coastline of Ashdod spreads over 8 km. Tourism in Ashdod has not developed and the Israel Ministry of Tourism does not consider Ashdod as a tourist destination. All efforts to attract tourism are made by the local municipality and the private sector. Ashdod has a marina, six declared bathing beaches, urban parks, museums, large sand dunes, and several archaeological sites. Tourism is based mainly on the use of summer homes in the city. In 2009, the first hotel meeting international standards was opened; during 2010-2011, a number of additional hotels in the area either opened or are scheduled to be opened.
- **Ashdod Marina:** Located approximately 2 km south of Ashdod Port. The marina, which started operations in 1999, spreads over 10 ha and has a maximum water depth of 4.5 m. The marina has a central pier with eight attached, accessory piers emerging from it, creating the shape of a nine-candle Menorah. Total pier length is 2,200 m, with accommodation for up to 550 boats. Two breakwaters surround the marina from the north and protect it from storms. These are currently being used as piers for larger vessels of up to 40-m length. The marina area includes a shipyard for boat maintenance. A marine center serves as a diving center and future surfing center.
- **Cruises:** Vacation cruises are a newly developing industry that is becoming increasingly popular among vacationing Israelis. A vacation cruise ship can accommodate as many as 4,000 passengers. Most vacation cruises leave from Haifa or Ashdod Port on a fixed route towards Turkey, Cyprus, and Greece. Other cruises leaving from Haifa or Ashdod are bound for Western Europe. The cruise industry is seasonal with most departures occurring between May and September. A few late season cruises depart in October and early November.

3.10.3 Shipping and Maritime Operations

3.10.3.1 Shipping Activity

Figures 55 through **59** are based on the Israel Ports Authority Annual Report (2009) and Israel Port Authority website. They present a summary of information on ship visits and source and destination data for containers passing through both Haifa and Ashdod ports; data are available for both cargo shipping and passenger traffic.

In the shipping figures, data for Haifa are presented in red, data for Ashdod are shown in green, and data for Eilat are provided in blue. **Figure 55** presents the annual number of ship visits to the ports of Israel between 2000 and 2009. The total number of ships decreased slightly during 2007-2008, mainly due to the world economic crisis. In 2009, the number of ships arriving started to return to previous levels.

Source and destination data for ship visits are presented in **Figures 56** and **57**. These figures indicate that Ashdod Port mainly serves shipping from west Europe, Asia, and the Far East, while Haifa Port mainly serves North America. Export of goods to Western Europe is primarily from the Haifa Port.

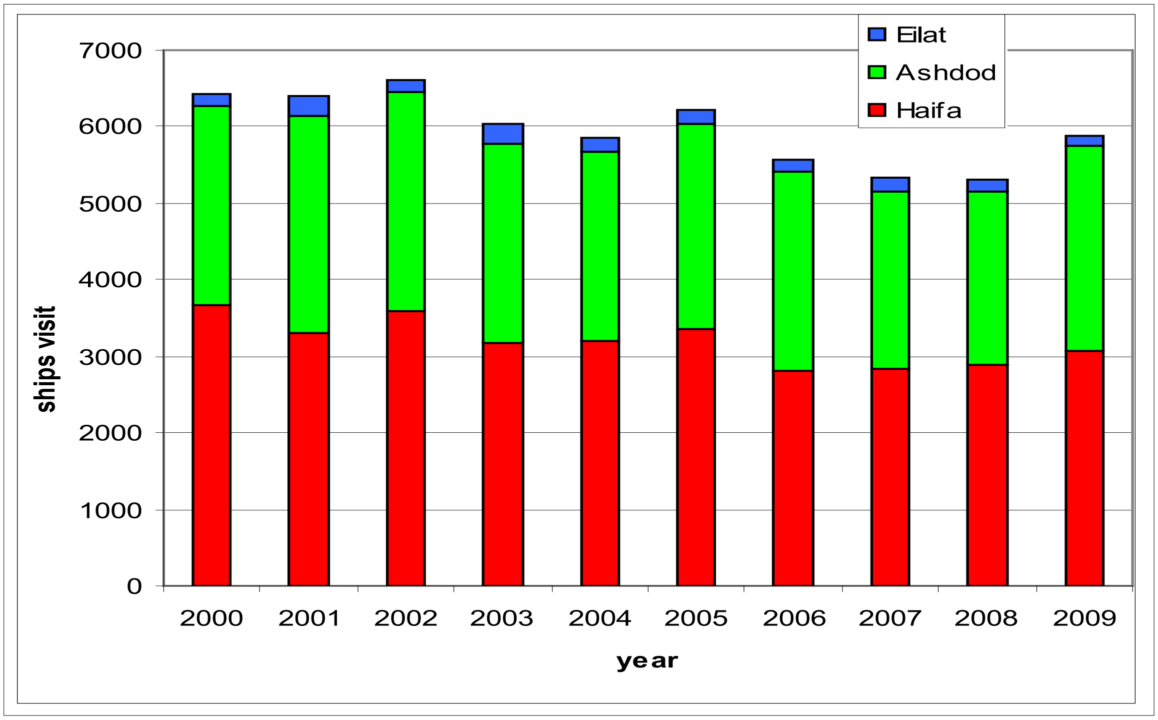


Figure 55. Ship docking at the ports of Israel, 2000-2009 (From: Ministry of Transport, National Infrastructure and Road Safety, Shipping and Ports Authority, 2009).

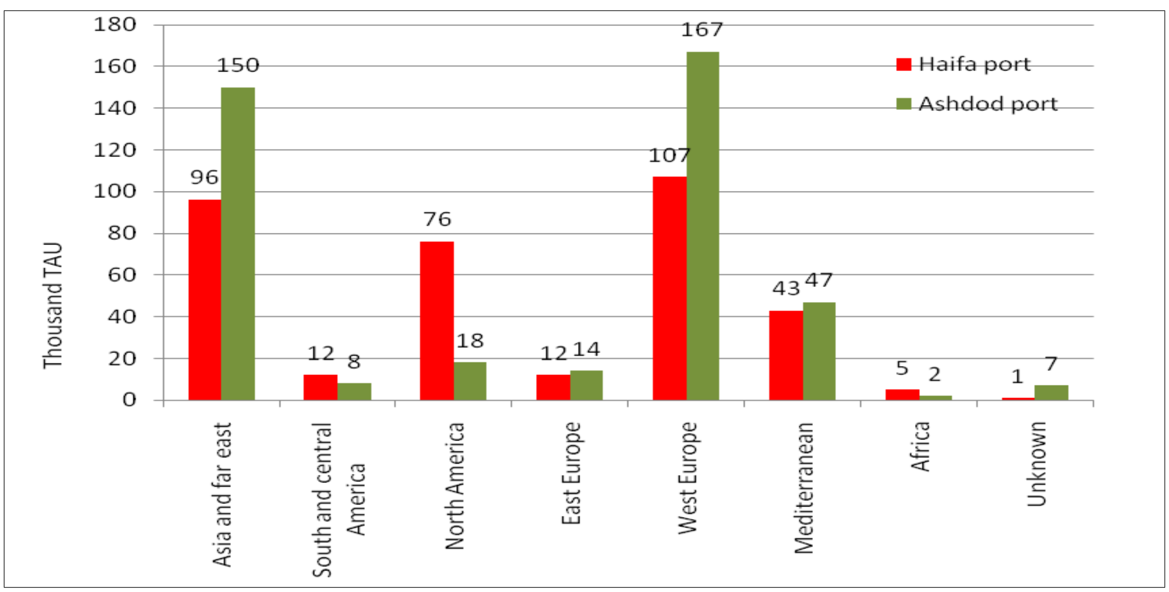


Figure 56. Sources of shipping containers arriving at the main ports of Israel (in thousand TEU) (From: Israel Ports Authority, 2011).

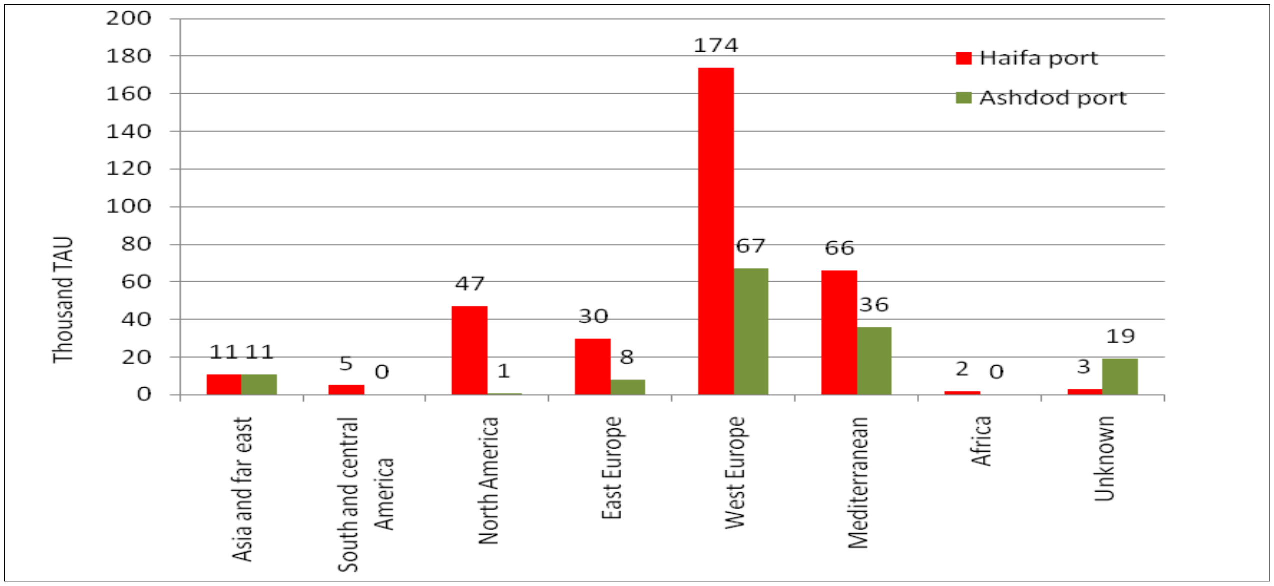


Figure 57. Destination of shipping containers from main ports of Israel (in thousand twenty-foot equivalent [TEU]) (From: Israel Ports Authority, 2011).

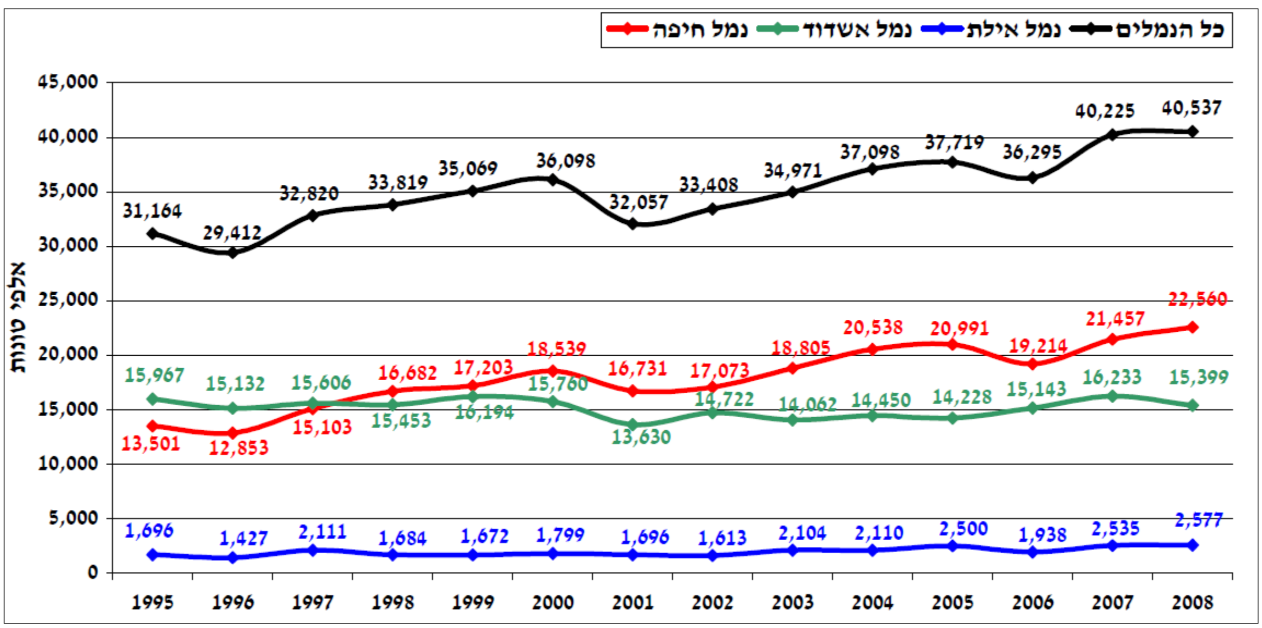


Figure 58. Cargo volumes passing through Israeli commercial ports, 1995-2008 (From: Ministry of Transport and Road Safety, Shipping and Ports Authority, 2009). (Blue = Eilat, green = Port of Askelon, Red = Port of Haifa, and Black = Total.)

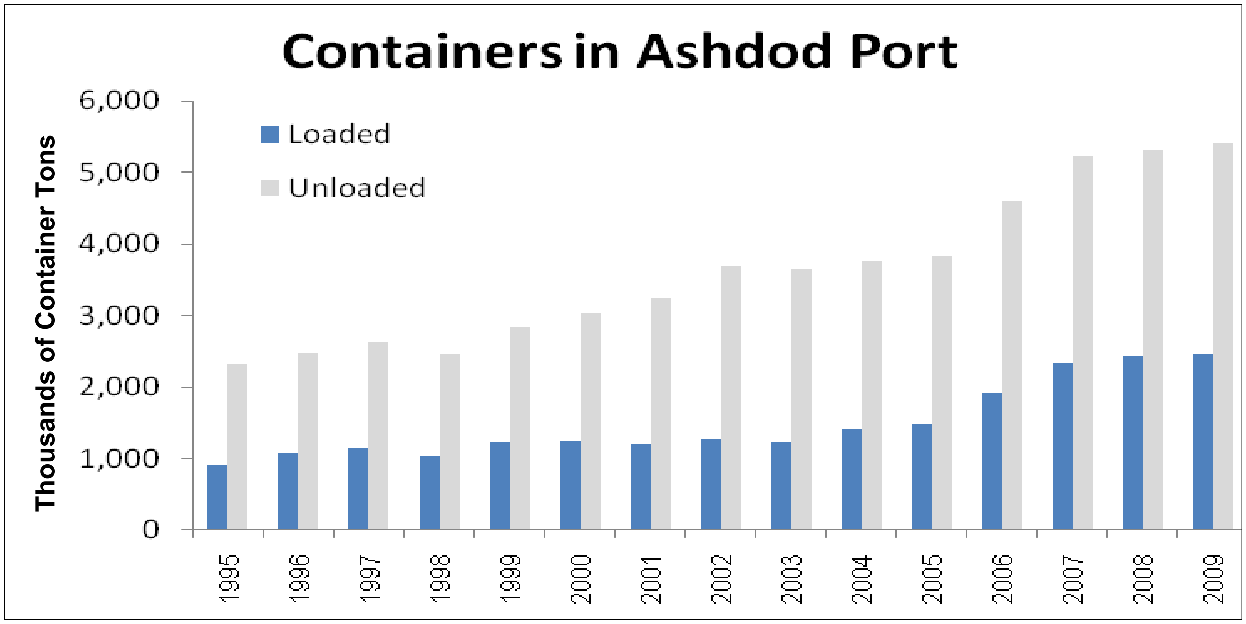


Figure 59. Loaded and unloaded weight for containers passing through Ashdod Port, 1995-2009 (From: Israel Ports Authority, 2011).

3.10.3.2 The Port of Ashdod

Ashdod Port is located 40 km south of Tel Aviv, close to the country's major commercial centers and highways. It is one of the few ports in the world built on open sea. Ashdod Port handled around 827,000 TEUs in 2008, the cargo unloaded and loaded in 2008 amounted to 15.4 million tons representing 38% of the Israeli cargo.

The harbor is enclosed by breakwaters, but there is no natural protection from wind and waves in the surrounding coastal or offshore areas. Ashdod harbor is protected by a 2,213 m-long breakwater which extends seaward at the southern extreme of the harbor and then northward. The entrance, about 274 m wide, is located inside the northern end of this main breakwater. A second breakwater about 905 m long, defining the northern limit of the harbor, extends offshore toward the harbor entrance (U.S. Navy, 2011). **Figure 60** provides a satellite image of Ashdod Port. Areas marked in orange represent future expansion. The port includes extensive container storage areas.

Figure 60. Satellite image of Ashdod Port (From: State of Israel Ministry of Transport National Infrastructures and Road Safety, 2012).

3.10.3.3 Passenger Traffic to Ashdod Port

The Ashdod Port also serves as an entering gate to Israel. Passenger traffic is presented in **Figure 61**. Passengers arriving to the ports of Israel are either part of a daily cruise or tourists arriving by sea. In 2004, as part of reform of the Ports Authority, the passenger terminal at Ashdod Port was upgraded, enabling passenger traffic into the port. In 2007, a new passenger terminal was launched, resulting in an increase the Ashdod share of the market from 42.9% to 47.8%.

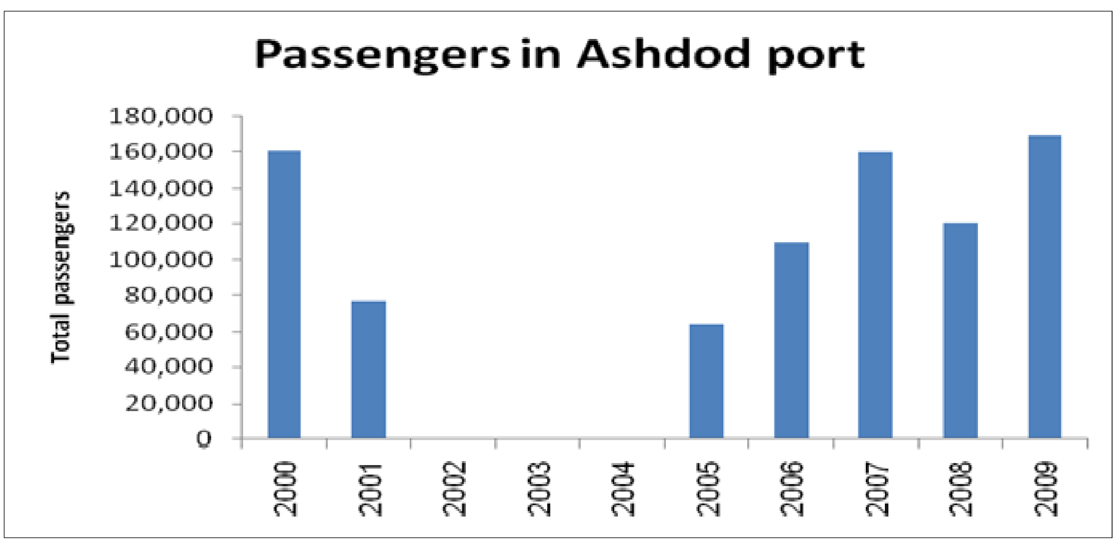


Figure 61. Passenger traffic, Port of Ashdod 2000-2009 (From: Israel Ports Authority, 2011).

The number of passenger ships visiting the ports of Israel was reduced in 2000 due to the Intifada, rioting by Arab residents of Israel. Between 2002 and 2004, passenger movement was negligible. Since then, the market has slowly recovered. A terminal upgrade in 2007 also has contributed to this recovery. As few as 204 passengers arrived in 2004; that number increased to 104,660 passengers in 2008 and 168,471 passengers in 2009.

3.10.3.4 The Port of Ashkelon

Katza Port in Ashkelon serves the energy industry, and is used as a crude oil terminal. The terminal was established to serve the oil pipeline laid in the 1970s from the commercial Port of Eilat to Ashkelon. The project was to serve as an alternative to using the Suez Canal to transmit oil originating in the Persian Gulf to the Mediterranean. The pipeline is no longer operational, but the port is still active. It is utilized for loading and unloading of crude oil, distillates. It is also expected to handle coal once the new power plant there becomes operational. The port area is restricted and detailed information about it is classified.

3.10.3.5 Shipping Lanes

Numerous shipping lanes cross Israel's territorial waters, including shipping lanes 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. Analysis of the shipping lanes crossing Israeli waters was conducted to identify potential conflict with the planned routing of the natural gas transmission pipeline from Tamar to Mari-B. The locations of Haifa, Hadera, and Ashdod Port exits were chosen as the westernmost exit point of their westbound shipping lanes, as charted in the British Admiralty Map. Crossings for ships bound to and from smaller ports such as Jaffa or Redding in Tel-Aviv or Herzeliya Marina may be extrapolated from their position between Hadera and Ashdod. A total of 14 potential crossing routes (i.e., where inbound or outbound vessels crossed the proposed pipeline route) were noted as follows, as shown in **Figure 62**:

- Two routes (1, 2) from Haifa and Hadera Ports west-northwest to Malta (Atlantic);
- Four routes (3, 4, 5, 6) from Hadera and Haifa west-southwest to Port-Said or Alexandria;
- Two routes (7, 8) from Ashdod and Hadera northwest to Rhodes (Aegean and Black Sea);
- Two routes (9, 10) from Ashdod northwest to Larnaka and Limassol (Cyprus); and
- Five routes (11, 12, 13, and 14) from El-Arish north-northeast to Haifa and Hadera, as well as the main ports of Lebanon and Syria (Beirut, Tripoli, Tartus, and Latakia).

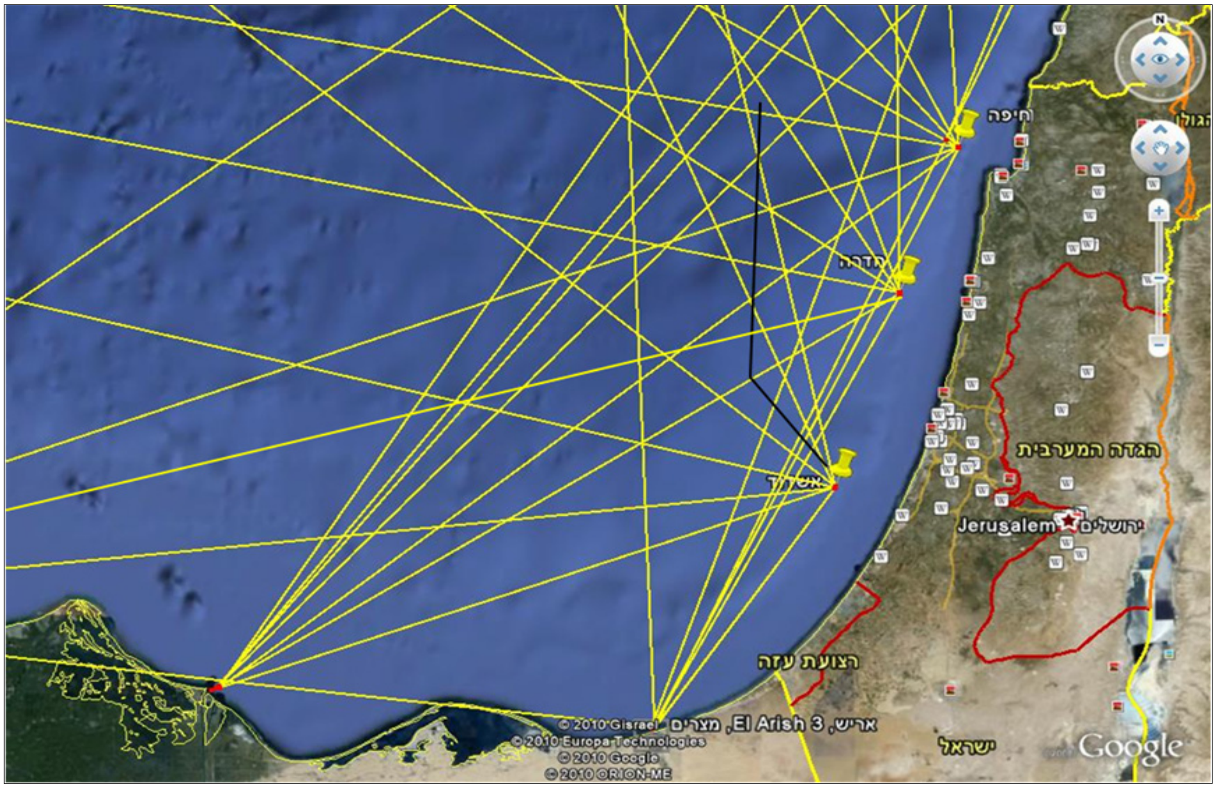


Figure 62. Shipping lanes crossing the natural gas pipeline route from the Tamar Gas Field to Mari-B.

For traffic moving north-south, it is assumed that vessels will maintain a 12- to 20-nmi distance from the Israeli coast. Under these scenarios, the majority of crossings would occur along the southeast Ashdod-bound section of the pipeline (i.e., pipeline segment from the Tamar Platform to shore at AOT).

3.10.3.6 Maritime Uses

The Mediterranean Sea offshore Israel provides a highly complex environment that is utilized by a diverse user group. The interface between the shelf zone and the shoreline is even more complex because it includes man-made elements. A schematic sea-use map is presented in **Figure 63** and depicts primary sea uses based upon distance from the coast.

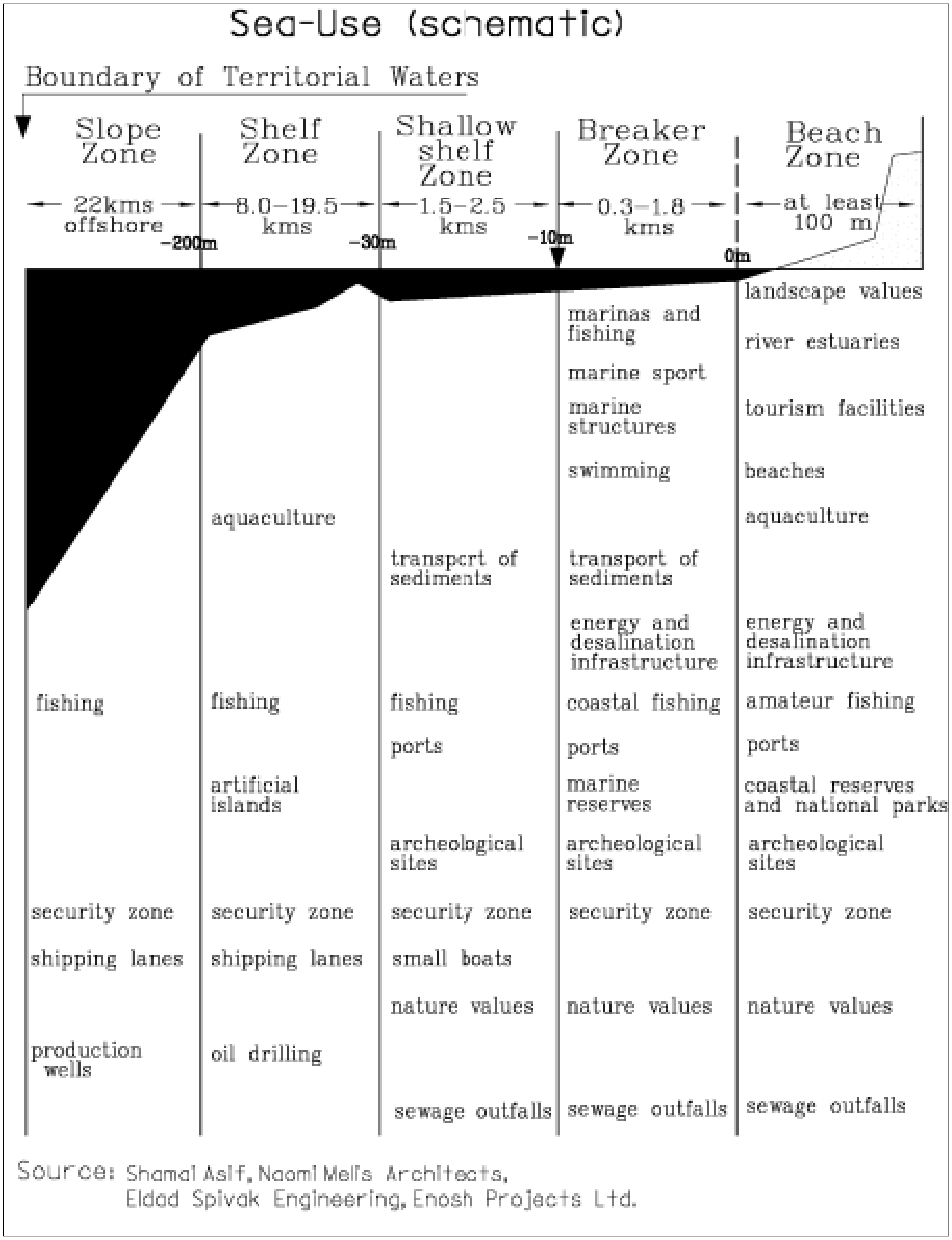


Figure 63. Schematic sea-use in the territorial waters of Israel (From: Enosh Projects & Systems, 1997).

3.10.3.7 Restricted Marine and Coastal Security Zones

Restricted maritime zones are determined by Order 100 issued by the Israeli Navy. Restricted marine and coastal zones may include Israeli Defense Force training zones and other security zones. The areas include sites of restricted facilities and international border zones as well as areas used for military training and maneuvers. The restriction is absolute. No civilian activities such as fishing, diving, and entry are allowed within these areas. The Order is updated from time to time and is available to the public.

Entrance to some restricted areas can be approved after prior coordination with the Israeli Navy. If approved, the Navy issues a temporary announcement, which is published in the general media as well as on the Shipping and Ports Authority website.

Restricted military zones opposite Ashdod and Ashkelon include zones numbered 24, 82, 608, 608a, 609, 610, 611, 611a, and a small area to the south of Ashdod Port (**Figure 64**). Entrance to zones numbered 24, 82, 608, 608a, 609, and 611 is allowed with a permit when there is no training being conducted in the area. Actual entry must be coordinated with the officers in charge. Other restrictions currently in effect include:

- No activity involving the seabed is allowed in Zone 608a due to the danger of unexploded ordinances.
- Entering Zone 611 is allowed only to Katza vessels.
- Entering Zone 611a is allowed during daytime.

Any work conducted by Noble Energy that requires entry or passage through security zones must receive prior approval. TAMA 37 Instructions clearly specify that no work should be conducted in an area defined as a security zone without a written permit from The Ministry of Defense representative in the Regional Planning and Building Commission.

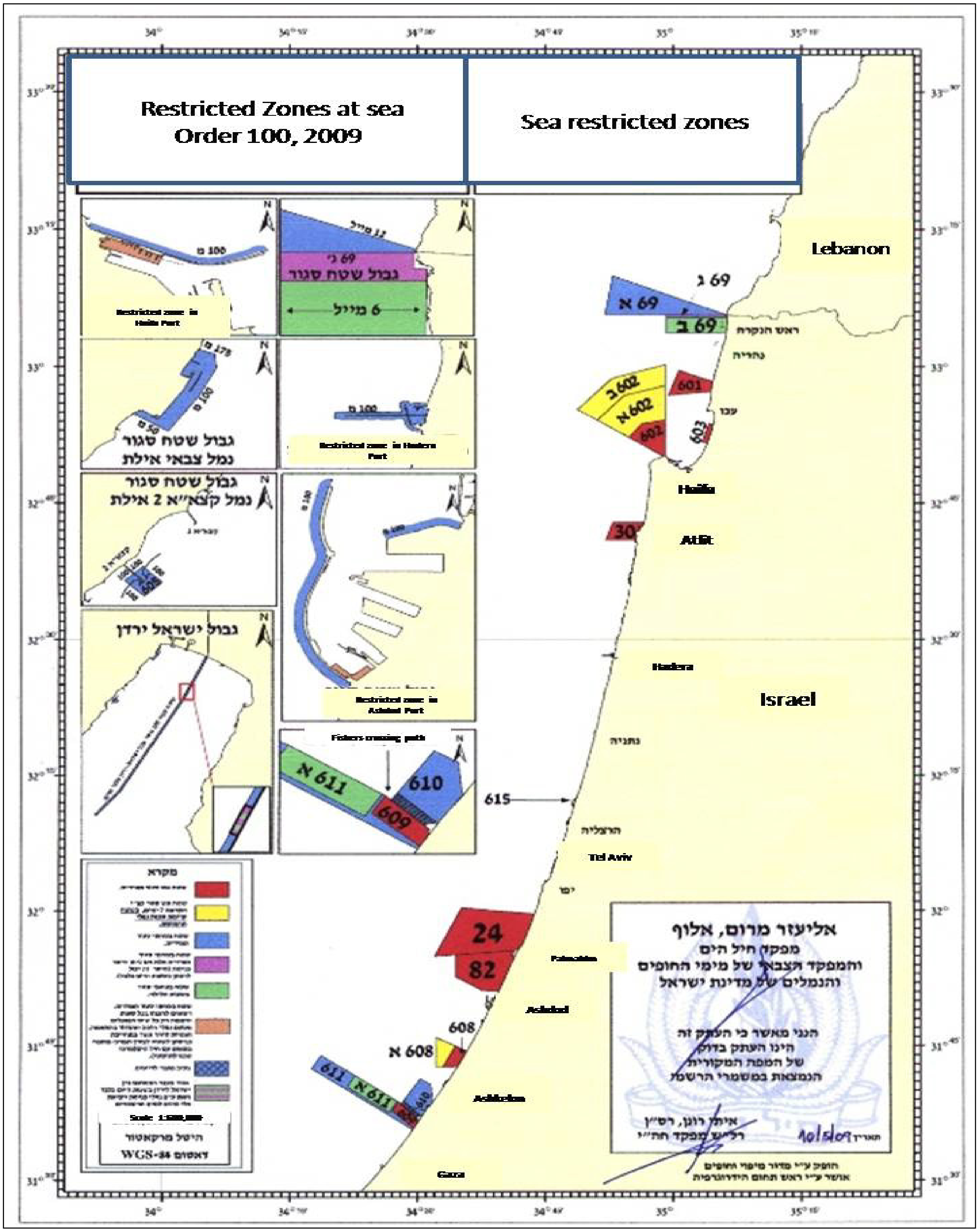


Figure 64. Restricted areas per Order 100, updated as of May 2009 (From: Ports Authority website, January, 2011).

3.10.3.8 Telecommunications

The telecommunication system in Israel is the most developed system in the region. It is based mainly on two sea-based cables operated by Med Nautilus: MED1 and LEV. The exact locations of the cables are classified, but general views of the cables' paths are shown in **Figures 65** and **66**.

Figure 65. Map of telecommunication cables connecting Israel (From: Mediterranean Nautilus, 2012).

Figure 66. LEV, CIOS, and EMOS 1 telecommunication cables (From: State of Israel Ministry of Communications, 2012).

In addition, a number of Israeli firms (Bezeq International, Tamres) have installed two additional fiber optic cables. Any new offshore oil and gas installations planned for offshore Israel will need to consider the presence of the various telecommunication cables.

3.10.4 Archaeological Resources and Coastal Cultural Heritage Sites

The underwater archaeological remains can be divided into the following five main categories:

- Submerged prehistoric settlements
  - Settlement: structures, installations, burials, tools
  - Seasonal settlement: installations, tools
  - Concentration of ancient remnants
- Coastal settlements
  - Coastal town: structures and installations on the coastline and in the sea
  - Coastal settlement: village, fortress, structures, installations
  - Concentration of ancient remnants
- Shipwrecks
  - Remains of wooden hull and cargo
  - Concentration of cargo and remnants of vessel lacking wooden sections of the hull
  - Concentration of ballast stones
  - Single find that originated from a ship
- Ports and Anchorages
  - Built-up port: docks, quays, and breakwaters
  - Anchorage: natural formation improved by man
  - Natural anchorage: temporary shelter ships in a bay or a natural feature
  - Anchorage in open sea: concentration of anchors offshore
- Rock-cut installations on the coastline
  - Quarries
  - Pools
  - Slipways
  - Channels
  - Installations for producing salt
  - Rock-cut bollards and mooring facilities

Most known and declared antiquity sites are just off the shoreline at a distance of less than 50 m and in relatively shallow waters with depth up to 30 m. Nevertheless, any archaeological finds, which may be found at a greater distance from the shore, even beyond the 12 nmi territorial waters, would be protected by the International Heritage Convention. Damage caused to antiquities during construction or operation is not related to the territorial waters or any other regulatory administrative boundaries.

3.10.4.1 Ashdod Area

Declared archaeological sites in the Ashdod area are presented on a map in **Figure 67**. Bathymetric mapping using high resolution multibeam sonar, conducted by the Israel Antiquities Authority (IAA) of declared and suspected archaeological sites is presented in **Figures 67** and **68**.

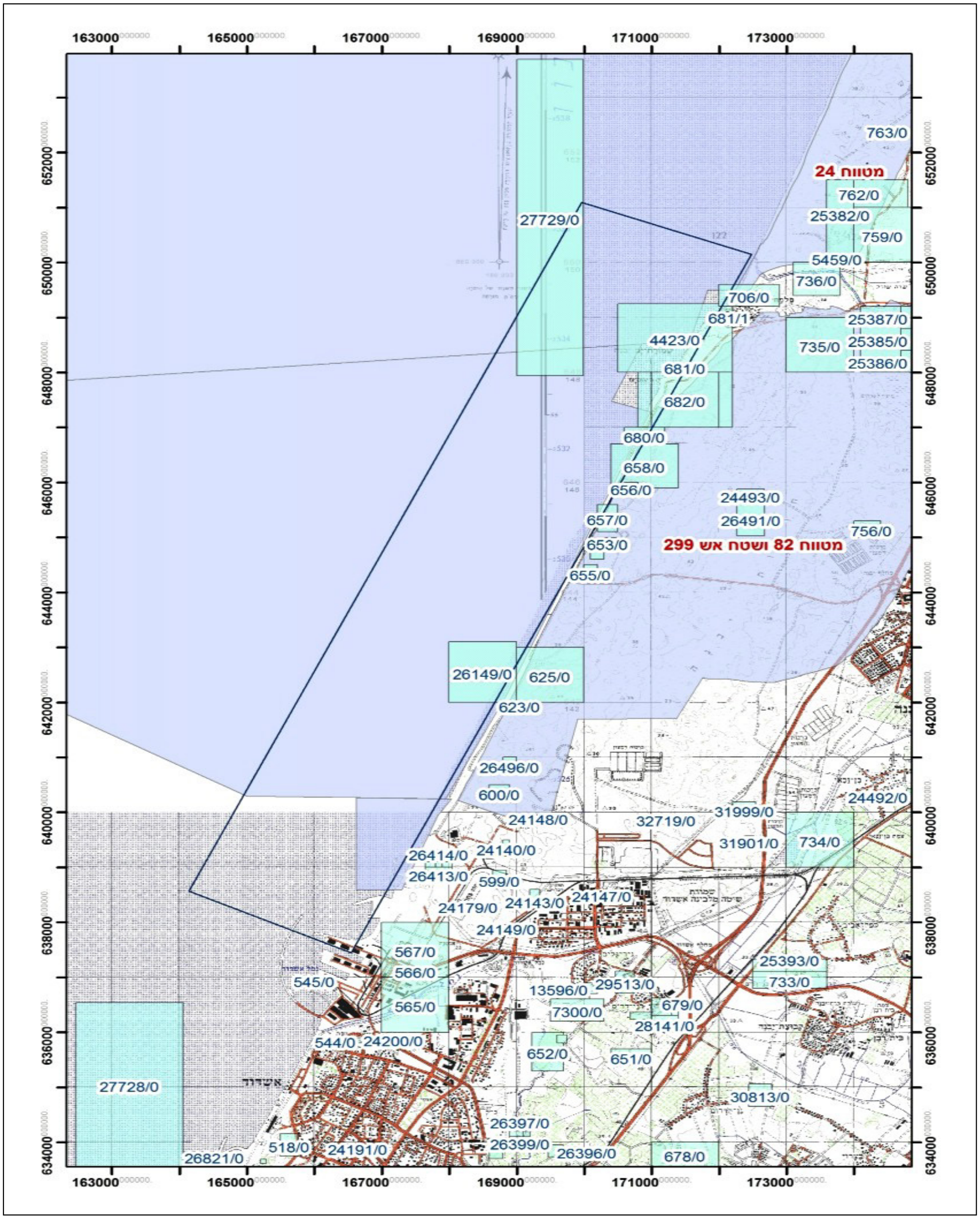
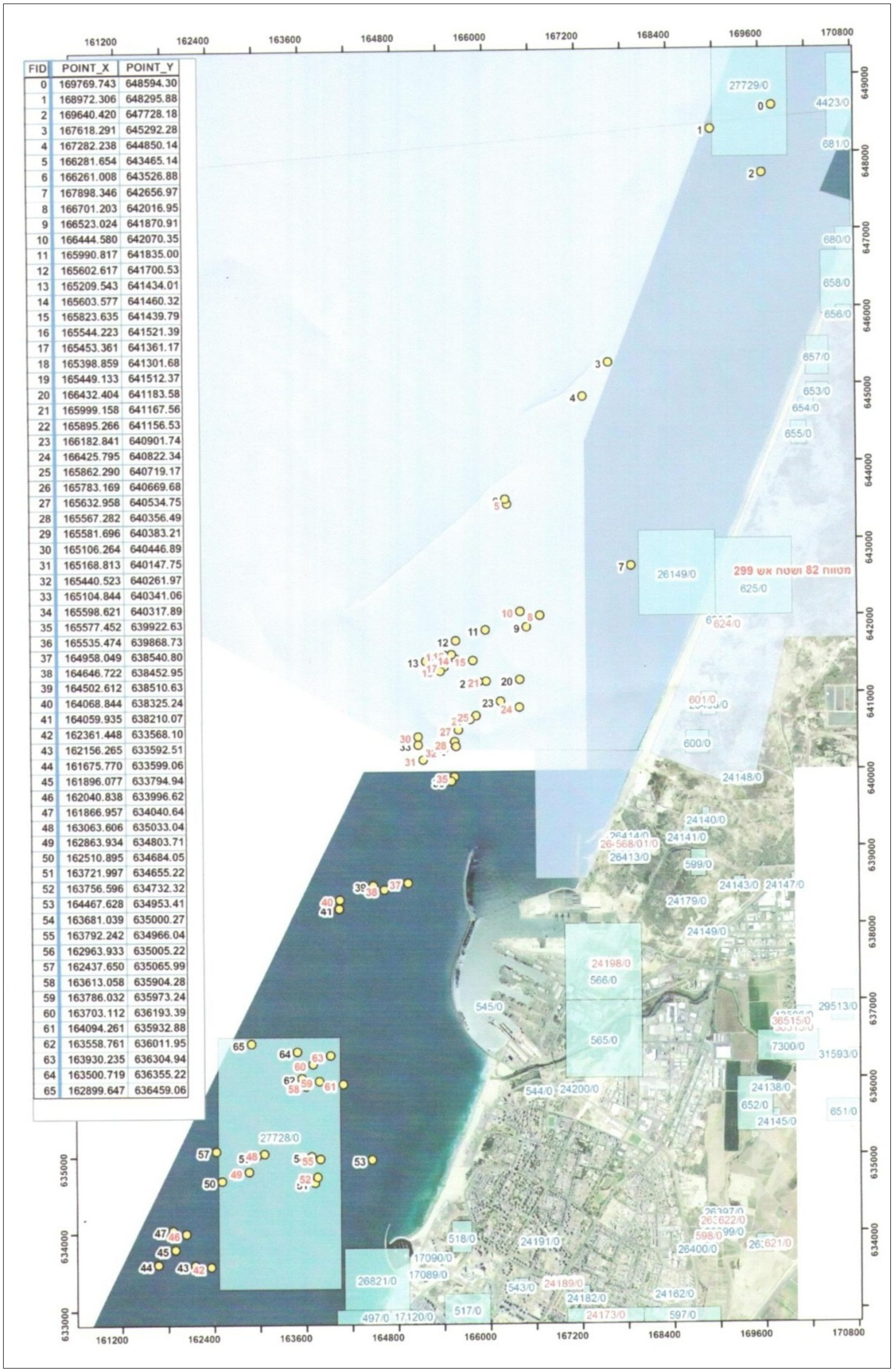


Figure 67. Offshore archaeological sites near Ashdod (From: Israel Antiquities Authority, 2010).



FID	POINT_X	POINT_Y
0	169769.743	648594.30
1	168972.306	648295.88
2	169640.420	647728.18
3	167618.291	645292.28
4	167282.238	644850.14
5	166281.654	643465.14
6	166261.008	643526.88
7	167898.346	642656.97
8	166701.203	642016.95
9	166523.024	641870.91
10	166444.580	642070.35
11	165990.817	641835.00
12	165602.617	641700.53
13	165209.543	641434.01
14	165603.577	641460.32
15	165823.635	641439.79
16	165544.223	641521.39
17	165453.361	641361.17
18	165398.859	641301.68
19	165449.133	641512.37
20	166432.404	641183.58
21	165999.158	641167.56
22	165895.266	641156.53
23	166182.841	640901.74
24	166425.795	640822.34
25	165862.290	640719.17
26	165783.169	640669.68
27	165632.958	640534.75
28	165567.282	640356.49
29	165581.696	640383.21
30	165106.264	640446.89
31	165168.813	640147.75
32	165440.523	640261.97
33	165104.844	640341.06
34	165598.621	640317.89
35	165577.452	639922.63
36	165535.474	639868.73
37	164958.049	638540.80
38	164646.722	638452.95
39	164502.612	638510.63
40	164068.844	638325.24
41	164059.935	638210.07
42	162361.448	633568.10
43	162156.265	633592.51
44	161675.770	633599.06
45	161896.077	633794.94
46	162040.838	633996.62
47	161866.957	634040.64
48	163063.606	635033.04
49	162863.934	634803.71
50	162510.895	634684.05
51	163721.997	634655.22
52	163756.596	634732.32
53	164467.628	634953.41
54	163681.039	635000.27
55	163792.242	634966.04
56	162963.933	635005.22
57	162437.650	635065.99
58	163613.058	635904.28
59	163786.032	635973.24
60	163703.112	636193.39
61	164094.261	635932.88
62	163558.761	636011.95
63	163930.235	636304.94
64	163500.719	636355.22
65	162899.647	636459.06

Figure 68. Archaeological sites off the coast of Ashdod (From: Israel Antiquities Authority, 2010).

The Palmachim site is located underwater at a depth of 17 to 30 m approximately 30 m offshore. Finds from this site are dated to the Bronze, Iron, Persian, Hellenistic, Roman, and Bizants periods.

A survey of the Yavne Sands site located north of Ashdod revealed remains from the Late Bronze, Late Roman, Byzantine, and Ottoman periods. A group of pre-historic sites (about 8,000 years before today) were located as well, but have yet to be studied.

The Hishvayahu Stronghold site is located about 1,700 m south of Yavne Yam. The stronghold spreads over 0.6 ha (Fantalkin, 2005) and is dated to the Iron Age, 6th to 7th century Before Common Era (BCE). The archaeological and historical evidence ascribe the stronghold to the king of Yehuda kingdom, Yoshiyahu, who ruled in the area after the retreat of the Assyrians (Na'aman, 2005). The stronghold plans and strategic location by the coastline raise the possibility that the site functioned as a harbor for trading ships.

The site of Tel Mor is situated on the outlet of Lachish River, 6.5 km from the coastline and 3.5 km northeast of Tel Ashdod. The earliest remains (stratum 12) are dated to the end of the Middle Bronze Age period (16th century BCE). A fort dated to the 14th century Late Bronze Age has been uncovered in stratum 9. During this period, the site served as a fort and harbor of the Ashdod Kingdom. These buildings were destroyed, probably by Seti I, and were replaced by a new Egyptian style square fortress (strata 8-7). The Egyptian fortress, probably under the rule of Ramses II, is dated to the end of the 13th century BCE. The fortress was destroyed by a conflagration, and the settlement contemporary to the fortress was destroyed in the second half of the 13th century BCE. The excavator of the site associates this destruction with the "campaign of the 'Israelites tribes' against the Canaanites." On the ruins of the fortress a small fort, a "Migdol," typical of the Iron Age was built (stratum 6). For a period the settlement continued without significant changes (strata 5-6). Later (strata 4 and 3) the settlement passed to the Philistines and the site became part of Philistia. The city of stratum 3 was conquered at the beginning of the 10th century BCE. The excavator has mentioned some possibilities for the identity of the conqueror of the city. One of these is King David in his campaign against the Philistines and the other is Pharaoh Siamun in his campaign against Philistia. After the destruction of the city, the site was abandoned for an extended period of time. In the 8th century BCE (stratum 2) the city was resettled and a new fortress was built, possibly by King Uzziah of Judah, but destroyed again by Sargon II. The last phase of occupation (stratum 1) from the Hellenistic period includes a large public building and an installation for extracting purple dye from murex shells. Shards and other small finds have been found from the Roman and the Byzantine periods, indicating the presence of a small, poor agricultural settlement at the site.

4.0 Social and Environmental Impacts

4.1 INTRODUCTION

The Tamar Field Development Project consists of four main inter-related elements:

- Gas development in the Tamar Field, accomplished through the installation of a subsea gathering system (i.e., flowlines and control lines) connecting five (or possibly six) of the Tamar wells;
- Transport of Tamar gas to a new production platform through a new pipeline system extending from the Tamar Field to a location near the Mari-B Platform; the pipeline system will be installed concurrently with MEG lines and control lines (umbilicals);
- Construction and installation of a new offshore platform – the Tamar Offshore Receiving and Processing Platform (Tamar Platform); and
- Processing of gas on Tamar Platform and transport of processed gas to shore, and during periods of low gas demand, transport of the gas to Mari-B for gas injection.

Based on the program description, several impact producing factors have been identified. **Table 39** identifies the sources of impact associated with the Tamar Field Development Project and the environmental resources that may be affected. The tabular matrix indicates which of the routine activities and accidental events could affect specific resources.

Table 39. Matrix of potential impacts. A "●" indicates a potential impact to a resource.

Project Activity/ Source of Impact	Environmental Resource											
	Physical/ Chemical			Biological					Socioeconomic and Cultural			
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine and Coastal Birds	Protected Marine Species and Habitats/Marine Habitats of Interest and Areas of Special Concern	Fishing	Shipping and Maritime Industry	Recreation and Aesthetics/Tourism	Archaeological Resources
ROUTINE, PROJECT-RELATED ACTIVITIES												
TAMAR FIELD INFRASTRUCTURE INSTALLATION												
Vessel arrival, in-field movement, departure									●	●		
Flowline, MEG line, control line (umbilicals) installation		●	●		●			●				
Buffer zone									●	●		
Physical presence including lights				●			●					
Noise from routine operations						●	●					
Emissions	●											
Discharges			●	●		●						
Solid waste		●	●	●	●	●						

Table 39. (Continued).

Project Activity/ Source of Impact	Environmental Resource											
	Physical/ Chemical		Biological						Socioeconomic and Cultural			
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine and Coastal Birds	Protected Marine Species and Habitats/Marine Habitats of Interest and Areas of Special Concern	Fishing	Shipping and Maritime Industry	Recreation and Aesthetics/Tourism	Archaeological Resources
PIPELINE ROUTE – PIPELINE, MEG LINE, UTILITY LINE, AND CONTROL LINE INSTALLATION												
DP pipelay vessel arrival, movement in-field & along the corridor, departure									●	●		
Pipeline, MEG line, utility line, and control line (umbilicals) installation		●	●		●			●				
Buffer zone									●	●		
Physical presence including lights				●			●					
Noise from routine operations						●	●					
Emissions	●											
Discharges			●	●								
Solid waste		●	●	●	●	●						
TAMAR PLATFORM INSTALLATION AND COMMISSIONING												
Tamar Platform arrival (float), flooding, and emplacement		●	●		●							
Platform presence including lights				●			●		●	●	●	
Buffer zone									●	●		
Noise from routine operations						●	●					
Emissions	●											
Discharges			●	●		●						
Solid waste		●	●	●	●	●						
GAS PROCESSING AND TRANSPORT												
Noise from routine operations						●	●					
Emissions	●											
Discharges			●	●		●						
Solid waste		●	●	●	●	●						
SUPPORT VESSEL AND HELICOPTER TRAFFIC												
Support vessel traffic and noise						●		●	●	●		
Helicopter traffic and noise						●		●				
ACCIDENTAL EVENTS The following impacts are "conditional" – they would occur only in the unlikely event of a spill.												
Large diesel fuel spill	●	●	●	●	●	●	●	●	●	●	●	●
Small diesel fuel spill			●			●	●	●	●		●	

The IPFs detailed in **Table 39** can be grouped into several major project phases (e.g., installation, operation) or IPF sources (e.g., routine discharges, combustion emissions). Each of these are briefly summarized below and discussed in individual subsections.

- **Tamar Field Infrastructure Installation: Barge and Support Vessel Transit; Flowline, MEG Line, and Control Line Installation; and Barge and Support Vessel Departure** – The short-term transit of the pipeline DP vessel, barge, and associated support vessels through Israeli waters and its arrival in the Tamar Field may cause temporary disruption of other sea uses although it is highly unlikely given the remote location of the Tamar Field. Sediment quality, water quality, and benthic communities will be affected by flowline, MEG line, and control line installation; if chemosynthetic communities are present within the Tamar Field, they may be affected by installation activities. Impacts may include turbidity due to resuspended sediment from line installation, temporarily affecting water quality; resuspension of sediment components (e.g., buried chemical species); and burial of benthic organisms by disturbed sediments. Discharges may affect water quality; solid waste (i.e., loss of trash and debris overboard) may affect sediment quality and water quality.
- **Pipeline Installation: DP Pipelay Vessel and Support Vessel Movements (in Support of) Flowline, MEG Line, Utility Line, and Control Line Installation)** – As a slow moving, floating structure, the DP pipelaying vessel will attract fishes and marine birds. Noise and lights from the DP pipelaying vessel and associated support vessels may temporarily affect the behavior of marine mammals, sea turtles, and birds (e.g., by causing attraction or avoidance). Also, vessels other than those associated with the project will be temporarily excluded from a 3- or 8-mi buffer zone around the pipelay vessel for safety reasons. Due to the distance from shore and the location of shipping lanes, only minor impacts on fishing or shipping are expected. If chemosynthetic communities are present along the pipeline corridor, they may be affected by installation activities. Impacts may include turbidity due to resuspended sediment from pipeline/flowline/control line installation, temporarily affecting water quality; resuspension of sediment components (e.g., buried chemical species); and burial of benthic organisms by disturbed sediments. Discharges may affect water quality; solid waste (i.e., loss of trash and debris overboard) may affect sediment quality and water quality.
- **Tamar Platform: Installation, Presence, and Operation** – The installation vessels (barges, crane vessel) and support vessel movements associated with Tamar Platform installation will generate noise and emit light, potentially affecting the behavior of marine mammals, sea turtles, and birds. Vessels not associated with Tamar Platform installation will be temporarily excluded from a 500-m buffer zone around the Tamar Platform site. Emplacement of the platform will disturb the benthos. Presence of the Tamar Platform will provide new substrate for epibiota to settle and grow and will provide shelter and food for fishes; periodic sloughing of the biofouling community will provide organic material to the sediments and benthic community at the base of, and in proximity to, the platform. Platform presence will also attract marine birds and will generate noise, with potential effects on marine mammals and sea turtles.
- **Routine Discharges** – Routine discharges will be released into the ocean in accordance with MARPOL regulations, including treated sewage and domestic wastes, deck drainage, and miscellaneous discharges; all discharges are expected to be diluted to background levels within tens to hundreds of meters of project vessels, with little or no impact on water quality or marine biota.
- **Solid Wastes** – There will be incremental contribution of solid wastes requiring landfill usage. The disposal of solid waste from any vessel into the sea is prohibited under MARPOL regulations. Ingestion of, or entanglement with, debris accidentally discarded into the marine environment can kill or injure marine mammals, turtles, and birds. Debris sinking to the seafloor can affect benthic

communities. All project vessels will operate under a Waste Management Plan to ensure adherence to MARPOL requirements, thereby minimizing the possibility of such impacts.

- **Combustion Emissions** – Vessel engines and generators and Tamar Platform and Mari-B engines will emit air pollutants into the atmosphere during installation, transit, and/or operation. The pollutants, emitted principally from diesel engines and fugitive emissions from fuel tanks, vents, and other emission points are the same as those generated by other ship traffic in the region. There will be temporary, local impacts on air quality near project vessels, but no effects to onshore air quality in Israel are expected due to distances from shore. Support vessel emissions will produce minor impacts on air quality along transit routes (i.e., between the Tamar Field and along the pipeline route) and onshore support base[s]). There will be negligible impacts on air quality from helicopter traffic along travel routes.
- **Support Vessel and Helicopter Traffic** – Project installation vessels, support vessels, and helicopter traffic and associated noise may disturb marine mammals, turtles, and/or birds. The impacts would be similar to those created by existing shipping and small aircraft traffic in the region. Support vessels would normally follow the most direct route between the installation locations and the shorebase and are not expected to interfere with fishing activities along the coast. Shipping and maritime operations in the vicinity of the Tamar Field, along the pipeline route, and at the Tamar Platform location may be affected to a very limited degree by support vessel operations. At the onshore support base, a short-term increase in harbor vessel activity is expected.
- **Accidents or Upsets** – The probability of an oil spill during the project is very small especially since gas is the target. An accidental spill of diesel fuel from a ruptured fuel tank on any project vessel or a spill during fueling operations offshore is more likely than a crude oil spill. If a large diesel spill did occur, it could affect marine life such as plankton, fishes, marine mammals, sea turtles, and birds and possibly affect socioeconomic resources. If the spill reached the shoreline, it could affect coastal habitats including beaches and seagrass beds, rocky shores, and associated wildlife. Noble Energy will prepare an Oil Spill Response Plan (OSRP) to respond to a spill and avoid or reduce potential impacts.

Section 3.0 described baseline conditions for the study area, including the Tamar Field, the pipeline/flowline/control line corridor to the Tamar Platform, the Tamar Platform and Mari-B area, and the utility line corridor from the Tamar Platform to AOT. Several physical resource topics discussed in **Section 3.0** will not be affected by activities associated with the Tamar Field Development Project, and subsequently are not listed in **Table 39**. These include bathymetry and topography, geology, physical oceanography, and meteorology.

Sources of potential impact from installation of the Tamar Field Development Project components and routine operations, as detailed in the following section, include

- Installation vessels (pipelay vessel, support vessels) – transit, onsite operations, and departure;
- Pipelines, MEG lines, control lines (umbilicals), and utility lines – installation and presence;
- Tamar Platform installation, presence, and operation;
- Routine discharges;
- Solid wastes;
- Combustion emissions; and
- Support vessel and helicopter traffic.

A large diesel fuel spill from the DP pipelay vessel and a small diesel fuel spill from a support vessel were considered in the analysis of accidents or upsets potentially resulting from the Tamar Field Development Project and the identification of their potential impacts.

As part of the impact assessment process, environmental hazards, and risks were identified that could arise from routine, project-related activities and non-routine activities (i.e., accidents or upsets) associated with installation and support operations. As a screening mechanism and to focus the impact assessment, a matrix was developed that identified specific sources of impact from each phase of the Tamar Field Development Project and the resource(s) potentially affected by each impact (see **Table 39**).

Two factors utilized to determine the significance of an impact provide the foundation for an environmental risk assessment – impact consequence and impact likelihood. Impact consequence reflects an assessment and determination of an impact's characteristics on a specific resource (e.g., air quality, water quality, benthic communities, etc.). Such determinations take into account resource-specific sensitivity to an impact, recovery capability, and spatial and temporal occurrence. Impact consequence also includes whether an impact is

- direct or indirect;
- reversible or irreversible; and
- short term (generally reflecting the duration of installation phases of a project, which typically is in the range of several weeks to several months) or long term (longer than project duration, which is typically on the order of years to decades). Long term elements also include the presence of the platform during the period of operational life expectancy.

Impact consequence classifications include **beneficial**, **negligible**, **minor**, **moderate**, and **severe**.

Impact likelihood is rated according to its estimated potential for occurrence:

- **likely** (>50% to 100%);
- **occasional** (>10% to 50%);
- **rare** (1% to 10%); or
- **remote** (<1%).

Impact analysis considered impact consequence and impact likelihood to determine overall impact significance. Impact consequence is resource-specific, with classifications ranging from beneficial through severe. Impact likelihood (i.e., probability of occurrence) was also determined for each activity-based impact and was characterized as likely, occasional, rare, or remote. The matrix that integrates impact consequence with impact likelihood, shown as **Table 40**, provided the basis for determining overall impact significance. In other words, impact significance is determined based on the relationship between the likelihood of an impact and impact consequence:

Impact Consequence x Impact Likelihood → Impact Significance

Table 40. Matrix combining impact consequence and likelihood to determine overall impact significance.

Likelihood vs. Consequence		Decreasing Impact Consequence ←				
		Beneficial	Negligible	Minor	Moderate	Severe
Decreasing Impact Likelihood ↓	Likely	Beneficial	Negligible	Low	Medium	High
	Occasional	Beneficial	Negligible	Low	Medium	High
	Rare	Beneficial	Negligible	Negligible	Low	High
	Remote	Beneficial	Negligible	Negligible	Low	Medium

To summarize the overall significance of each risk, an impact consequence and likelihood matrix were both used as shown in **Table 40**. The result is an overall impact significance rating that includes beneficial and several negative impact levels that range from Negligible to High. Impacts rated as High or Medium in significance are priorities for mitigation. Mitigation was also considered for some less significant impacts to further reduce the likelihood or consequence of impacts.

4.2 IMPACT CLASSIFICATIONS

The impact classifications employed in this environmental impact analysis were broadly divided into negative and beneficial impacts, with negative impacts further subdivided based on severity of impact, spatial and temporal aspects of the impacts, and the sensitivity of various resources to the impact. Impact categories included **beneficial**, **negligible**, **low**, **medium**, and **high**. Definitions of each impact category are outlined in **Table 41**.

4.3 IMPACT DETERMINATIONS

4.3.1 Installation Vessels – Transit, Onsite Operations, and Departure

Installation vessels include specialized vessels used to install Tamar Field infrastructure (e.g., subsea trees, production control systems, infield umbilicals, MEG lines); a DP pipelaying vessel (for pipelines, MEG lines, and control lines) along the pipeline route between the Tamar Field and the Tamar Platform; tow assist vessels, barges, and crane vessel for transport of the Tamar Platform jacket and topsides (floated to the Tamar Platform site, lifted or flooded, and installed), and vessels necessary to install the Tamar Platform-AOT utility lines, as well as support vessels that provide equipment, personnel, and supplies for all installation operations.

4.3.1.1 Impacts on Air Quality

During vessel transit, installation operations, and departure, air emissions from vessel engines will increase ambient levels of pollutants near the area of operations. Support vessels moving between the shorebase and the installation sites will also introduce pollutants into the atmosphere. Vessel movements are short term in nature. Emissions calculations for installation and operation were previously provided in **Table 8**, albeit only a small percentage of the tabular values are applicable to air emissions resulting from transit, installation operations, and departure. Except for the single exceedance noted (i.e., NO_x in 2011), all emissions were well below, or are expected to be well below regulatory thresholds. Impacts to local air quality are expected to be minor. Given the likely nature of this impact, overall impact significance is low.

Table 41. Definitions of impact significance.

Significance	Physical/Chemical Environment	Biological Environment	Socioeconomic and Cultural Environment
High	One or more of the following impacts: • Widespread, persistent contamination of air, water, or sediment • Frequent, severe violations of air or water quality standards or guidelines	One or more of the following impacts: • Extensive, irreversible damage to sensitive habitats such as sensitive deepwater communities, hard/live bottom communities, seagrass beds, marshes, and/or coral reefs, and other sites identified as MPAs, marine protected habitats, or areas of special concern • Death or injury of large numbers of a species listed by the IUCN as endangered, critically endangered, or vulnerable, or irreversible damage to their critical habitat	One or more of the following impacts: • Extensive, irreversible damage to recreational resources such as beaches, boating areas, and/or tourism • Impacts posing a significant threat to public health or public safety • Impacts of a magnitude sufficient to alter the nation's social, economic, or cultural characteristics, or result in social unrest
Medium	One or more of the following impacts: • Occasional and/or localized violation of air or water quality standards or guidelines • Persistent sediment toxicity or anoxia in a small area	One or more of the following impacts: • Localized, reversible damage to sensitive habitats such as sensitive deepwater communities, hard/live bottom communities, seagrass beds, marshes, and/or coral reefs, and other sites identified as MPAs, marine protected habitats, or areas of special concern • Extensive damage to nonsensitive habitats to the degree that ecosystem function and ecological relationships could be altered • Death, injury, disruption of critical activities (e.g., breeding, nesting, nursing), or damage to critical habitat of individuals of a species listed by the IUCN as endangered, critically endangered, or vulnerable	One or more of the following impacts: • Disruption of fishing activities at any location for more than 30 days or exclusion from more than 10% of the fishable area at a given time • Impacts leading to greater than a 10% change in fishery harvest • Localized, reversible impacts on recreational resources such as beaches, boating areas, and/or tourist area
Low	• Changes that can be monitored and/or noticed but are within the scope of existing variability, and do not meet any of the High or Medium definitions (above)		
Negligible	• Changes unlikely to be noticed or measurable against background activities		
+ Beneficial	• Likely to cause some enhancement to the environment or the social/economic system		

IUCN = International Union for Conservation of Nature; MPA = Marine Protected Area.

4.3.1.2 Impacts on Fishing and Shipping and Maritime Industry

There will be limited operating access around the installation vessels and barges at three points in time – as the installation vessels and barges arrive from a mobilization port outside the region and transit through Eastern Mediterranean waters, during installation of infrastructure, and as vessels and barges depart the region. Vessels typically operating in the area, including fishing boats, will be required to maintain a safe distance from the installation vessels and barges. When the installation vessels and barges arrive and depart, any inconvenience to local vessel traffic is expected to be minimized by consulting in advance with local port authorities and providing appropriate Notice to Mariners in advance of the arrival of the project vessels (e.g., DP pipelay vessel; crane vessel; umbilical vessel; transport barges). Due to the distance from shore, very few vessels are expected to be present in the project area, with the possible exception of the Tamar Platform location and the Tamar Platform-AOT corridor to shore.

As the origin location for several installation vessels and barges is unknown at this time, they could possibly transit potential fishing areas, resulting in negative impacts on commercial fishing. However, due to the relatively brief mobilization period, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.1.3 Impacts on Marine Mammals

Some marine mammals may avoid the installation vessels due to noise. Others might be attracted to fish populations around stationary vessels. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area.

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 installation operations are sufficient to be audible and to produce behavioral responses, but much lower than those known to cause hearing loss, discomfort, or injury.

Low-frequency noise from vessel movement and equipment can be detected by marine mammals (Richardson et al., 1995). Mysticetes (baleen whales such as the humpback, minke, and Bryde’s whales) are more likely to detect low-frequency sounds than are most odontocetes (e.g., dolphins), which have their best hearing in high frequencies. Noise associated with installation operations is relatively weak in intensity, and the animals’ exposure to these sounds will be transient. Some of the noise (from vessel engines and propellers) will be similar to the existing noise associated with shipping traffic in the region. However, due to the relatively brief mobilization period, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.1.4 Impacts on Sea Turtles

Some sea turtles may be attracted to offshore structures (Rosman et al., 1987; Lohoefener et al., 1990). It has been suggested that sea turtle hatchlings could be attracted to brightly lit offshore platforms, where they may be subject to increased predation by birds and fishes (National Oceanic and Atmospheric Administration, National Marine Fisheries Service [NOAA NMFS], 2001). However, since the project vessels will be limited in numbers and slow moving, any impacts on turtle populations are likely to be minor or negligible. Due to the relatively brief mobilization period, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.1.5 Impacts on Marine Birds

Some birds may be attracted to offshore vessels because of the lights and the fish populations that may be attracted to stationary or slowly moving vessels. Birds may use offshore vessels for resting, feeding, or as temporary shelter from inclement weather. However, birds migrating over water at night have been known to strike vessels, resulting in death or injury (Wiese et al., 2001; Russell, 2005). The relatively short-term presence of support vessels offshore is unlikely to have any significant impact, either positive or negative, on seabirds or migratory birds. Due to the relatively brief mobilization period, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.1.6 Impacts on Recreation and Aesthetics/Tourism

Offshore vessels may be visible 5 km from shore. Since the support vessels will be located beyond 5 km from the shore (except in the nearshore portion of the utility line), they will not be visible from shore and will have no impact on nearshore recreational activities, aesthetics, and tourism. With the possible exceptions of deep-sea fishing and yachting, it is not expected that any other recreational activities will be conducted in the vicinity of the installation location.

Transiting support vessels will be visible to shoreline visitors as they enter and leave the shorebase during support operations. The additional support vessel trips resulting from the installation operations are not expected to adversely affect recreation activities, aesthetics, or tourism in the area of the shorebase. Due to the relatively brief mobilization period, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.2 Pipelines, MEG Lines, Control Lines (Umbilicals), and Utility Lines – Installation and Presence

Pipelines, MEG lines, control lines, and utility lines will be installed by a DP pipelaying or similar vessel. Lines will be placed on the seafloor along the pipeline and utility lines routes, and between the Tamar Platform and the AOT. Trenching in shallow water may occur along the nearshore utility line segment.

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

Emplacement of the pipelines, MEG lines, control lines, and utility lines will disturb surficial sediments, causing increased localized turbidity, possible mobilization, and transport of sediment-associated contaminants, and crushing and/or burial of benthic communities near the pipeline corridor. Impacts on water quality, sediment quality, and benthic communities are expected to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.2.2 Impacts on Fishing and Shipping and the Maritime Industry

All vessels (including fishing boats) will be excluded from a 3 to 8 mile radius around installation operations for safety reasons. The standby vessels will monitor this buffer zone and help minimize the potential for other vessels to enter this area. Any inconveniences associated with the buffer zone are expected to be minimized by advance consultation with local port authorities and provision of a Notice to Mariners prior to the vessel's arrival.

Due to the distance from shore and the absence of fishing activities in the area where field infrastructure and pipelines will be placed, no significant impacts on fishing are expected. The installation vessels will not be positioned near any major shipping lanes and will be well marked with all the appropriate navigational markers. No impacts on shipping or maritime operations are expected from installation activities in the Tamar Field and along the pipeline corridor to the Tamar Platform. Between the Tamar Platform and the AOT, the utility lines will be installed within the existing pipeline corridor (as established per TAMA 37). Because the new utility lines will be placed within the corridor where existing pipeline infrastructure currently exists, there will be no additional interference with nearshore fishing activities.

Support vessels will enter and leave their shorebase, producing a minor incremental increase in port activity. The additional support vessel trips resulting from the Tamar Field Development Project will not adversely affect shipping and vessel traffic.

The deepwater pipeline will have minor to negligible effects on commercial fishing due to the deep route and shallow nature of the Israeli fishery. Installation of the utility pipelines between the Tamar Platform and the AOT will have a moderate short-term impact on the intensively fished shallow water area during installation. The extent of long-term impacts on the shallow water commercial fishery will depend on factors concerning the relief of the pipeline, its location relative to the seafloor, and the potential for snagging trawl gear. Due to the relatively brief mobilization period, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.2.3 Impacts on Archaeological Resources

The State of Israel protects antiquities through the Antiquities Law, 1978. The Antiquities Law was designed to prevent any activity that could damage or remove antiquities. The Israel Antiquity Authority (IAA) is responsible for enforcing the Antiquities Law. As a statutory governmental body, IAA has the authority to declare anywhere an antiquities site legally defining it as Statutory Declared Antiquities Site. Furthermore, the IAA has authority to approve or overrule any construction work planned to be carried out on a Statutory Declared Antiquities Site. According to the Law, it is forbidden to conduct excavations, road building, or any other construction work on Statutory Declared Antiquities sites without explicit permission from the IAA. Work must be executed according to the terms, conditions, and limitations set by the IAA. The IAA assumes *a priori*, that any excavation or construction works on archaeological sites, which are not carried out scientifically, cause damage to the antiquities and destroy part of the cultural heritage of Israel. The main guideline of the IAA is to therefore avoid construction in areas that include important archaeological sites. This enables the IAA to overrule any project and freeze all construction activities until archeologists of the IAA conclude archaeological surveys, and the site is released for construction.

The IAA has produced maps of the entire country marked with rectangles defined as Statutory Declared Antiquities sites. These rectangles are based on preliminary surveys. Any development project conducted within the declared triangles requires release and supervision by the IAA.

Offshore Declared Antiquities sites are located mainly at a distance of up to 30 m from the shoreline, and cover most of the shallow waters of Israel. It is known that the entire area offshore Ashdod-Ashkelon was used for shipping over a period of thousands of years with ancient ports in Ashkelon and Ashdod-Yam. Shipwrecks could be expected to be found offshore. They may be exposed during construction activities. Some of these may date back for over 3,000 years. The Antiquity Law 1978 requires that the IAA be informed of any such discovery.

Historically, there were no major projects planned for the deep sea and there has been no need to declare sites farther offshore. Furthermore, the chance of finding archaeological remains decreases with increasing distance from the shore. It is noted that Noble Energy may be required to conduct a detailed survey along the alignment of the planned utility lines to determine the possible existence and extent of any archaeological site. Such a survey would be done in cooperation with and following guidelines by the IAA. If the proposed alignment of the utility lines is found to cross through a Statutory Declared Antiquities Site, excavation will require prior authorization from the IAA.

Survey results will be considered during pipeline placement operations, including the possible presence of submerged archaeological resources, particularly within the shallow water zone approaching the AOT. In the absence of any mitigation measures, the consequence of the accidental loss of archaeological resources is considered to be severe. Given the remote nature of this impact, overall impact significance would be medium.

4.3.3 Tamar Platform Installation, Presence, and Operation

The physical presence of the newly installed Tamar Platform will attract fishes, generate noise, produce light in the offshore environment, one or more of which may affect marine biota such as plankton and fish and fishery resources, marine mammals, sea turtles, and marine birds.

4.3.3.1 Impacts on Plankton and Fish and Fishery Resources

Zooplankton and ichthyoplankton may be attracted to lights associated with offshore structures. Fish larvae are strongly attracted to lights at night (Victor, 1991). Light emissions from operations are likely to have negligible impacts on planktonic communities due to the small area of ocean affected.

The presence of the Tamar Platform will attract fishes, providing shelter and food in the form of attached fouling biota (Gallaway and Lewbel, 1982). Offshore structures typically attract epipelagic fishes such as tunas, dolphin, billfishes, and jacks (e.g., Holland et al., 1990; Higashi, 1994). This "artificial reef effect" is generally considered a beneficial impact. The effect, either positive or negative, is likely negligible. Given the likely nature of this impact, overall impact significance is low.

4.3.3.2 Impacts on Sediment Quality and Benthic Communities

Installation of the Tamar Platform will produce localized impacts to sediments and the benthic community. Jacket placement on the seafloor will disturb sediments below and immediately adjacent to each of the six platform legs. Platform leg diameters range between 76 to 96 in. (1.93 to 2.44 m). Considering maximum leg diameter, an area of approximately 5 m^2 will be directly affected below each leg. Total area directly affected by platform leg emplacement will be approximately 30 m^2. Additional seafloor may be disturbed by platform cross members located near each leg. During installation of the platform, sediments will be mobilized and localized mound formation may occur as the jacket legs are positioned and settle into place. Pollutants in the sediments, if present below the sediment-water interface, will be resuspended. Localized increases in turbidity will occur during installation.

Benthic communities immediately below each platform leg will be crushed; benthic fauna within several meters of each leg will be buried as sediments are resuspended and settle during platform placement. The total area of the benthic community expected to be affected by platform installation will include areas beneath and in proximity to each platform leg (i.e., >30 m^2). Impacts on sediment quality and benthic communities from platform installation will be minor. Given the likely nature of this impact, overall impact significance is low.

Over time, as the Tamar Platform acquires a biofouling community, fouling organisms will regularly slough off from the platform and provide organic material to benthic communities below, although the volume of organic inputs and their effect will be mediated by ambient currents and water depth. In the 234-m water depth of the Tamar Platform, the deposition field of sloughed biota may be expected to extend tens of meters or more from the platform. Impacts on the benthic community from this periodic sloughing will range from beneficial (i.e., from organic input) to negligible (i.e., from burial). Given the likely nature of this impact, overall impact significance is beneficial to negligible.

4.3.3.3 Impacts on Marine Mammals

Some marine mammals may avoid the Tamar Platform area due to noise. Others might be attracted to fish populations around the new platform. The most likely impacts would be short-term behavioral changes such as diving and evasive swimming, disruption of activities, or departure from the area. As resident marine mammals become accustomed to the operation noise, they will return to their routine behavior patterns.

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 Tamar Platform operations are sufficient to be audible and to produce behavioral responses, but much lower than those known to cause hearing loss, discomfort, or injury.

Low-frequency noise from engines and equipment aboard the Tamar Platform can be detected by marine mammals (Richardson et al., 1995). Mysticetes (baleen whales such as the humpback, minke, and Bryde's whales) are more likely to detect low-frequency sounds than are most odontocetes (e.g., dolphins), which have their best hearing in high frequencies. Because the Mari-B platform, adjacent to the Tamar Platform, has been in place for an extended period of time, marine mammals in the area have become acclimated to platform noise. Tamar Platform noise will be relatively weak in intensity. Some of the noise (from vessel engines and propellers) will be similar to the existing noise associated with shipping traffic in the region. Due to the duration of platform operations, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is low.

4.3.3.4 Impacts on Sea Turtles

Some sea turtles may be attracted to offshore structures (Rosman et al., 1987; Lohoefener et al., 1990). It has been suggested that sea turtle hatchlings could be attracted to brightly lit offshore platforms, where they may be subject to increased predation by birds and fishes (NOAA NMFS, 2001). The presence of the Tamar Platform lights will be in addition to those currently aboard Mari-B. Impacts on turtle populations are likely to be minor or negligible. In the Gulf of Mexico where thousands of offshore structures are present, platform lighting is considered unlikely to appreciably reduce the reproduction, numbers, or distribution of sea turtles (NOAA NMFS, 2001). Due to the duration of platform operations, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is low.

4.3.3.5 Impacts on Marine Birds

The presence of offshore gas platforms may have an effect on birdlife both as an attractant as well as a harmful agent (Montevecchi et al., 1999; Baird, 1990; Fraser et al., 2006). While the bulk of the bird migration over Israel occurs inland, its margins pass over sea. The radius of the bird monitoring radar located in Latrun, Israel, reaches to about 15 km off the Ashdod shoreline and regularly detects activity up to its margin (http://www.birds.org.il/820-en/Birding-Israel.aspx). It is therefore expected that migrating birds will see the Tamar Platform (and Mari-B) even if they do not fly directly over the platforms.

The causes for the well documented attraction of seabirds to structures at sea have been postulated to be attraction to the structure itself and the light it emits (Tasker et al., 1986; Baird, 1990; Wolfson et al., 1979; Wiese et al., 2001), as well as to the increased concentration of food sources around the structure (Montevecchi et al., 1999; Baird, 1990). 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 preventing collisions. Many seabirds in the offshore environment are strongly attracted to light. Birds often circle platforms for days (e.g., when flaring is being conducted), with the potential for dying from starvation (Bourne, 1979). Particularly sensitive species would be petrels and other Procellariforms who forage on vertically migrating bioluminescent prey. Offshore structures also provide a substrate for colonization of benthic organisms, increasing the levels of benthic flora and fauna and of zooplankton and fish. Thus, birds who have discovered the platforms will have found a predictable food source in an otherwise highly unpredictable environment, especially when considering the oligotrophic nature of the region, thus potentially altering their migratory course. Birds migrating along the Mediterranean coast usually turn east along the Sinai coastline. The presence of the platform may enable some species to "cut the corner" and shorten migrating distance.

It has been noted that the presence of offshore structures has had both a positive and negative impact on birds. Some birds may be attracted to offshore structures because of the lights and the fish populations that aggregate around these structures. 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). The presence of the Tamar Platform is expected to have a negligible impact on marine (seabirds or migratory) birds. Given the likely nature of this impact, overall impact significance is negligible.

4.3.3.6 Impacts on Recreation and Aesthetics/Tourism

Offshore structures such as platforms typically are visible from shore at distances of 5 to 16 km, with small structures barely visible at 5 km from shore. On a clear night, lights on top of offshore structures may be visible to a distance of approximately 32 km (USDOI, MMS, 2007). Since the Tamar Platform will be located 25 km from the nearest shoreline, the platform will be barely visible from shore. Impacts on nearshore recreational activities, aesthetics, and tourism are expected to be minor. With the possible exceptions of fishing and yachting, it is expected that no other recreational activities will be conducted in the vicinity of or near the Tamar Platform location. Given the likely nature of this impact, overall impact significance is low.

4.3.3.7 Impacts on Fishing and Shipping and the Maritime Industry

All vessels (including fishing boats) will be excluded from a 500-m radius around the Tamar Platform for safety reasons. Support vessels will monitor this buffer zone and help minimize the potential for other vessels to enter this area. Any inconveniences associated with the buffer zone are expected to be minimized over time; Noble Energy will provide advance consultation with local port authorities and provision of a Notice to Mariners prior to installation of the Tamar Platform.

Although no conclusive studies have been conducted to quantify catch losses resulting from Tamar Platform presence, only a limited number of fishing vessels traditionally use the area where the platform will be located. The impacts to commercial fishing activities are expected to be minor. The Tamar Platform will not be positioned near any major shipping lanes and will be well marked with all the appropriate navigational markers. No impacts on shipping or maritime operations are expected. Given the likely nature of this impact, overall impact significance is low.

Installation of the Tamar Platform may have two types of impacts on commercial fisheries, including:

- Impacts during installation, where the short- and long-term distribution and abundance of commercial species may be altered, as well as fishermen's ability to operate in areas affected by the installation activity. These impacts pertain to all fishing gears used in and near the platform location.
- Post-installation impacts may also occur due to the presence of the platform, affecting the long-term distribution of demersal or pelagic resources and adversely affecting fishing activity. This impact is most likely associated with mobile gear types, such as bottom trawling.

Due to the duration of platform operations, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is low.

Security zones are not expected to be affected by the construction or operation of the Project. It is assumed that any activity in security zones will be coordinated with the Ministry of Defense and will be affected only after duly receiving the necessary permission. Due to the duration of platform operations, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is low.

Currently there are two major operational communication cables. The exact alignment of these cables in confidential. Crossing of these cables requires coordination with the owners of the cables as well as with the Ministry of Defense. Platform placement will consider the location of existing telecommunication cables. Due to the duration of platform operations, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is low.

4.3.4 Routine Discharges

4.3.4.1 Impacts on Water Quality, Plankton, and Fish and Fishery Resources

Routine discharges will include treated sewage and domestic wastes (including food waste), deck drainage (including condensed water from the MEG and TEG regeneration systems aboard the Tamar Platform), and miscellaneous discharges originating from the Tamar Platform and DP pipelay vessel. Support vessels and other installation vessels may discharge sewage and domestic wastes and small amounts of deck drainage. Sewage, or sanitary waste, consists of human body wastes from toilets and urinals. Sanitary waste will be treated by means of a marine sanitation device that produces an effluent with a minimum residual chlorine concentration of 1.0 mg/L and no visible floating solids or oil and grease. Wastewater treatment sludge will be transported to shore for disposal at an approved facility. Domestic waste, or “gray water,” includes water from showers, sinks, laundries, galleys, safety showers, and eye-wash stations. Aside from screening to remove solids, domestic waste does not require treatment before discharge. Support vessels will be equipped with an approved marine sanitation device (U.S. Coast Guard Type I or equivalent). Food waste, a type of domestic waste, will be ground prior to discharge, in accordance with MARPOL and Barcelona Convention requirements.

Sanitary and domestic waste from the Tamar Platform, DP pipelaying vessel, other installation vessels, and support vessels may affect concentrations of suspended solids, nutrients, and chlorine in the water column as well as generate BOD. However, these discharges are expected to be diluted rapidly in the open ocean (U.S. Environmental Protection Agency [USEPA], 1993; USDOI, MMS, 2007). Impacts would likely be undetectable beyond tens of meters from the source.

Deck drainage consists of all waste resulting from rainfall, equipment and deck washings, tank cleaning operations, and runoff from curbs and gutters, including drip pans and work areas. Small amounts of condensed water from the MEG and TEG regeneration units will be included in the deck drainage discharge stream. Vessels are designed to contain runoff and prevent oily drainage from being discharged. The flow is diverted to separation systems depending on the area collected. Measures will be taken to prevent any discharge of free oil in deck drainage that would cause a film, sheen, or discoloration of the surface of the water or a sludge or emulsion to be deposited beneath the surface of the water. Only nonoily water (no visual sheen) will be discharged overboard. If the deck becomes contaminated, oily deck drainage will be contained by absorbents or collected by a pollution pan for recycling and/or disposal. Because of the separation and treatment of water from oily areas prior to discharge, deck drainage is not expected to produce a visible sheen or any other detectable impacts on water quality.

Additional miscellaneous discharges typically occur from numerous sources on project vessels. Examples include uncontaminated freshwater and seawater used for cooling water, ballast, and/or fire test water, desalination unit discharges, and boiler blowdown discharges (USEPA, 1993). These discharges must meet MARPOL and Barcelona Convention requirements and are expected to be diluted rapidly in the open ocean. Impacts on water quality would likely be undetectable beyond tens of meters from the source. The potential for impacts on plankton and fish and fishery resources is negligible.

Pipeline, MEG line, and utility line testing may result in the discharge of varying quantities of untreated seawater, with no impacts to near-surface water quality. The potential for impacts on plankton and fish and fishery resources is negligible.

Due to the nature of routine discharges and their dilution in the receiving environment, impacts to water quality, plankton, fish and fishery resources are expected to be minor. Given the likely nature of this impact, overall impact significance is low.

4.3.4.2 Impacts on Marine Birds

Monitoring programs that have been initiated at oil and gas drilling sites off the Canadian shore (Baillie et al., 2005; Montevecchi et al., 1999) have found that a) bird concentrations have increased on an order of magnitude around the platforms, and b) these birds were at risk from two main impact sources – flares and produced water. Neither flaring nor the discharge of produced water is expected at the Tamar Platform, however, the presence of the platform is expected to attract marine birds for foraging and resting.

Birds that will be foraging near produced water emissions from the Tamar Platform will be exposed to chronic pollution from substances found in routine discharges – nutrients and chlorine in treated sanitary waste, nutrients in macerated food wastes, and low levels of hydrocarbons in discharges from the oil-water separators. Given that levels of these discharge constituents are low and discharges are rapidly diluted in receiving waters, the impacts of routine discharges on marine birds are considered to be negligible. Due to the duration of platform operations, this impact is anticipated to be minor. Given the likely nature of this impact, overall impact significance is negligible.

4.3.4.3 Impacts on Marine Mammals, Sea Turtles, Recreation and Aesthetics/Tourism

Routine discharges from the Tamar Platform, DP pipelaying vessel, other installation vessels, and support vessels will produce localized increases in the water column concentration of suspended solids, nutrients, and chlorine. Elevated nutrient levels associated with the discharges will also increase BOD. All discharges are expected to be diluted rapidly in the open ocean.

Marine mammals and sea turtles swimming near the Tamar Platform, DP pipelaying vessel, other installation vessels, and support vessels (while on station or in transit) may pass through the discharge plumes resulting from routine discharges. Due to the high level of dilution expected, and the relatively benign nature of the composition of routine discharges, impacts on marine mammals and sea turtles are expected to be negligible. Given the likely nature of this impact, overall impact significance for marine mammals and sea turtles is negligible.

The Tamar Platform location, approximately 25 km from shore, and the rapid dilution of routine discharges will preclude any significant impact to recreation and aesthetics/tourism. Discharges will not reach shallow coastal waters where recreation and aesthetic/tourism resources could be affected. No adverse changes to water quality are expected in nearshore coastal waters as a result of routine discharges. Impacts to recreation and aesthetics/tourism are expected to be negligible. Given the likely nature of this impact, overall impact significance for recreation and aesthetics/tourism is negligible.

4.3.5 Solid Wastes

4.3.5.1 Impacts on Sediments and Benthic Communities

While the disposal of trash and debris in the ocean is prohibited under MARPOL and all project vessels will operate under a Waste Management Plan to ensure adherence to MARPOL, occasionally, debris such as welding rods, buckets, pieces of pipe, etc. may accidentally fall overboard and accumulate on the seafloor. Pieces of debris may be colonized by epibiota and attract fishes (due to their physical structure on the otherwise flat seafloor), resulting in a minor, local impact on the benthic community (Shinn et al., 1993). Due to the restrictions on dumping and expected adherence to MARPOL regulations, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.5.2 Impacts on Marine Mammals, Sea Turtles, and Marine Birds

Materials accidentally lost overboard during offshore oil and gas operations could 1) entangle marine fauna or 2) cause injury through the ingestion of trash and debris (Laist, 1996). Marine debris is among the threats affecting the population status of both humpback and sperm whales (NOAA NMFS, 1991, 2006). Similarly, ingestion of or entanglement with accidentally discarded 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 (NRC, 1990). Leatherback turtles are especially attracted to floating debris, particularly plastic bags, because it resembles their preferred food, jellyfish. Ingestion of plastic and Styrofoam can result in drowning, lacerations, digestive disorders or blockage, and reduced mobility. Finally, marine debris can also injure or kill birds that ingest or become entangled in it. Compliance with the Noble Energy Waste Management Plan will ensure adherence to MARPOL restrictions and reduce potential impacts to marine mammals, sea turtles, and marine birds. Impacts on these resources are expected to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.5.3 Impacts on Protected Marine Species and Habitats/Marine Habitats of Interest, and Areas of Special Concern

Floating debris accidentally lost overboard may be carried by surface currents to shore. Debris accidentally lost overboard, should it reach shore, will produce minor impacts on coastal habitats, including areas where protected marine species and habitats/marine habitats of interest and areas of special concern. Given the occasional nature of this impact, overall impact significance is low.

4.3.6 Combustion Emissions

4.3.6.1 Impacts on Air Quality

The installation vessels will emit air pollutants, including CO, NO_x, SO_x, VOCs, and particulates as well as greenhouse gases such as CO_2 and CH_4. Air pollutant emissions, including greenhouse gases, have been estimated for all project vessels and were previously presented in **Table 8**. Support vessels and helicopters will also emit air pollutants from the combustion of diesel fuel (vessels) and aviation fuel (helicopters). Quantities have not been estimated for helicopter emissions, but the emissions are assumed to have a negligible impact on air quality, both offshore and onshore.

Under certain atmospheric conditions, some of these gases are known to react or degrade to form different secondary compounds. These degradation products and transformation processes are important in the context of problems such as global warming, O_3 formation, and acidification.

Air pollutant emissions from the platform and other project vessels are expected to be rapidly diluted and dispersed in the offshore atmosphere. There may be some decrease in ambient air quality within several hundred meters around the platform and each vessel. However, no detectable impacts on air quality in Israel are expected based on the relatively small quantities of pollutants emitted and the distance from shore for most operations.

Except for the single exceedance noted (i.e., NO_x in 2011), all emissions were well below, or are expected to be well below regulatory thresholds. The estimated greenhouse gas emissions (i.e., CH_4) for the Tamar Field Development Project are expected to range from 0.1 to 4,412 tons per year, or 1,863 to 215,455 tons CO_2 equivalent. These emissions are expected to produce minor to no impact on air quality in Israel. Given the likely nature of this impact, overall impact significance is low.

4.3.7 Support Vessel and Helicopter Traffic

4.3.7.1 Impacts on Marine Mammals

There is a small possibility of a supply boat striking a marine mammal during routine operations. The risk is similar to that associated with existing vessel traffic in the region. Collisions with dolphins or whales are considered highly unlikely; most dolphins are agile swimmers and are unlikely to collide with vessels. Of the 11 marine mammal species known to have been hit by vessels, fin whales are struck most frequently, sperm whales are hit commonly, and records of collisions with Bryde's whales are rare (Laist et al., 2001). Although all sizes and types of vessels can collide with whales, most lethal or severe injuries are caused by ships 80 m or longer and traveling 14 knots or faster (Laist et al., 2001).

Vessel strikes are among the threats affecting the population status of both humpback and sperm whales (NOAA NMFS, 1991, 2006). Sperm whales are vulnerable to ship strikes because they typically spend up to 10 minutes "rafting" at the surface between deep dives (Jacquet et al., 1998). There have been many reports of sperm whales of different age classes being struck by vessels, including passenger ships and tugboats. There were also instances in which sperm whales approached vessels too closely and were injured by propellers (NOAA NMFS, 2006). Due to the short duration of the project, the low number of support vessel trips, and support vessel size, the likelihood of striking a marine mammal is considered remote to rare. Overall significance of vessel strikes to marine mammals is considered to be low.

Noise will be generated from support vessels and helicopter traffic during transit. Vessel traffic is a major contributor to noise in the world's oceans (Ocean Studies Board, 2003), especially at low frequencies between 5 and 500 Hz. Low-frequency vessel noise sources include propeller noise and propulsion machinery (e.g., diesel engines, gears, and major auxiliaries, such as diesel generators). Helicopter noise, typically in the range of 160 to 162 dB (re 1 μPa @ 1 m, rms), is predominantly in the lower frequencies (i.e., 500 to 2,000 Hz). Aircraft noise refracts off the ocean surface except when directly overhead; airborne sounds attenuate relatively rapidly with depth. Odontocetes (and baleen whales, to a lesser extent) show some tolerance of vessels but may react at distances of several kilometers or more under some circumstances or when they learn to associate the noise with harassment (Richardson et al., 1995). Due to the short duration of the project and the low levels of support vessel and helicopter traffic, the likelihood of vessel or helicopter traffic significantly disturbing marine mammals is considered negligible. Given the likely nature of this impact, overall impact significance is low.

4.3.7.2 Impacts on Sea Turtles

There is a remote possibility of a supply boat striking a sea turtle during routine operations. Vessel strikes are among the threats affecting the endangered population status of several sea turtle species (NRC, 1990). The risk for this project is similar to that associated with existing vessel traffic in the region. Studies indicate that sea turtles are at the sea surface only about 10% of the time and readily sound (dive) to avoid approaching vessels (Byles, 1989; Lohoefener et al., 1990; Keinath and Musick, 1993; Keinath et al., 1996). Due to the short duration of the project and the infrequent nature of the support vessel traffic, the likelihood of striking any sea turtle is considered remote to rare. Overall impact significance is low.

Noise from approaching vessels and aircraft are expected to elicit a similar avoidance response. Impacts of noise to sea turtles from support vessels and aircraft is considered negligible. Given the likely nature of this impact, overall impact significance is negligible.

4.3.7.3 Impacts on Marine Birds

Vessel and helicopter traffic could periodically disturb individuals or groups of coastal birds. It is likely that individual birds would experience, at most, a short-term behavioral disruption. Review of helicopter flight paths relative to coastal bird habitat will allow for consideration of flight height restrictions. Due to the duration of helicopter support operations, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.7.4 Impacts on Fishing and Shipping and Maritime Industry

The short-term physical presence of the support vessels in fishing areas may prevent and/or disturb commercial fishing activities. However, the resulting impacts are estimated to be of minor importance. Support vessels would normally be expected to follow the most direct route between the installation locations and the shorebase, weather permitting. It is assumed that support vessels would avoid traveling close to the coast, except at the approach to the shorebase, and that they would not traverse coastal waters at night when longlines or nets left overnight could be damaged.

Support vessel transit routes may cross normal shipping routes. These impacts are anticipated to be of minor importance due to the transit period. Support vessels would normally be expected to follow the most direct route between the installation locations and the shorebase, weather permitting. It is assumed that support vessels would avoid traveling close to the coast, except at the approach to the shorebase, and they would not traverse coastal waters at night when longlines or nets left overnight could be damaged. Accordingly, significant impacts on shipping and maritime industry are expected to be avoided.

As support vessels utilize the shorebase, a minor increase in vessel traffic will occur. No significant impacts to vessel traffic in Israel ports are expected from the installation operations. Due to the duration of support vessel operations, this impact is anticipated to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.3.7.5 Impacts on Protected Marine Species and Habitat Areas/Marine Habitats of Interest and Areas of Special Concern and Recreation and Aesthetics/Tourism

Helicopter traffic along the route between the Israeli coast and the installation locations will not affect any protected areas. Helicopters have a potential for disturbing coastal birds or affecting recreation and aesthetics/tourism as they fly over the coast. Due to the limited number of helicopter trips expected to occur in support of proposed installation operations, impacts to protected species and habitats, recreation, and aesthetics/tourism are considered to be minor. Given the occasional nature of this impact, overall impact significance is low.

4.4 ACCIDENTS OR UPSETS

Noble Energy proposes development of the gas reserves of the Tamar Field; therefore, modeling of a crude hydrocarbon release is not necessary. However, the possibility exists that diesel fuel could be released during installation operations as diesel fuel will be utilized and stored on all of the project vessels.

The potential impacts of a hypothetical large diesel release and a small diesel release are discussed below.

4.4.1 Probability of a Diesel Fuel Release

A large diesel release on any of the project vessels, such as one resulting from a diesel tank rupture, would be an extremely rare event. The probability has not been estimated, but historical data for the Gulf of Mexico include no such incidents between 1981 and 1999 (Anderson and LaBelle, 2000; USDOI, MMS, 2007). A study conducted in 2000 (USDOI, MMS, 2000) indicates that, historically, most diesel releases have been <1 bbl, and for releases greater than this, the median size is 5 bbl.

4.4.2 Hydrocarbon Release Trajectory

No simulation modeling has been conducted for a small or large diesel spill at the Tamar Field, along the pipeline corridor, or at the Tamar Platform location. However, simulations of gas/condensate release at one of the Tamar wellsites indicates that surface oil (including diesel fuel) will be transported in an easterly direction towards shore.

4.4.3 Potential Impacts of a Diesel Fuel Release

Previous modeling under comparable conditions provides a point of reference relative to the fate of a hypothetical diesel release in the marine environment. The following discussion applies to a hypothetical diesel release of several hundred barrels. In addition, a hypothetical small diesel release occurring during a fuel transfer was also considered. A 10-bbl diesel fuel release will undergo extensive weathering via evaporation and dispersion. After 8 hours, 35% of the diesel fuel will have evaporated and 54% of the diesel will have dispersed, leaving only 11% of the diesel fuel on the surface of the water.

4.4.3.1 Impacts on Air Quality

A diesel fuel release would affect air quality in the vicinity of the oil slick by introducing VOCs through evaporation. Emissions would not last long due to rapid volatilization of hydrocarbons. Evaporation is greatest within the first 24 hours. The more toxic, light aromatic and aliphatic hydrocarbons are lost rapidly by evaporation and dissolution (NRC, 1985; Payne et al., 1987). Evaporated hydrocarbons are degraded rapidly by sunlight. Biodegradation of diesel fuel on the water surface and in the water column by marine bacteria and fungi initially removes the n-alkanes and subsequently the light aromatics. Other components are biodegraded more slowly. Photo-oxidation attacks mainly the medium and high molecular weight PAHs of a diesel release. The extent and persistence of impacts would depend on meteorological and oceanographic conditions at the time. Little or no impact on air quality in coastal areas would be expected due to the distance of Tamar Field from shore and the degree of weathering expected. Overall impact significance is low.

4.4.3.2 Impacts on Water Quality and Sediments

A diesel fuel release would affect marine water quality by increasing hydrocarbon concentrations due to dissolved components and small oil droplets. Natural weathering processes are expected to rapidly remove the diesel fuel from the water column and dilute the constituents to background levels. Diesel releases are unlikely to affect sediments unless carried into shallow water, which is not expected given current trajectories and weathering characteristics. Overall impact significance is low.

4.4.3.3 Impacts on Marine Biota

Plankton and Fish and Fishery Resources

A diesel fuel release could affect phytoplankton and zooplankton because they do not have the ability to avoid contact with oil. Planktonic communities drift with water currents and recolonize from adjacent areas. Because of these attributes and their short life cycles, plankton usually recovers relatively rapidly to normal population levels following disturbances.

While adult and juvenile fishes may actively avoid a large diesel release, planktonic fish eggs and larvae would be unable to avoid contact. Eggs and larvae of fishes will die if exposed to certain toxic fractions of diesel fuel. Most fishes inhabiting oceanic waters have planktonic eggs and larvae. However, due to the wide dispersal of early life history stages of fishes, a diesel release would not be expected to have significant impacts at the population level. In the event of a large diesel release, fishing activities near the project area could be temporarily disrupted. The area affected would be relatively small, and the duration would presumably be only a few days. Overall impact significance is low.

Benthic Communities

A diesel fuel release in surface waters would have no impact on benthic communities. Diesel is unlikely to reach the seabed, especially at the water depth of the Tamar Field, pipeline route, or Tamar Platform location. A diesel fuel release occurring nearshore will evaporate very quickly, especially during warm temperatures. Should a small release occur inside a port or harbor, any remaining released fuel would be contained and cleaned up quickly. Overall impact significance is low.

Marine Mammals, Sea Turtles, and Marine Birds

Diesel fuel may 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, 1987, 1988, 1990; Loughlin et al., 1996). Cetacean skin is highly impermeable and is not seriously irritated by brief exposure to diesel fuel; direct contact is not likely to produce a significant impact. Whales and dolphins apparently can detect slicks on the sea surface but do not always avoid them; therefore, they may be vulnerable to inhalation of hydrocarbon vapors, particularly those components of diesel fuel that are readily evaporated. Ingestion of the lighter hydrocarbon fractions found in diesel fuel can be toxic to marine mammals. Ingested diesel fuel 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 of diesel fuel (i.e., aromatic hydrocarbons, PAHs) include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms. Released diesel fuel may also foul the baleen fibers of mysticete whales, thereby impairing food-gathering efficiency or result in the ingestion of diesel fuel or diesel fuel-contaminated prey.

Diesel fuel in the marine environment may affect sea turtles through various pathways: direct contact, inhalation of diesel fuel and its volatile components, ingestion of diesel fuel (directly or indirectly through the consumption of fouled prey species), and ingestion of floating tar (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 diesel fuel or volatile hydrocarbons may produce irritation and inflammation. Diesel fuel can adhere to turtle skin or shells. Turtles surfacing within or near a diesel release would be expected to inhale petroleum vapors. Ingested diesel fuel, 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 (including diesel fuel).

Direct contact of marine birds with diesel fuel 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.

A diesel fuel release is expected to have a low impact to marine mammals, sea turtles, or marine birds due to the expected low density of these resources, relatively short period of release presence on the sea surface, and low areal coverage. Overall impact significance is low to medium.

4.4.3.4 Impacts on Protected Marine Species and Habitats, Marine Habitats of Interest and Areas of Special Concern

Diesel fuel spills could occur as a result of vessel collision or leaks (e.g., during fuel transfer). A small or large diesel spill at the Tamar Field is expected to dissipate rapidly, and would only likely affect organisms in the immediate location of the accident. Fuel and diesel used for operation of survey vessels is light and would float on the water surface. Diesel fuel spilled at the ocean surface will disperse and weather, with volatile components evaporating.

The potential for impacts from a diesel fuel spill would depend greatly on the size and location of a spill, the meteorological conditions at the time of the accidental release, and the speed with which cleanup equipment could be employed. Due to the location of the Tamar Field approximately 90 km offshore, it is extremely unlikely that a diesel fuel spill will reach shore and any sensitive coastal habitats (e.g., protected marine habitats, marine habitats of interest, or areas of special concern, including nature reserves, marine nature reserves, and national parks) in sufficient concentrations to produce impacts. Diesel will disperse rapidly, with the volatile, toxic components quickly evaporating.

Sensitive species, including those previously outlined in **Table 34**, include select species of invertebrates, sharks, fish, marine mammals, turtles, and marine and coastal birds. Because diesel floats, with only a small percentage potentially adhering to water-borne particulates and sinking, water column, pelagic, and benthic species would be at minimal risk of exposure when present. Accident impacts to marine mammals, sea turtles, and marine and coastal birds from diesel fuel exposure, outlined previously in **Section 4.4.3.3**, were expected to be low to moderate. While individual birds may be oiled during a diesel spill, such impacts will be unlikely to affect marine and coastal birds at a population level. Overall impact significance of a diesel spill to protected marine species and habitats, marine habitats of interest and areas of special concern is low, with the possible exception of sea turtles and marine and coastal birds, where impacts are expected to range from low to moderate.

4.4.3.5 Impacts on Fishing and Shipping and Maritime Industry

A large diesel release from the Tamar Field would not be expected to affect socioeconomic or cultural conditions onshore Israel. For diesel fuel, natural weathering processes would remove the released hydrocarbons from the water column and dilute the constituents to background levels relatively quickly. The impacts would be limited to offshore waters near the release site and would persist from a few hours to a few days. Except for exclusion from the area, impacts on fishing from an offshore diesel release at the Tamar Field are unlikely because of the distance from shore and the likelihood that any fishers would be warned away from a release site. Similarly, impacts on shipping from a diesel release offshore are unlikely. Overall impact significance is low.

4.4.3.6 Impacts on Recreation and Aesthetics/Tourism

Impacts from a diesel fuel spill will depend on the size and location of a spill, the meteorological conditions at the time of the accidental release, and the speed with which cleanup equipment could be employed. Due to the location of the Tamar Field approximately 90 km offshore, it is extremely unlikely that a diesel fuel spill will reach coastal waters where recreation and tourism activities are located. Diesel will disperse rapidly, with the volatile, toxic components quickly evaporating. As a result, it is very unlikely that diesel will reach coastal waters in sufficient amounts to adversely affect the aesthetics of the coastal zone and beaches. Cleanup operations will be localized to the Tamar Field area, therefore no impacts to recreations and aesthetics/tourism are expected from vessel and equipment operations associated with a spill. Overall impact significance to recreation and aesthetics/tourism is low.

4.4.3.7 Impacts on Archaeological Resources

A small or large diesel spill at the Tamar Field is expected to dissipate rapidly, and would only likely affect resources the immediate location of the accident. Because diesel floats, with only a small percentage potentially adhering to water-borne particulates and sinking, water column, pelagic, and benthic resources would be at minimal risk of exposure when present. Only a small percentage of diesel fuel spilled adheres to particulate material, which moves and disperses with subsurface currents. Affected particulates reach the seafloor in extremely low concentrations. Submerged archaeological resources are unlikely to be affected by surface spilled diesel fuel. Overall impact significance of a diesel spill to archaeological resources is low.

4.5 CUMULATIVE IMPACTS

Cumulative impacts are those resulting from the incremental effects of the proposed project when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes them. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over time.

In addition to this project, other sources of impact that may contribute to cumulative impacts include future exploratory activity in Israel waters and other human activities in the offshore region, including fishing and ship traffic.

In general, potential impacts from the installation phases of the project are expected to be of short duration and concentrated mostly within a few hundred to several thousand meters of the Tamar Field, along the pipeline corridors, and at the Tamar Platform location. Due to the localized nature of the impacts and the absence of other installation activity in the area, there is little chance of cumulative or synergistic impacts with other activities in the region. Cumulative impacts to fishing and ship traffic will be minimal, due primarily to the short-term duration of the installation activities and low levels of impact resulting from ongoing fishing and shipping activity in the region. Therefore, the potential for cumulative impacts is low.

4.6 TRANSBOUNDARY IMPACTS

Impacts from routine activities associated with the Tamar Field Development Project are localized and transient for short term activities (i.e., installation). Operation of the Tamar Platform will produce long term impacts to select resources, while the extent of such impacts will be limited to the immediate area around the platform. In general, such routine, project-related impacts will diminish in intensity and severity with increasing distance from the source. The potential for routine, project-related impacts to result in transboundary impacts is extremely small.

Small or large diesel spills from the Tamar Field Development Project are expected to be transported in an easterly or northeasterly direction under the influence of ambient surface currents and winds. Spills occurring at the ocean surface will disperse and weather. Volatile components of the fuel will evaporate. Fuel and diesel used for operation of survey vessels is light and would float on the water surface. There is the potential for a small proportion of the heavier fuel components to adhere to particulate matter in the upper portion of the water column and sink. Given the relative size of the diesel spills evaluated under the accident scenario, coupled with spill response capabilities, the potential for transboundary effects (e.g., transport into waters to the north of Israel) are considered to be extremely small.

5.0 Mitigation and Residual Impacts

The identification and application of mitigation measures is intended to 1) reduce the severity or magnitude of identified impacts; 2) reduce their longevity; and/or 3) reduce their probability of occurrence. Based on the analysis of the Tamar Field Development Project impacts previously summarized in **Section 4**, feasible mitigation measures were evaluated. The effectiveness of each mitigation measure was also determined (i.e., what residual impact remained following application of the mitigation).

Mitigation measures were identified for the majority of project-related impacts and for all of the impacts identified in association with accidents or upsets. Individual mitigation measures for each environmental resource, organized by IPF, are described below, separated by routine, project-related activities and accidents. It is important to note that the following mitigation measures represent available and feasible mechanisms and approaches to reduce impacts to one or more resources; they are not to be viewed as required, and are offered as recommendations for consideration by Noble Energy.

Table 42 summarizes impacts, mitigation, and residual impacts for the Tamar Field Development Project, based on IPFs found with each major project phase (e.g., installation) or IPF grouping (e.g., routine discharges). Under this approach, it is evident how individual IPFs may affect one or more environmental resources.

Table 43 summarizes overall impact significance for project-related activities and accidents associated with the Tamar Field Development Project, based on residual impact determinations (i.e., after mitigation). **Table 43** has been organized by the IPF groupings previously presented in **Section 4** – where IPFs were grouped into several major project phases (e.g., installation, operation) or IPF sources (e.g., routine discharges, combustion emissions).

5.1 ROUTINE, PROJECT-RELATED ACTIVITIES

5.1.1 Installation Vessels (Pipelay Vessel, Support Vessels) – Transit, Onsite Operations, and Departure

To reduce impacts on air quality:

- maintain routine maintenance procedures and emissions monitoring; and
- when practical, utilize low sulfur fuels to limit SO_x production.

To reduce impacts to fishing and shipping and maritime industry:

- enforce a buffer zone around the DP pipelay vessel;
- ensure that Noble consults with Haifa port authorities and provides notices to mariners that a DP pipelay vessel and other support vessels will be conducting pipeline installation operations between the Tamar Field and the Tamar Platform;
- whenever practical, position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible;
- mark the DP pipelay vessel with appropriate navigational markers;

- ensure support vessels follow the most direct route possible—weather conditions; permitting—between the Tamar Field or pipeline corridor and the marine transportation hub (Haifa);
- avoid travelling close to the coast, except for when approaching shorebase; and
- ensure support vessels do not transverse coastal waters at night.

No mitigation measures are available to reduce impacts from noise to marine mammals and vessel presence and movement to sea turtles from DP pipelay vessel and associated vessel transit, onsite operations, and departure.

To reduce impacts to marine birds:

- when feasible and when vessel navigational safety is not compromised, shield lights (i.e., orient downward) to maximize work areas and minimize lighting of the sea surface.

No mitigation measures are available to reduce impacts to recreation and aesthetics/ tourism from the presence or movement of the DP pipelay vessel.

5.1.2 Pipelines, MEG Lines, Control Lines, and Umbilicals – Installation and Presence

To reduce impacts on water quality, sediment quality, and benthic communities:

- use shallow geohazards data to verify the absence of hard bottom or chemosynthetic communities within the pipeline and umbilical corridors.

To reduce impacts to fishing and shipping and maritime industry:

- enforce a buffer zone around the DP pipelay vessel;
- ensure that Noble consults with Haifa port authorities and provides notices to mariners that a DP pipelay vessel and other support vessels will be conducting pipeline installation operations between the Tamar Field and the Tamar Platform;
- whenever practical, position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible; and
- mark the DP pipelay vessel with appropriate navigational markers.

To reduce impacts to archaeology:

- conduct a detailed survey along the alignment of the planned utility lines to determine the possible existence and extent of any archaeological site.

5.1.3 Tamar Platform Installation, Presence, and Operation

No mitigation measures are available to reduce impacts to water quality, plankton, fish and fishery resources, benthic communities, sediment quality, marine mammals, and sea turtles.

To reduce impacts to marine birds:

- when navigational safety is not compromised, shield lights (i.e., orient downward) to maximize work areas and minimize lighting of the sea surface.

To reduce impacts to fishing and shipping and maritime industry:

- enforce a 500-m buffer zone around the Tamar Platform.

No mitigation measures are available to reduce impacts to recreation, aesthetics, or tourism.

5.1.4 Routine Discharges

To reduce impacts on water quality, plankton, fish and fishery resources, and marine birds:

- maintain routine maintenance procedures and verify that all equipment associated with discharge sources (e.g., oil-water separators, sanitary wastes, domestic wastes, food wastes) is working within stated discharge specifications, in compliance with permitted discharge limitations or acceptable standards.

No mitigation measures are available to reduce impacts to marine mammals, sea turtles, recreation, aesthetics, tourism, or archaeological resources.

5.1.5 Solid Wastes

To reduce impacts on sediment quality, benthic communities, marine mammals, sea turtles, marine birds, recreation and aesthetics/tourism (coastal habitats):

- comply with MARPOL restrictions on overboard dumping of waste; and
- conduct a site clearance survey along the pipeline corridor following pipeline installation to verify the absence of marine debris.

No impacts to archaeological resources were identified associated with solid waste.

5.1.6 Combustion Emissions

To reduce impacts to air quality from the Tamar Platform and support vessels:

- maintain routine maintenance procedures and emissions monitoring; and
- when practical, utilize low sulfur fuels to limit SO_x production.

No mitigation measures are available for impacts from helicopter emissions.

5.1.7 Support Vessel and Helicopter Traffic

To reduce impacts to marine mammals and sea turtles from the potential for ship strike:

- train vessel operators in marine mammal and sea turtle observation techniques, and require vessel operators to slow or avoid marine mammals and sea turtles while in transit; and
- ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa).

To reduce impacts from vessel noise on marine mammals, sea turtles, marine birds (particularly nesting coastal birds), protected marine species and habitat areas, recreation and aesthetics/tourism:

- train vessel operators in marine mammal and sea turtle observation techniques, and require vessel operators to slow or avoid marine mammals and sea turtles while in transit;
- ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa), avoiding sensitive areas, wildlife areas, bird colonies, and tourist spots.

To reduce impacts from support vessel traffic on fishing and shipping and maritime industry:

- ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa), avoiding sensitive areas, wildlife areas, bird colonies, and tourist spots; and
- vessel operators to follow applicable maritime navigation rules.

To reduce impacts from helicopter traffic (and associated noise) to marine mammals, sea turtles, marine birds (particularly nesting coastal birds), protected marine species and habitat areas, recreation and aesthetics/tourism:

- plan flight paths to avoid populated areas, wildlife areas, bird colonies, and set minimum cruise altitudes when crossing the coast or offshore islands; and
- conduct routine flights during daylight hours only.

5.2 ACCIDENTS

To reduce the likelihood and impact of an oil spill (small diesel spill, large diesel spill), as outlined in **Section 4.4**:

- develop and implement an oil spill response plan (OSRP)/emergency management plan (EMP), which outlines In-Country Tier I equipment and response timelines for Tier II and Tier III equipment;
- routinely check equipment stockpiles onshore and aboard supply vessels (e.g., *Bee Hive*; *Honey Bee*);
- conduct spill drills to familiarize personnel with emergency response procedures;
- comply with Noble's Energy Environmental, Health, and Safety (EHS) Global Management System (GMS), including its Environmental Policy and Health and Safety Policies, as outlined in **Section 6**;
- ensure that real-time monitoring of Tamar Field gas production operations occurs 24 hours per day, 7 days per week; and
- inspect and regularly test well control equipment.

To assist in the allocation of spill response resources, completion and review of an oil spill simulation modeling exercise would assist in the determination of likely spill trajectories and resources at risk.

Table 42. Impact determinations for routine project-related activities and accidents associated with the Tamar Field Development Project. Impact significance before and after mitigation (i.e., residual impact) noted. Significance definitions are provided in **Section 4.**

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Routine Operations							
DP Pipelay Vessel and Associated Vessel Transit, Onsite Operations, and Departure							
Emissions	Air Quality	Air emissions from vessel engines will increase ambient levels of pollutants near the area of operations. Support vessels moving between the shorebase and the installation sites will also introduce pollutants into the atmosphere.	Likely	Direct; Short term; Reversible; Consequence: Minor	Low	• Maintain routine maintenance procedures and emissions monitoring; and • When practical, utilize low sulfur fuels to limit SOx production	Low
DP pipelay vessel movements, presence	Fishing; Shipping and Maritime Industry	Limited operating access around the DP vessel and support vessels during installation; vessels operating in the area, including fishing boats, will be required to maintain a safe distance.	Likely	Direct; Short term; Reversible; Consequence: Minor	Low	• Enforce a buffer zone around the DP pipelay vessel; • Ensure that Noble consults with Haifa port authorities and provides notices to mariners that a DP pipelay vessel and other support vessels will be operating offshore between the Tamar Field and the Tamar Platform site; • Position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible; • Mark the DP pipelay vessel with appropriate navigational markers; • Ensure support vessels follow the most direct route possible—weather conditions; permitting—between the Tamar Field or pipeline route and the marine transportation hub (Haifa); • Avoid travelling close to the coast, except for when approaching shorebase; and • Ensure support vessels do not transverse coastal waters at night.	Low

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Noise from DP pipelay vessel operation	Marine Mammals	Marine mammals may avoid the pipelay vessel due to noise; others may be attracted to fish populations around stationary vessels. Impacts likely will be short term behavioral changes (e.g., diving, evasive swimming, disruption of activities, or departure from the area).	Likely	Direct; Short term; Reversible; Consequence: Minor	Low	• None available.	Low
DP pipelay vessel presence and movement	Sea Turtles	Attracted to offshore structures and potential for ship strike.	Likely	Direct; Short term; Reversible; Consequence: Minor to Negligible	Low	• None available.	Low
DP pipelay vessel presence	Marine Birds	Attracted to offshore structures (lights).	Likely	Direct; Short term; Reversible; Consequence: Minor	Low	• When feasible and when vessel navigational safety is not compromised, shield lights (i.e., orient downward) to maximize work areas and minimize lighting of the sea surface	Low
Transiting and presence of DP pipelay vessel	Recreation and Aesthetics/ Tourism	Adverse impacts to recreation, aesthetics, or tourism (reduction in aesthetic value to reduce the interest in tourists or others to visit coastal venues).	Remote	Direct; Short term; Reversible; Consequence: Minor	Negligible	• None available.	Negligible
Pipelines, MEG Lines, Control Lines, and Utility Lines – Installation and Presence							
Installation of pipelines and control lines	Water Quality; Sediment Quality; Benthic Communities	Emplacement will cause increased localized turbidity, possible mobilization, and transport of sediment-associated contaminants, and crushing and/or burial of benthic communities within the pipeline corridor.	Likely	Direct; Short term; Reversible; Consequence: Minor	Low	• Use shallow geohazards data to verify the absence of hard bottom or chemosynthetic communities within the pipeline and control line corridor.	Low

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Vessel exclusion	Fishing; Shipping and Maritime Industry	All vessels (including fishing boats) will be excluded from a 3- to 8-mile radius around installation operations for safety reasons. Post-installation impacts may also occur due to the presence of the pipelines, with impacts to the long-term distribution of demersal or pelagic resources and impacts to associated fishing activity. Support vessels will enter and leave their shorebase, producing a minor incremental increase in port activity.	Likely	Direct; Short term; Reversible; Consequence: Minor	Low	• Enforce a buffer zone around the DP pipelay vessel; • Ensure that Noble consults with the appropriate port authorities and provides notices to mariners that a DP pipelay vessel will be conducting pipeline installation operations between the Tamar Field and the Tamar Platform; • Position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible; and • Mark the DP pipelay vessel with appropriate navigational markers.	Low
Installation of utility lines	Archaeological Resources	Potential damage to submerged archaeological sites, artifacts in nearshore waters.	Remote	Direct; Long term; Irreversible; Consequence: Severe	Medium	• Conduct a detailed survey along the alignment of the planned utility lines to determine the possible existence and extent any archaeological site.	Low
Tamar Platform Installation, Presence, and Operation							
Platform installation	Sediment Quality; Benthic Communities	Disturbance of the benthos; crushing or burial of benthic communities during emplacement of the jacket; mobilization of surficial sediments; localized alteration of bathymetric contours, mound formation	Likely	Direct; Long term; Reversible; Consequence: Minor	Low	• None available.	Low
Platform presence	Plankton; Fish and Fishery Resources	Attraction to lights; structure provides shelter and food, in the form of attached biota – artificial reef effect.	Likely	Direct; Long term; Reversible; Consequence: Negligible	Beneficial to Negligible	• None available.	Beneficial to Negligible
Platform presence	Benthic Communities; Sediment Quality	Fouling organisms will regularly slough off from the platform and provide organic material to sediments and benthic communities below.	Likely	Indirect; Long term; Reversible; Consequence: Negligible	Beneficial to Negligible	• None available.	Beneficial to Negligible
Platform noise	Marine Mammals; Sea Turtles	Low frequency noise from engines and equipment aboard the Tamar Platform may affect marine mammals and sea turtles (attraction, avoidance).	Likely	Indirect; Long term; Reversible; Consequence: Minor	Low	• None available.	Low

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Platform lights	Marine Birds	Potential collision with the platform.	Likely	Indirect; Long term; Reversible; Consequence: Minor	Negligible	• When navigational safety is not compromised, shield lights (i.e., orient downward) to maximize work areas and minimize lighting of the sea surface.	Negligible
Vessel exclusion	Fishing; Shipping and Maritime Industry	All vessels (including fishing boats) will be excluded from a 500-m radius around the Tamar Platform for safety reasons.	Likely	Direct; Long term; Reversible; Consequence: Minor	Low	• Enforce a 500-m buffer zone around the Tamar Platform.	Low
Platform visible, lights	Recreation and Aesthetics/ Tourism	Tamar Platform will be located 25 km from the nearest shoreline; the platform will be barely visible from shore.	Likely	Direct; Long term; Reversible; Consequence: Minor	Low	• None available.	Low
Routine Discharges							
Treated and untreated discharges	Water Quality; Plankton; Fish and Fishery Resources; Marine Birds	Treated wastes (sanitary and domestic, deck drainage, miscellaneous wastes) from the Tamar Platform, DP pipelaying vessel, crane vessel, other installation vessels, and support vessels may affect concentrations of suspended solids, nutrients, chlorine, and/or hydrocarbons, as well as generate BOD. Other discharges to include untreated hydrotest water (seawater) and food wastes.	Likely	Direct; Long term; Reversible; Consequence: Minor	Low	• Maintain routine maintenance procedures and verify that all equipment associated with discharge sources (e.g., oil-water separators, sanitary wastes, domestic wastes, food wastes) is working within stated discharge specifications, in compliance with permitted discharge limitations or acceptable standards.	Low
Treated and untreated discharges	Marine Mammals; Sea Turtles; Recreation and Aesthetics/ Tourism	Treated wastes (sanitary and domestic, deck drainage, miscellaneous wastes) from the Tamar Platform, DP pipelaying vessel, crane vessel, other installation vessels, and support vessels may affect concentrations of suspended solids, nutrients, chlorine, and/or hydrocarbons, as well as generate BOD. Other discharges to include untreated hydrotest water (seawater) and food wastes.	Likely	Direct; Long term; Reversible; Consequence: Negligible	Negligible	• None available.	Negligible

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Solid Wastes							
Marine debris	Sediment Quality; Benthic Communities	Debris (e.g., welding rods, buckets, pieces of pipe, etc.) may accidentally fall overboard and accumulate on the seafloor.	Likely	Direct; Long term; Reversible; Consequence: Minor	Low	• Comply with Noble's Waste Management Plan and adherence to MARPOL restrictions on overboard dumping of waste; and • Conduct a site clearance survey at the Tamar Field and along the pipeline corridor to verify the absence of marine debris.	Low
Marine debris	Marine Mammals; Sea Turtles; Marine Birds; Recreation and Aesthetics/ Tourism (Coastal Habitats)	Debris (e.g., plastic bags, plastic containers, sheet plastic, etc.) may accidentally fall overboard and be ingested, or entangle pelagic marine animals; debris may wash ashore.	Likely	Direct; Long term; Reversible; Consequence: Minor	Low	• Comply with Noble's Waste Management Plan and adherence to MARPOL restrictions on overboard dumping of waste.	Low
Combustion Emissions							
Tamar Platform and support vessel operations	Air Quality	Minor impacts on air pollutant concentrations at and near the platform from platform equipment and support vessels. Coastal/onshore impacts may be limited due to quantities emitted, short term nature of pipelaying, distance from shore. Following installation/start up, support vessel trips to the Tamar Platform will continue.	Likely	Direct; Long-term for Platform equipment and support vessels; Reversible; Consequence: Minor	Low	• Maintain routine maintenance procedures and emissions monitoring; and • When practical, utilize low sulfur fuels to limit SOx production.	Low
Helicopter emissions	Air Quality	Negligible impacts on air pollutant concentrations along travel routes.	Likely	Direct; Short term for installation; long-term for support vessels (Tamar Platform); Reversible; Consequence: Negligible	Negligible	• None required.	Negligible

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Support Vessel and Helicopter Traffic							
Vessel strike	Marine Mammals; Sea Turtles	Potential for a supply vessel striking a marine mammal or sea turtle, resulting in injury or mortality.	Remote to Rare	Direct; Short term for installation; long-term for support vessels (Tamar Platform); Irreversible; Consequence: Minor	Low	• Train vessel operators in marine mammal and sea turtle observation techniques, and require vessel operators to slow or avoid marine mammals and sea turtles while in transit; and • Ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa).	Low
Support vessel noise	Marine Mammals; Sea Turtles; Marine Birds; Protected Marine Species and Habitat Areas; Recreation and Aesthetics/ Tourism	Potential for disturbing marine mammals, sea turtles, coastal birds, protected natural areas, recreation and aesthetics. Support vessels will be visible and possibly audible from shore during transit.	Occasional	Direct; Short term for installation; long-term for support vessels (Tamar Platform); Reversible; Consequence: Minor	Low	• Ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa), avoiding sensitive areas, wildlife areas, bird colonies, and tourist spots.	Negligible to Low
Support vessel traffic	Fishing; Shipping and Maritime Industry;	Support vessel traffic may interfere with fishing, or may cross shipping lanes potentially interfering with commercial vessel traffic.	Occasional	Direct; Short term for installation; long-term for support vessels (Tamar Platform); Reversible; Consequence: Minor	Low	• Ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa), avoiding sensitive areas, wildlife areas, bird colonies, and tourist spots; and • Vessel operators to follow applicable maritime navigation rules.	Negligible to Low

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Helicopter noise	Marine Mammals; Sea Turtles; Marine Birds (nesting, coastal); Protected Marine Species and Habitat Areas; Recreation and Aesthetics/ Tourism	Potential for disturbing marine mammals, sea turtles, coastal nesting birds, or affecting recreation and aesthetics.	Occasional	Direct; Short term installation; long-term for support vessels (Tamar Platform); Reversible; Consequence: Minor	Low	• Plan flight paths to avoid populated areas, wildlife areas, bird colonies, setting minimum cruise altitudes when crossing the coast or offshore islands; and • Conduct routine flights during daylight hours only.	Negligible to Low
Accidents							
Small diesel fuel spill	Air Quality; Water Quality; Plankton; Fish and Fishery Resources; Marine Mammals; Sea Turtles; Marine Birds	Contamination of water column with hydrocarbons. Due to rapid weathering of diesel, mainly offshore resources would be at risk, including air quality, water quality, marine mammals, turtles, and marine birds.	Occasional	Direct; Short term; Reversible; Consequence: Negligible to Minor	Negligible to Low	• Develop and implement an oil spill response plan (OSRP)/emergency management plan (EMP), which outlines In-Country Tier I equipment and response timelines for Tier II and Tier III equipment; • Routinely check equipment stockpiles onshore and aboard supply vessels (e.g., *Bee Hive*; *Honey Bee*); • Conduct spill drills to familiarize personnel with emergency response procedures; • Comply with Noble's Energy Environmental, Health, and Safety (EHS) Global Management System (GMS), including its Environmental Policy and Health and Safety Policies; • Conduct oil spill dispersion modeling to determine likely trajectories and resources at risk.	Negligible

Table 42. (Continued).

Project Activity/ Source of Impact	Resources Affected	Impact Description	Impact Likelihood	Impact Characteristics and Consequence	Impact Significance	Mitigation Measures	Residual Impact
Large diesel fuel spill	Air Quality; Water Quality; Plankton; Fishes; Marine Mammals; Sea Turtles; Marine Birds; Protected Marine Species and Habitat Areas; Fishing	Contamination of water column with hydrocarbons. Due to rapid weathering of diesel, mainly offshore resources would be at risk, including water quality, marine mammals, turtles, and seabirds, fishes, etc. Coastal resources could be at risk if a large spill moved into coastal areas, or occurred close to shore.	Rare	Direct; Short term; Reversible; Consequence: Moderate	Low to Medium	• Develop and implement an oil spill response plan (OSRP)/emergency management plan (EMP), which outlines In-Country Tier I equipment and response timelines for Tier II and Tier III equipment; • Routinely check equipment stockpiles onshore and aboard supply vessels (e.g., Bee Hive; Honey Bee); • Conduct spill drills to familiarize personnel with emergency response procedures; • Comply with Noble's Energy Environmental, Health, and Safety (EHS) Global Management System (GMS), including its Environmental Policy and Health and Safety Policies; • Conduct oil spill dispersion modeling to determine likely trajectories and resources at risk.	Low

MARPOL 73/78 = International Convention for the Prevention of Pollution from Ships.

Table 43. Summary of residual impacts, by resource category and impact producing factor, Tamar Field Development Project.

Source of Impact – Impact Producing Factor	Resource											
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine Birds	Protected Marine Species and Habitats/Marine Habitats of Interest and Areas of Special Concern	Fishing	Shipping and Maritime Industry	Recreation and Aesthetics/Tourism	Archaeological Resources
ROUTINE, PROJECT-RELATED ACTIVITIES												
DP Pipelay Vessel and Associated Vessel Transit, Onsite Operations, Departure	Low	--	--	--	--	Low	Low	--	Low	Low	Negl	--
Mitigation Measures: Air Quality: Maintain routine maintenance procedures and emissions monitoring; when practical, utilize low-sulfur fuels to limit SO_x production Fishing, Shipping and Maritime Industry: Enforce a buffer zone around the DP pipelay vessel; ensure that Noble consults with Haifa port authorities and provides notices to mariners that a DP pipelay vessel and other support vessels will be operating offshore between the Tamar Field and the Tamar Platform site; position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible; mark the DP pipelay vessel with appropriate navigational markers; ensure support vessels follow the most direct route possible, weather conditions permitting, between the Tamar Field or pipeline route and the marine transportation hub (Haifa); avoid travelling close to the coast, except when approaching shorebase; and ensure support vessels do not transverse coastal waters at night. Marine Birds: When feasible and when vessel navigational safety is not compromised, shield lights (i.e., orient downward) to maximize work areas and minimize lighting of the sea surface. Marine Mammals, Sea Turtles; Recreation and Aesthetics/Tourism: None available.												
Residual Impact	Low	--	--	--	--	Low	Low	--	Low	Low	Negl	--
Pipelines, MEG Lines, Control Lines, Utility Lines – Installation and Presence	--	Low	Low	--	Low	--	--	--	Low	Low	--	Med
Mitigation Measures: Water Quality, Sediment Quality, Benthic Communities: Use shallow geohazards data to verify the absence of hard bottom or chemosynthetic communities within the pipeline and umbilical corridors. Fishing, Shipping and Maritime Industry: Enforce a buffer zone around the DP pipelay vessel; ensure that Noble consults with the appropriate port authorities and provides notices to mariners that a DP pipelay vessel will be conducting pipeline installation operations between the Tamar Field and the Tamar Platform; position the DP pipelay vessel away from major shipping lanes to the maximum extent feasible; and mark the DP pipelay vessel with appropriate navigational markers. Archaeological Resources: Conduct a detailed survey along the alignment of the planned utility lines to determine the possible existence and extent any archaeological site.												
Residual Impact	--	Low	Low	--	Low	--	--	--	Low	Low	--	Low
Tamar Platform Installation, Presence, and Operation	--	Ben Low	--	Ben Negl	Ben Low	Low	Negl	--	Low	Low	Low	--
Mitigation Measures: Marine Birds: When navigational safety is not compromised, shield lights (i.e., orient downward) to maximize work areas and minimize lighting of the sea surface. Fishing, Shipping and Maritime Industry: Enforce a 500-m buffer zone around the Tamar Platform. Plankton, Fish and Fishery Resources, Benthic Communities, Sediment Quality, Marine Mammals, Sea Turtles, Recreation and Aesthetics/Tourism: None available.												
Residual Impact	--	Ben Low	--	Ben Negl	Ben Low	Low	Negl	--	Low	Low	Low	--
Routine Discharges	--	--	Low	Low	--	--	Negl	--	--	--	--	--
Mitigation Measures: Water Quality, Plankton, Fish and Fishery Resources, Marine Birds: Maintain routine maintenance procedures and verify that all equipment associated with discharge sources (e.g., oil-water separators, sanitary wastes, domestic wastes, food wastes) is working within stated discharge specifications, in compliance with permitted discharge limitations or acceptable standards. Marine Mammals, Sea Turtles, Recreation, Aesthetics, Tourism, Archaeological Resources: None available.												
Residual Impact	--	--	Low	Low	--	Negl	Low	--	--	--	Negl	--

Table 43. (Continued).

Source of Impact – Impact Producing Factor	Resource											
	Air Quality	Sediments/Sediment Quality	Water Quality	Plankton, Fish and Fishery Resources	Benthic Communities	Marine Mammals and Sea Turtles	Marine Birds	Protected Marine Species and Habitats/Marine Habitats of Interest and Areas of Special Concern	Fishing	Shipping and Maritime Industry	Recreation and Aesthetics/Tourism	Archaeological Resources
Solid Wastes	--	Low	--	--	Low	Low	Low	Low	--	--	--	--
Mitigation Measures: Sediment Quality, Benthic Communities: Comply with Noble's Waste Management Plan and adherence to MARPOL restrictions on overboard dumping of waste; conduct a site clearance survey at the Tamar Field and along the pipeline corridor to verify the absence of marine debris. Marine Mammals, Sea Turtles, Marine Birds, Recreation and Aesthetics/Tourism: Comply with Noble's Waste Management Plan and adherence to MARPOL restrictions on overboard dumping of waste.												
Residual Impact	--	Low	--	--	Low	Low	Low	Low	--	--	--	--
Combustion Emissions	Negl Low	--	--	--	--	--	--	--	--	--	--	--
Mitigation Measures: Air Quality: Maintain routine maintenance procedures and emissions monitoring; and when practical, utilize low sulfur fuels to limit SOx production.												
Residual Impact	Negl Low	--	--	--	--	--	--	--	--	--	--	--
Support Vessel and Helicopter Traffic	--	--	--	--	--	Low	Low	Low	Low	Low	Low	--
Mitigation Measures: Marine Mammals, Sea Turtles: Train vessel operators in marine mammal and sea turtle observation techniques, and require vessel operators to slow or avoid marine mammals and sea turtles while in transit; and ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa). Marine Mammals, Sea Turtles, Marine Birds, Protected Marine Species and Habitat Areas, Recreation and Aesthetics/Tourism: Ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa). For helicopter flights: Plan flight paths to avoid populated areas, wildlife areas, bird colonies, setting minimum cruise altitudes when crossing the coast or offshore islands; and conduct routine flights during daylight hours only. Fishing, Shipping and Maritime Industry: Ensure support vessels follow the most direct route possible—weather conditions permitting—between the Tamar Platform and the marine transportation hub (Haifa), avoiding sensitive areas, wildlife areas, bird colonies, and tourist spots; and vessel operators to follow applicable maritime navigation rules.												
Residual Impact	--	--	--	--	--	Negl Low	Negl Low	Negl Low	Negl Low	Negl Low	--	--
ACCIDENTS												
Small diesel fuel spill	Negl Low	--	Negl Low	Negl Low	--	Negl Low	Negl Low	Negl Low	--	--	--	--
Large diesel fuel spill	Low Med	--	Low Med	Low Med	--	Low- Med	Low- Med	Low Med	--	--	--	--
Mitigation Measures: Air Quality, Water Quality, Plankton, Fishes, Marine Mammals, Sea Turtles, Marine Birds, Protected Marine Species and Habitat Areas, Fishing: Develop and implement an oil spill response plan (OSRP)/emergency management plan (EMP), which outlines In-Country Tier I equipment and response timelimes for Tier II and Tier III equipment; routinely check equipment stockpiles onshore and aboard supply vessels (e.g., *Bee Hive*; *Honey Bee*); conduct spill drills to familiarize personnel with emergency response procedures; comply with Noble's Energy Environmental, Health, and Safety (EHS) Global Management System (GMS), including its Environmental Policy and Health and Safety Policies; conduct oil spill dispersion modeling to determine likely trajectories and resources at risk.												
Residual Impact	Negl Low	--	Negl Low	Negl Low	--	Negl Low	Negl Low	Negl Low	--	--	--	--

6.0 Environmental, Health, and Safety Management

6.1 INTRODUCTION

Environmental 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. These policies and procedures are framed and implemented within the Noble Energy Environmental, Health, and Safety (EHS) Global Management System (GMS) for all program activities.

To ensure that Noble Energy's corporate environmental, health, and safety policies are systematically applied and that industry best practices are adopted within all of its operations, Noble Energy has developed its Global EHS Management System (GMS) that integrates health, safety, and environmental considerations into all elements of the management process. The hierarchy of this system is illustrated in **Figure 69**.

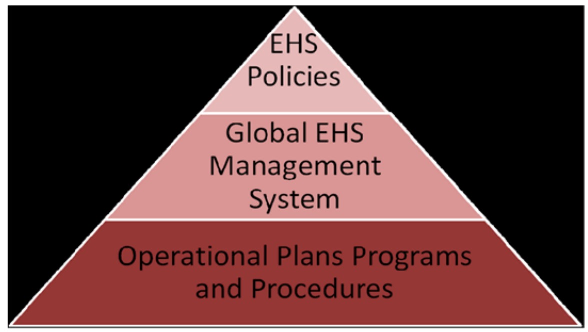


Figure 69. Environmental, Health, and Safety management hierarchy.

The EHS policies are at the top of the EHS management hierarchy and demonstrate the commitment and intentions of the Company. At the next level are the Corporate EHS Standards and Guidelines documented in the Noble Energy GMS, which support the policies. At the base of the structure are the project-specific Operational Plans, Programs, and Procedures that provide the specifics of how things are done within each project.

The GMS 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 Occupational Safety and Health Management Systems (OSHMS) and Environmental Management Systems (EMS).

Because the Tamar Field Development Project will be undertaken using equipment and personnel provided by third parties (e.g., owner/operators of selected vessels), the Noble Energy GMS will be implemented by personnel who will operate under their respective corporate EMS and safety systems. These systems include elements such as the environment; general shipboard management; and procedures for the bridge, engine room, deck, cargo, and the use of activity-specific equipment. Noble Energy will ensure that vessel plans will be aligned with Noble Energy's GMS by use of an Interface Document.

The GMS Interface Document will identify common processes and approaches to address any differences in procedures between Noble Energy and the vessel contractor as well as any site-specific hazards of the Tamar Field Development project. Noble Energy will conduct an extensive comparison and review of vessel plans, processes, and procedures relative to the Noble Energy GMS to ensure that the contractor's plans are acceptable for use as the primary system during the Tamar Field Development project.

6.2 ENVIRONMENTAL, HEALTH, AND SAFETY POLICIES

6.2.1 Environmental Policy

Noble Energy's environmental policy comprises three key philosophies:

- **Continuous Improvement** – Noble Energy has numerous initiatives in place to analyze, monitor, and continuously improve its environmental performance. Noble actively evaluates the availability and performance of green technologies (e.g., drilling fluids). Noble is also actively involved in adopting technologies and practices that improve operational efficiency while reducing methane emissions.
- **Internal Responsibility** – In addition to enforcing stringent policies and adopting best practices for environmentally responsible operations, Noble Energy has created forums dedicated to improving performance. For example, the Noble Environmental Council meets quarterly to share experiences, issues, and concerns and to advise management on fostering a culture of environmental excellence.
- **Preservation of Wildlife** – Noble Energy's commitment to the environment extends to the preservation of wildlife and natural areas. Representative efforts include measures to protect the protected birds and mangrove reforestation.

Noble has also implemented an environmental protection policy whose key components include:

- **Environmental Training** – Noble Energy provides environmental education for various personnel that includes hands-on training and may incorporate third-party trainers and computer-based training.
- **Spill Prevention** – In addition to meeting all regulations regarding the timely reporting of hydrocarbon and produced water discharges, Noble Energy has a procedure to report and track spills and unintentional discharges that are below the requirements for reporting. Noble Energy periodically reviews and updates its storm water, spill prevention, and countermeasure plans to ensure compliance and the best possible performance.
- **Waste Management** – Waste management plans developed by Noble Energy for its North American operations and many of its international locations are based on a strategy of *Reduce, Reuse and Recycle*. Noble perpetually seeks ways to reduce the amount of operational wastes and strives to reuse materials when feasible. Noble Energy has implemented a series of recycling programs and encourages its employees to participate.
- **Environmental Regulatory Compliance** – Recognizing the potential environmental risks associated with exploratory activities and production operations, Noble has developed both an internal and external environmental audit program.

6.2.2 Health and Safety Policies

One of Noble Energy's primary EHS policies is that safety is central to the job of every employee and contractor. To attain this goal, Noble Energy fosters a culture based on genuine care and compassion that encourages individual responsibility for protecting people and the environment. Noble Energy provides a solid foundation for responsible operations with safety and environmental training. Noble Energy promotes individual vigilance and responsibility by assigning every person working at a Noble Energy facility the authority – and duty – to stop work when necessary to protect health, safety, or the environment. Noble Energy strives for continuous improvement through teamwork and collaboration. The Noble Energy Safety Council, made up of representatives from various areas of operations, meets quarterly to share safety-related experiences, issues, and concerns. They draw on shared experiences to advise management on fostering a safety and health-conscious culture. Area Safety Committees work together to improve EH&S performance within each specific region.

Four key components comprise Noble Energy's health and safety policies:

- **Safe Work and Operating Practices** – Noble Energy has developed Safe Work and Operating Practices for its personnel. Designed to provide a framework for effective health, safety, environmental, and sustainability practices, these guidelines include detailed plans, procedures, and strategies to protect people and the environment. In addition to procedures that govern day-to-day operations, Noble Energy practices include job analyses to proactively identify and address potential health and safety hazards. Noble requires third-party contractors to follow their own Safe Work and Operating Practices, which must meet the same general requirements.
- **Emergency Preparedness and Community Awareness** – Noble develops and implements incident management plans at each of its operations and also at the corporate level in order to coordinate emergency response at all of its facilities. The plans contain provisions for dealing with potential emergencies and clearly assign authority and duties to ensure timely and effective response.
- **Safety and Environmental Training** – All personnel at Noble Energy-operated facilities are trained to perform their functions in a manner that protects people, the environment, and equipment. Noble Energy requires its contractors to provide comparable training to their employees before they start work at Noble Energy facilities and to submit documentation or verification of adequate training.
- **Contractor Safety Management** – Noble Energy is committed to a safe, healthful, and environmentally responsible work environment. Recognizing the role of its contractors in achieving EHS excellence, it is intended that contractors work under conditions and rules that are at least as protective as those governing Noble Energy's own employees. Noble Energy does not take control of a contractor's safety program or relieve any contractor of its safety responsibility; Noble Energy has developed a separate Contractor Safety Management Plan to achieve compliance with this element of the GMS. Noble Energy's plan includes the evaluation of contractor safety performance prior to contract award through the ISNetworld Contractor Database. Dedicated to effective EHS communication with its contractor workforce, Noble Energy has also worked with various business units to host several contractor symposiums in strategic areas. These symposia communicate the value that Noble Energy places on each individual, the environment, and the communities in which it works, and underscores Noble Energy's expectations for superior EHS performance from its contract workforce. The symposia also introduce resources designed to help small contractors develop effective EHS programs within their own organizations. Through these symposia, Noble Energy partners with its contractor workforce to improve EHS performance throughout its operations.

7.0 Conclusions

Seven separate sources of potential impact were identified in association with routine, project-related activities (i.e., pipeline, flowline, control line, utility line installation; Tamar Platform installation; Tamar Platform operations [pre-commissioning]) for the Tamar Field Development Project, including:

- Installation Vessels – covering Tamar Field Infrastructure installation (barge and support vessel transit; flowline, MEG line, and control line installation; and barge and support vessel departure) – transit, onsite operations, and departure;
- Pipelines, MEG lines, control lines (umbilicals), and utility lines – installation and presence;
- Tamar Platform: installation, presence, and operation;
- Routine discharges;
- Solid wastes;
- Combustion emissions; and
- Support vessel and helicopter traffic.

Two accident scenarios were also considered in the analysis – a large diesel fuel spill from the pipelay vessel and a small diesel fuel spill from a support vessel – and their impacts identified.

Installation Vessels: The movement and presence of installation vessels (i.e., transit, onsite operations, and departure of barge and support vessels) may be expected to produce impacts from discharges, vessel presence and movement, and noise. Most resources were affected, including water quality, sediment quality, benthic communities, plankton and fishes, marine mammals, sea turtles, marine birds, fishing, shipping and maritime industry, recreation, and aesthetics/tourism. ***Residual impact significance to each of these resources was negligible or low for identified impact producing factors.***

Pipelines, MEG lines, control lines, and utility lines: The installation and presence of project infrastructure, including pipelines, MEG lines, control lines, and utility lines, may be expected to produce impacts from installation activity and vessel exclusion. ***Residual impact significance to each of these resources was low for all identified impact producing factors.***

Tamar Platform installation, presence, and operation: The installation, presence, and operation of the Tamar Platform may be expected to produce impacts from installation (bottom disturbing activities), presence of the structure, noise, lights, vessel exclusion, and platform visibility. Resources potentially affected by platform installation, presence, and operation include water quality, sediment quality, plankton and fishes, benthic communities, fish and fishery resources, marine mammals, sea turtles, marine birds, shipping and maritime industry, and recreation and aesthetics/tourism. ***Residual impact significance to each of these resources was negligible or low for identified impact producing factors, with beneficial impacts also noted.***

Routine Discharges: Operation of the Tamar Field Development Project, including the presence of personnel aboard the Tamar Platform, may be expected to produce impacts associated with treated and untreated discharges and marine debris. Resources potentially affected by routine discharges included water quality, sediment quality, plankton and fishes, benthic communities, fish and fishery resources, marine mammals, sea turtles, marine birds, recreation and aesthetics/tourism. ***Residual impact significance to each of these resources was negligible or low for identified impact producing factors.***

Solid Wastes: Operation of the Tamar Field Development Project and the presence of personnel aboard the Tamar Platform may be expected to produce impacts associated with accidental loss of debris. Resources potentially affected by solid wastes included sediment quality, benthic communities, marine mammals, sea turtles, marine birds, and recreation and aesthetics/tourism. ***Residual impact significance to each of these resources was low for all identified impact producing factors.***

Combustion Emissions: Tamar Platform operations, as well as support vessels and helicopters operating in support platform operations, may be expected to produce impacts from internal combustion engines. Resources potentially affected by combustion emissions included air quality. ***Residual impact significance to this resource was negligible or low.***

Support Vessel and Helicopter Traffic: The use of support vessels and helicopters during normal operations of the Tamar Field Development Project may be expected to produce impacts associated with potential vessel strike, vessel traffic and noise, and helicopter noise. Resources potentially affected by support vessel and helicopter traffic included marine mammals, sea turtles, marine birds, fishing, shipping and maritime industry, protected marine species and habitat areas, and recreation and aesthetics/tourism. ***Residual impact significance to these resources was negligible or low for identified impact producing factors.***

Accidents: A large diesel release on any of the project vessels, such as one resulting from a diesel tank rupture, would be an extremely rare event. The probability has not been estimated, but historical data for the Gulf of Mexico include no such incidents between 1981 and 1999. A study conducted by the U.S. Minerals Management Service in 2000 indicates that, historically, most diesel releases have been <1 bbl, and for releases greater than this, the median size is 5 bbl.

Should a small diesel fuel spill occur, the impacts would potentially affect water quality, plankton, fishes, marine mammals, sea turtles, and marine birds. If a large diesel spill occurred, the same resources would be at risk, as well as protected marine species and habitat areas, fishing, and onshore socioeconomic conditions. The severity of the impacts would depend upon the size of the spill, its location, oceanographic and climatologic conditions at the time of the spill, and the response of Noble (i.e., how quickly the spill is identified, resources committed to containment and clean up).

A series of oil spill-related mitigation measures were identified in the impact analysis, many of which are already in place. Noble has developed and implemented an oil spill response plan (OSRP)/emergency management plan (EMP), which outlines In-Country Tier I equipment and response timelines for Tier II and Tier III equipment. Noble routinely checks its equipment stockpiles onshore and aboard its contracted supply vessels (e.g., *Bee Hive*; *Honey Bee*). Noble personnel also comply with Noble's Energy Environmental, Health, and Safety (EHS) Global Management System (GMS), including its Environmental Policy and Health and Safety Policies. ***Residual impact significance to these resources for a small or large diesel spill was negligible or low***.

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Appendices

Appendix A

Vessel Specifications

Photo by Nick Franken

AUDACIA

BULKCARRIER CONVERTED INTO DYNAMICALLY POSITIONED PIPELAY VESSEL

Builders: Keppel Verolme Shipyard, Rozenburg, The Netherlands
Owners: Allseas, Châtel-Saint-Denis, Switzerland

When the bulk carrier 'Geeview', built in China, came up for sale shortly after delivery in 2005, Allseas saw this as an excellent opportunity to expand its fleet of deepsea pipelaying vessels. Offshore contractors often prefer a conversion over a newbuilding because things need to go a little faster in that industry. The 'Geeview' was sold because price fluctuations in the bulk carrier market meant that more profit could be made by selling the vessel than by operating it for many years. The acquisition price of around 38 million euros for an almost new vessel is small in comparison to the additional conversion cost of 300 million euros. One can almost consider this as a Dutch newbuilding project, with the hull and primary systems built in China. Allseas operates a fleet of well-known pipelaying vessels such as the 'Lorelay', 'Tog Mor' and 'Solitaire', the world's largest pipelaying vessel. Unlike the 'Seven Oceans' from Subsea 7 featured in June this year, which stores its pipes (up to 16" diameter) pre-welded on a large reel, the 'Audacia' is equipped to perform the welding of rigid pipe at sea. This allows the installation of thicker pipes, with an outside diameter up to 60 inches. Depending on the diameter, 'Audacia' can lay pipes up to a depth of 3500 m at a rate of 4 to 7 km per day.

Bulk carrier conversion

The concept of the ship was entirely developed in-house by Allseas Engineering in Delft (NL). Besides considerable time and cost savings, the modification of an existing bulk carrier gives the 'Audacia' a clear advantage in speed. The original propulsion system has entirely been retained, giving the vessel a cruising speed of 16 knots. This has been achieved by laying the pipes over the bow, instead of the stern as seen on other vessels in her class.

With a maximum beam of 32.6 m, the 'Audacia' can pass through the Panama Canal. Its length without the stinger is 225 m. The

Bulkcarrier 'Geeview' before for the conversion

accommodation has been entirely renewed to provide for the 240 crew employed on board, in single and double cabins. The original accommodation tower was taken off in the shipyard and replaced with a new, longer superstructure. The accommodation was installed by OACG from Rotterdam.

Main characteristics

The vessel is classed by Lloyd's Register of Shipping with class notation ✠ 100 A1 DP(AAA). She has the following dimensions:

Principal particulars

Length incl. stinger	330 m
Length excl. stinger	225 m
Stinger length	106 m
Breadth	32.26 m
Depth to main deck	19.2 m
Draught excl. thrusters	9 m

Performance

Cruising speed	16 knots
Diesel-electric power	35.100 kW
Diesel power	10.500 kW
Pipe storage capacity	16.000 ton

Pipelaying

Maximum diameter including coating	60 inch
Maximum water depth	3.500 m
Laying speed	5 to 7 km/day

Firing line

The area where the pipes are assembled, welded, tested and coated is called the "firing line". This area runs from the stern to the bow and is covered by a shelter. Usually, the ship will receive a regular supply of pipes from other ships during pipe laying (a 24 ton capacity pipe transfer crane loads the pipes on board), but to provide a buffer for bad weather, the ship also has four holds for a total of 16.000 tons of pipes. The pipes can be taken out of the storage holds with overhead beam cranes.

They are then transferred to the beginning of the firing line. In the firing line are 12 workstations for welding, non-destructive examination of the welds and field joint coating. Several stations each do a welding pass and then several stations carry out the non-destructive examination and the coating of the welds. The seven welding stations make use of the Phoenix automatic welding system, which was designed and fabricated in-house by the shipowner, Allseas. For every step, the ship sails 12 m forward allowing a new pipe to be added to the firing line at the stern.

Constant tension

While dynamic positioning can keep the ship at a certain location, the ship will still move because of the waves and wind. During pipe installation, the goal is to keep the pipe as stationary as possible. This is done by applying a constant tension on the pipe. With any given motion of the ship, the tensioners will haul in or let out a bit of the pipe to keep it exactly in the same place relative to the bottom. Another crucial role of the tensioners is to prevent the pipe from buckling under its own weight. The amount of tension applied is dictated by the depth, the weight of the pipe and the vessel motions. The tensioners on 'Audacia' were taken off 'Solitaire' during its last refit. The three 175 ton tensioners together can provide a pull of 525 tons. They are placed on special bearings that are capable to absorb all loads (including uplift) during pipelaying activities. This is achieved by using specially designed elastomeric elements built into the structure. The welding stations in the firing line are positioned in carts on rails which are attached to the pipe, so they remain stationary to the pipe independent of the ship's motions. The 'Audacia' has no active stabilizers, yet with this arrangement she can lay pipes in seastates with a significant wave height of up to 3 metres.

106 m stinger

Whereas all other pipelaying vessels lower the pipes from the aft of the vessel, on the 'Audacia' this is done from the bow. A gigantic 106 m long stinger is fitted for this purpose. The stinger is a cantilevered slide, guiding the pipeline gently into the water from the horizontal position on deck to a vertical position aimed at the depths. It is composed of three hinged sections with a total weight of 770 tons. During transit, the stinger can be lifted out of the water by a large 550 ton crane on the bow. It then extends some 40 m above the surface to avoid any damage from wave impact.

Load sensors

To accurately govern the tensioners and the DP system, the 'Audacia' is equipped with a wealth of measuring devices. Technofysica from Barendrecht has supplied, a.o. the following devices:

- Stinger pipe load monitoring system,
- Control & load measurement of stinger handling system,

The conversion at full steam

– Control & load measurement of stinger adjusting system,
– Load measurements in various guide sheaves related to: tail anchor winch, TSA winch, A & R guide sheaves,
– Tensioner (load verification) load link load cell, capacity 350 tonnes.

Diesel-electric propulsion

To allow for exact dynamic positioning, the original propulsion system has been extended with 6 retractable electric thrusters, each converting 5 MW of electric power into 80 metric tons of bollard pull. The power for these thrusters is generated in two added engine rooms, each holding three 5850 kW generator sets based on Wärtsilä 9L38B engines. In normal operation, only two of the three generator sets in each engine room will be running, with one on standby.

One of the two added engine rooms

The Phoenix automated welding system

The tensioners keep the pipe stationary and prevent buckling

The six retractable Wärtsilä thrusters are of the type FS3500 and can be steered through 360 degrees. The propellers are located in nozzles. The total installed electrical power amounts to a solid 35.100 kW. By comparison, the original propulsion installation (non-electric) delivered only 10.500 kW. The vessel is classed as a DP (AAA) vessel, which means that it can still be dynamically positioned even if one of the engine rooms goes totally off-line. The original bow thruster was kept in service to provide for low-speed manoeuvring in shallow waters.

During transit, the 'Audacia' always sails on the original direct-drive diesel installation. While pipelaying, the diesel-electric propulsion with 6 retractable thrusters is used for dynamic positioning and the conventional propulsion is taken off-line.

The 550 ton A-frame being placed onboard

Bosch Rexroth supplied the hydraulic installation

Collaborative effort

The electrical engineering for the propulsion was done by Imtech Marine & Offshore from Rotterdam, collaborating with GTI. Together they installed 8000 cables totalling 375 km, with 20.000 connections.

The work represented 400.000 man-hours, but was completed in only 40 weeks. GTI also took care of the outfitting and piping installation of the two newly added engine rooms, a work of 175.000 man-hours which took about 8 months. With Bakker from Sliedrecht also involved in the electrical installation, drive, control and automation systems, this is a rare case where the two Dutch giants of electro-technical engineering were working side by side.

The 'Audacia' was christened on May 8th 2007

Hydraulic power

Many systems on board the ship make use of hydraulic power. The entire system was engineered by Bosch Rexroth and is based on 2 hydraulic power units. The larger one is powered by 5 main pumps of 240 kW and a smaller one with 2 x 66 kW main pumps. The hydraulic consumers include the various cranes, the pipe tensioners and a number of winches supplied by Emcé. A 550 ton abandonment and recovery winch allows the pipelaying to be interrupted for bad weather and to be resumed later on.

A large A-frame with a safe working load of 550 ton on the starboard side approximately amidships is used for the installation of pipe line end manifolds (PLEMs). These are attached to the end of a pipeline and allow pipelines to be routed from this point.

Two bridges

The 'Audacia' is equipped with two separate bridges: one for normal navigation and one dedicated to dynamic positioning. The navigation and communication equipment was supplied by Radio Holland. Sperry Marine took care of the complete refit and commissioning of the bridge equipment. For the main engine, electronic control has been provided through the systems supplied by SAM Electronics. They supplied a diesel manoeuvring system (DMS 2100), an electronic governor system (EGS 2000) and an engine safety system (DPS 2100). The bridge interface is based on a familiar Windows environment.

Conclusion

The 'Audacia' was christened on May 8th 2007, in the presence of about 700 guests. After finishing her first job in the North Sea, the 'Audacia' will sail to the Bay of Bengal in India, where she will lay gas pipelines together with other Allseas ships to a total length of 313 km at a water depth up to 1200 m. The repair of damages caused by hurricane Katrina and the high oil price has caused a boom in the offshore construction market, which keeps on going till today. In 2006 the Keppel Verolme yard booked a record turnover of 160 million euro. After the refit of 'Solitaire', the conversion of 'Audacia' has strengthened the customer-supplier bond between Allseas and Keppel Verolme.

Subcontractors and suppliers of equipment fitted on board the 'Audacia'
(partial list)

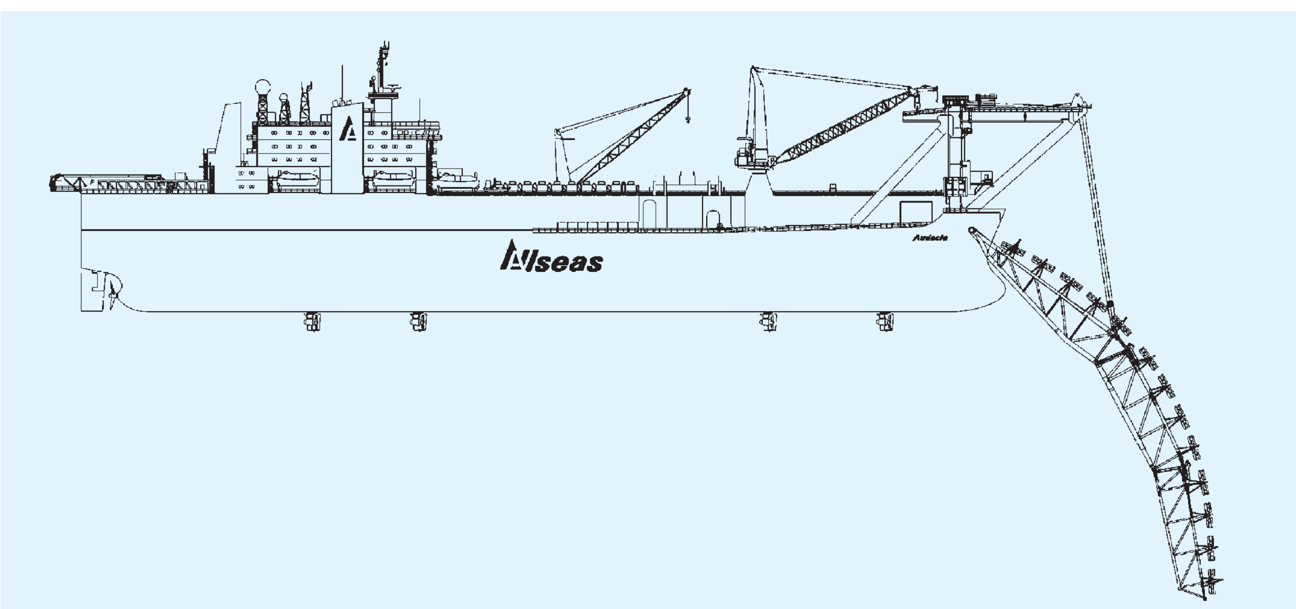
Aalborg Industries, Spijkeniss	Energy Management System; extension / modification steamboiler plant; system components
ABB Marine & Turbocharging, Rotterdam	checking main engine turbocharger;
Aces Direct, Tilburg	computer harware & software
Advantec Electronics, Oudenbosch	encapsulated power supplies
AE Sensors, Dordrecht	sensor ("string-pot")

The helipad is on the aft deck

The emergency diesel generator

Elastomeric bearing tensioners

Air Products Nederland, Amsterdam: gasses cutting- and welding processes
Ajax Fire Protection Systems, Amsterdam: sprinklers; watermist system
Alfa Laval Benelux, Breda: freshwater generator; bilge water separator
Allweiler Pumps Benelux, Utrecht: pumps
Amatec, Alphen ad Rijn: stainless steel technical springs
Anker, Het, Schelluinen: windows & portholes
Batt Cables, Oud Beijerland: flexible halogen free shipboard cable
Bayards Aluminium Constructies, Nieuw-Lekkerland: helideck; engineering; platforms; lighting & firefighting
Blok-Interrek, Rotterdam: office furniture; desk-chairs
Blomsma Signs & Safety, Zoetermeer: safety signalling marks IMO / SOLAS
Bodewes Winches, Nieuwekerk a/d IJssel: stinger winches
Boer Plastik de, Heemskerk: polycarbonate clear faceshields
Boer Staal, De, Uitgeest: steel plates; bulb flats; tubes
Bosch Rexroth, Boxtel: hydraulic power units-, equipment-, piping & installation
Breedveld Staal, Krimpen a/d IJssel: steel
Castrol Marine, Rotterdam: lube oils
Consilium Marine Systems, Schoonhoven: fire detection equipment
Corrosion & Water-Control, Moerkapelle: anode system stinger protection
Datema Delzijl, Delfzijl: nautical inventory & safety-, fire-fighting, medical-, distress signals & rescue equipment; nautical electronic charts & books; navigation lights; *Light Partner* lighting systems & safety signs; navigational instruments
Econosto Nederland, Capelle a/d IJssel: valves & fittings
Eekels Pompen, Barendrecht: pumps
EMCE Machinefabriek, Voorhout: winches; capstans; storage reels, bollards, rollers, chocks
Emha Technisch Bureau, Ridderkerk: *Chockfast Orange*® epoxy installation works; pipe handling equipment
Fuglesangs, Rotterdam: *Garbarino* engine pumps
Future Pipe Industries, Hardenberg: glassfibre reinforced pipe systems for sea water cooling systems
Goffin Meyvis Analytical & Medical Systems, Etten-Leur: *Rion* sound level meters
GMS Instruments, Rotterdam: thermometers, meters; measurements; switches; calibration equipment; sight glasses
GTI Marine Offshore, Rotterdam: ships electrical systems; piping installation
GTI Seton Pijpleidingen, Dordrecht: electrical installation; piping systems
GN Piping / IHC Piping, Sliedrecht: piping installation forward equipment room
Hatenboer-Water, Schiedam: freshwater treatment equipment; freshwater hydrophore & treatment unit; hot water calorifiers
Hempel (The Netherlands), Vlaardingen: paint systems
Hertel CKT, Rotterdam: persons accommodation
Hollandia, Krimpen a/d IJssel: steelstructure new accommodation; reinforcement & alteration sections hull and decks
Hoogland & Massee, Dordrecht: steel tubes; flanges; elbows; fittings
Huisman Special Lifting Equipment, Schiedam: *Itrec* mast crane; pedestal mounted offshore crane with automatic overload protection
Hytop Hydrauliek, Sliedrecht: hydraulic engineering for flipper system
International Paint, Rhoon: coating systems pipeholds, engine rooms, tanks
Intersona, Heerde: calculations
Imtech Marine & Offshore, Rotterdam: *LV* switchboards; additional thrusters; thrusterdrivs for A&R winch and tensioners; electrical installation & engineering;
Johnson Controls Systems & Service, Dordrecht: *HVAC* system; chilled water plant; mechanical ventilation; steam unitheaters
Jong & Lavino, De, Geldermalsen: steel plates
Kooyman-Shipchandlers, Dordrecht: galley-, cabin equipment/utensils; all catering supplies food & non-food
Kranendonk, Rotterdam: insulation; persons accommodation upholstery; floor systems; floor coverings; sanitary systems
Kroon Techn. Groothandel, Hoogezand: ship's locks & hardware
Lankhorst Touwfabrieken, Dordrecht: *Eurofloat* mooring ropes
Leeuwen Jr's Buizenhandel, Van, Zwijndrecht: pipes & components
MAN Rollo, Zoetermeer: emergency marine genset
Materiaal Metingen Europe, Ridderkerk: anodes for thrusters
Mechelen Lifting Gear, Van, Bergen op Zoom: steel wire rope sheaves; sheaves
Mennens Schiedam, Schiedam: steel wire ropes; chains; shackles; high pressure hydraulics
Nieuwburg L. & Zn, Krimpen a/d IJssel: rubber hoses & flanges
Nobel en Zn Filtration & Separation, A., Zwijndrecht: all filter spares main- & auxiliary engines and equipment
Northrop Grumman Sperry Marine, Vlaardingen: upgrade navigation & communication systems; re-fit & commissioning all bridge equipment
Observator Instruments, Ridderkerk: *Hepworth* window wipers
ODS, Barendrecht: pipes, tubes; flanges; welding elbows; reducers; couplings
Radio Holland Netherlands, Rotterdam: navigation- & communication systems; audiovisual equipment
Redwise Maritime Recruitment, Bunschoten: crew
Reikon, Spijkenisse: *Azcue* pumps
Rubber Design, Heerjansdam: flexible suspension exhaust system; stainless steel bellows exhaust system
SAM Electronics Nederland, Rotterdam: diesel manoeuvering system; electronic governor system; engine safety system
Ships Spares Logistics, Rotterdam: custom formalities; express deliveries spare parts & furniture
Techno Fysica, Barendrecht: monitoring system; stinger handling system (SHS); stinger adjusting system (SAS); load measurements; tensioner load link load cell
Temaro, Rotterdam: fire retardent curtains; roller blinds; *Solasolve*® sunscreens
Theunissen Technical Trading, Malden: *Aqua Signal* lighting; *MCT Brattberg* cable transit seals; *Zenite*l communication equipment; *SeaTeleCom* communication equipment
Trelleborg Bakker, Ridderkerk: design, manufacturing, testing, supplying bearings tensionsers
Uittenbogaart, T.B.U., Rotterdam: *Deerberg* waste management system; *Biocompact* sewage treatment plant & transfer plant; *Jets* vacuum toilet system; *Winel* WT doors, WT sliding-doors, firedoors, tank vent check valves
Venteville, Rotterdam: *Chloropac Eletrocatalytic* anti-fouling system; pump; *Kockum Sonics* TYFON auto controller
Viking Life Saving Equipment, Zwijndrecht: life boat; rescue craft; life raft
Wärtsilä Nederland, Zwolle: *Wärtsilä* diesel generator sets; steerable thruster retractable design
Westfalia Separator Nederland, Cuijk: fuel and (lube-) oil separators & *Visco* booster units
Winel, Assen: WTS doors; weatertight musketeer doors, tank check valves, A60 interior doors
Witt, Jan de, Bussum: *Momec* doors
Wolf Products, De, Yerseke: embarkation and pilot ladders; life jackets; safety pictograms



Pipelaying Vessel "SOLITAIRE"

Electrical Propulsion System
10 kV Supply and Distribution System

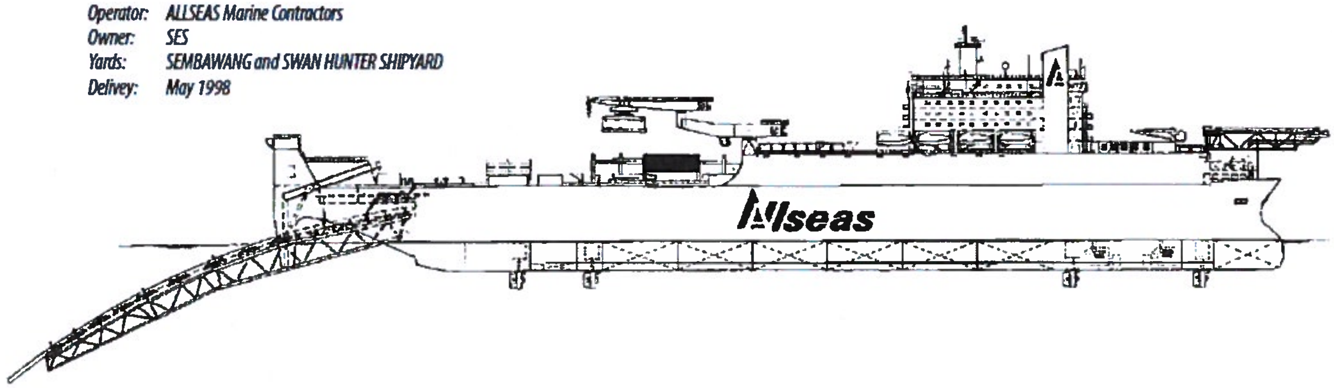
SAM Electronics

an L3 communications company

Pipelaying Vessel "SOLITAIRE"

The World's Largest Pipelaying Vessel

Operator: *ALLSEAS Marine Contractors*
Owner: *SES*
Yards: *SEMBAWANG and SWAN HUNTER SHIPYARD*
Delivey: *May 1998*



Main Data

Length incl. stinger	368 m
Width	40.6 m
Draught	14.5 m
Displacement	76909 t
Accommodation capacity	420 pers.
Pipelaying rate	6 km/day
Max. pipe diameter	60 inches
Cruising speed	12 kn
Generator power	48 MW
Thruster drives cont. load	34.4 MW
Thruster drives peak load	44 MW

SAM Electronics had the system responsibility for: diesel-electric propulsion system, 10 kV power generation, 10 kV switchgear, 10 kV transformers, navigation, communication, entertainment and C.C.T.V. system.

Propulsion and power components delivered by SAM Electronics:

- 8 diesel-electric azimuth thruster drives incl.:
  - 8 synchronous motors 4.3 MW, 465 rpm, six-phase (peak load 5.5 MW, 520 rpm)
  - 8 synchro-converters incl. control and monitoring system, 24/12-pulse
  - 16 cast resin transformers 3 MVA, 10 kV / 790 V
- 8 diesel generators 8 MVA, 10 kV, 60 Hz, 514 rpm
- 2 switchboards 10 kV with 36 panels for high voltage distribution
- 12 cast resin transformers for low voltage supply 2.0 - 3.5 MVA

Pipelaying Motor Vessel

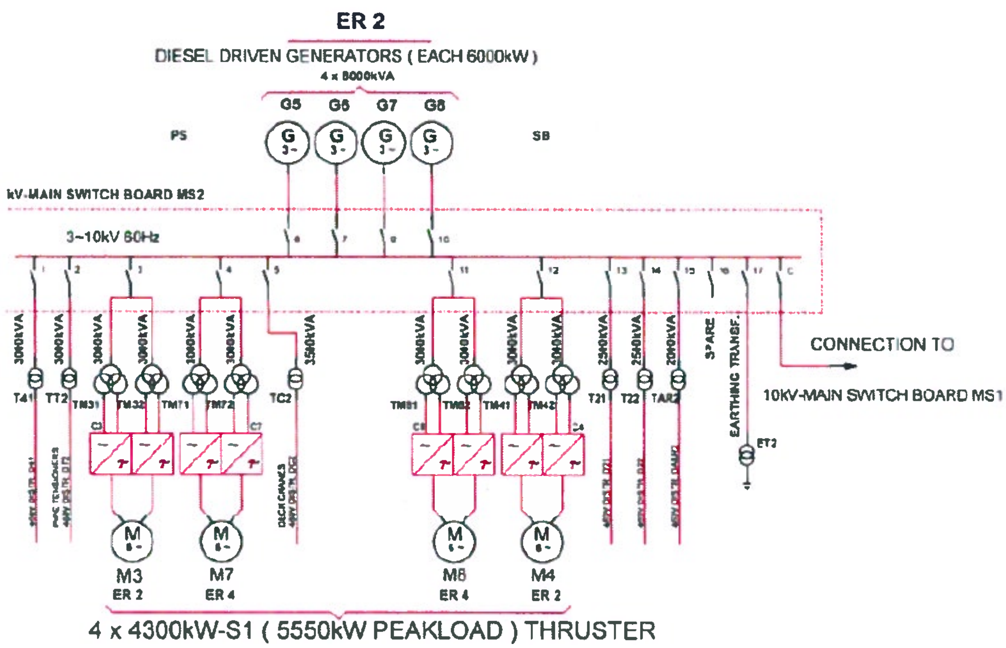
The "Solitaire", the world's largest pipelaying vessel, has been in service since spring 1998. The offshore company ALLSEAS has the ambitious aim of laying the largest pipe diameters at twice the speed of the best competing vessels. With its displacement of 76909 tons, its dynamic positioning system according to NMD Class 3, extended firing line and 108 m stinger, the vessel has been designed to lay pipes with a diameter of up to 60 inches at a rate of up to 6 km per day at water depths exceeding those reached by moored barges.

The "Solitaire" is equipped with 8 azimuth thrusters having fixed-pitch propellers for the dynamic positioning and propelling of the vessel. The vessel´s large hull and dynamic positioning permit work to be performed at unlimited water depths and under adverse weather conditions, since tug boats for mooring are not required. With the integrated propulsion power of 34.400 kW, the vessel achieves a transit speed of 12 knots.

Pipelaying Vessel "SOLITAIRE"

The Layout of the Electrical Power Plant

Power generation and distribution according to the power station principle are performed by 8 diesel generators via linked busbars. The engine rooms are divided into 4 separate watertight compartments (2 forward and 2 aft). Each 10 kV busbar supplies 2 aft and 2 forward thrusters and six 460 V substations. An earthing transformer with secondary resistor in each 10 kV system limits the earth fault current at the 10 kV busbar to 10 A and 20 A with open and closed bus tie breaker, respectively. The earthing system is designed for continuous operation with a single earth fault.



Generator Data

- Rating 8000 kVA, 6000 kW at 514 rpm
- 10 kV, 60 Hz
- Stator with vacuum-impregnated windings (VPI)
- Salient-pole rotor
- Brushless excitation with monitored rotating diodes and protective wiring
- 2 sleeve bearings with hydrostatic pumps for regular slow turning of the diesel engines
- Enclosure IP54

Diesel generators 1-4

Pipelaying Vessel "SOLITAIRE"

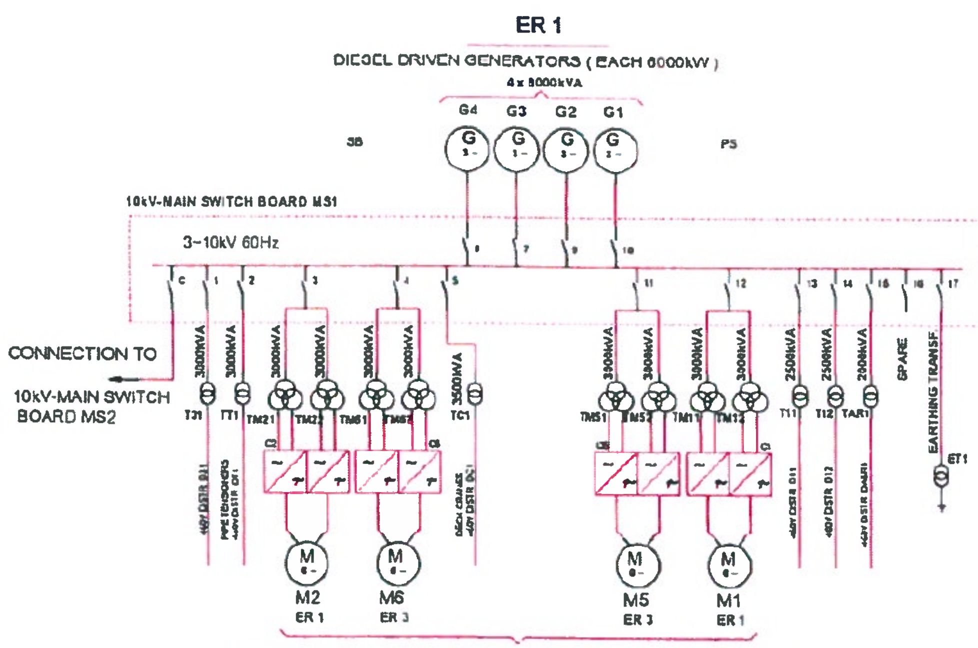
The Thruster Propulsion System

The "Solitaire" is driven and positioned by 8 variable-speed, 360° rotatable azimuth thrusters with fixed-pitch propellers. The synchronous motors with brushless excitation are fed by synchro-converters.

Advantages of Variable-speed Thruster Drives

The variable-speed drives offer many advantages as compared to thruster drives with controllable-pitch propellers:

- Variable-speed drives reduce operating costs since only the power for the thrust actually required is taken from the network. Under no-load conditions, less than 5% of the rated current (including excitation) is required. Asynchronous motors require 20 to 35% of the rated current under no-load conditions.
- The losses of a CP propeller at low load amount to approximately 25% of the propeller design power. The losses of the synchro-converter drive in the low power range amount to approx. 1% of the rated power.
- High efficiency over the entire speed range. Even at rated speed, the efficiency of a CP propeller is lower than that of a fixed-pitch propeller due to the larger diameter of the propeller hub.
- In the partial load range, FP propellers produce less noise and cavitation than CP propellers.
- The current during acceleration of the drive to rated speed is similar to the rated current. Therefore, severe voltage drops in the supply network - as in the case of uncontrolled drives - do not occur.
- Stable operation of the vessel´s network due to immediate power limitation on sudden loss of a generator.

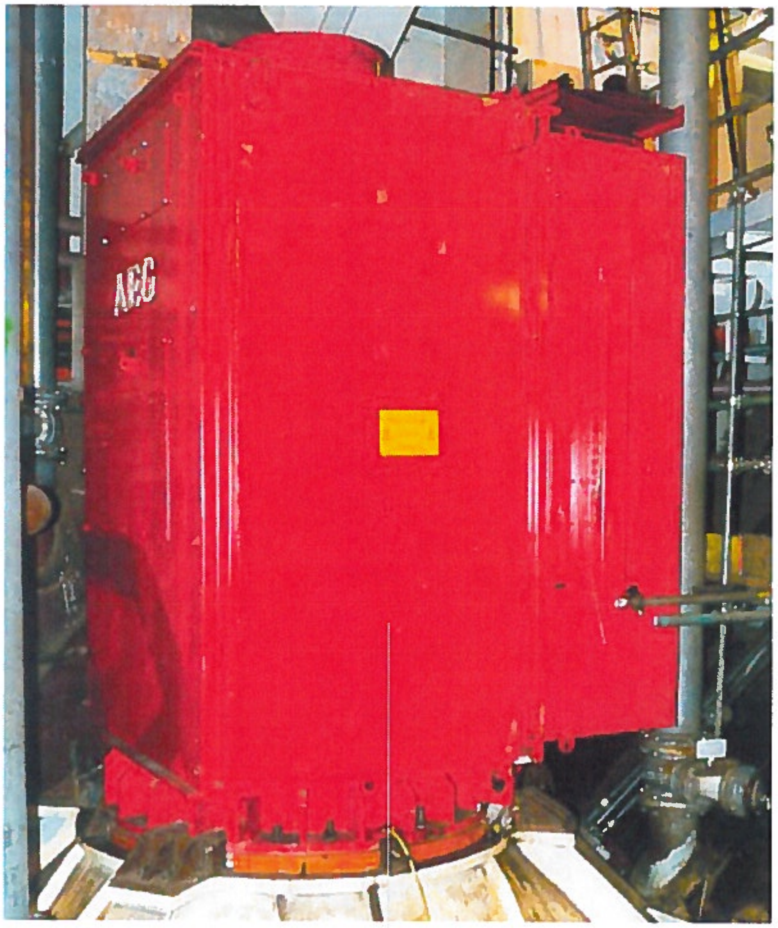


The Eight Propulsion Motors

The synchronous motors are designed for variable-speed drives with brushless excitation. The stator winding comprises two star-connected 3-phase systems of 1300 V each which are electrically shifted by 30° (6-phase motor). The motor shafts are arranged vertically, and the motors are equipped with 3 preloaded ball bearings each for 100000 operating hours. The motors are of the enclosure type IP55, and they are cooled by two external fans in a closed circuit via an air/water heat exchanger installed laterally. In the case of failure of the vessel's cooling water system, continued operation of the motors with approx. 80% of rated power is possible by opening up emergency flaps and cooling with ambient air. The asynchronous exciter with its monitoring devices ensures maintenance-free operation.

Propulsion Motor Data

- Rating 4300 kW at 465 rpm (5550 kW peak at 520 rpm)
- Stator with 2 separate winding systems
- Non-salient pole rotor with damping winding
- Brushless excitation with rotating diodes and thyristor protection device
- IM V1 design with vertical shaft arrangement
- 3 preloaded ball bearings with an operating time of 100000 hours
- Enclosure IP55



Thruster motor

Pipelaying Vessel "SOLITAIRE"

The Eight Synchro-Converters

The synchro-converter system with its proven and simple converter configuration has been in use in various applications aboard various vessels for many years. The converters of the "Solitaire", with a rated power of 5500 kW, are constructed with 24-pulse design for low network distortion. The low total harmonic distortion factor (THD) in the 460 V distributions is achieved without the use of filters.

Characteristics of the 24/12 Pulse Synchro-Converter System

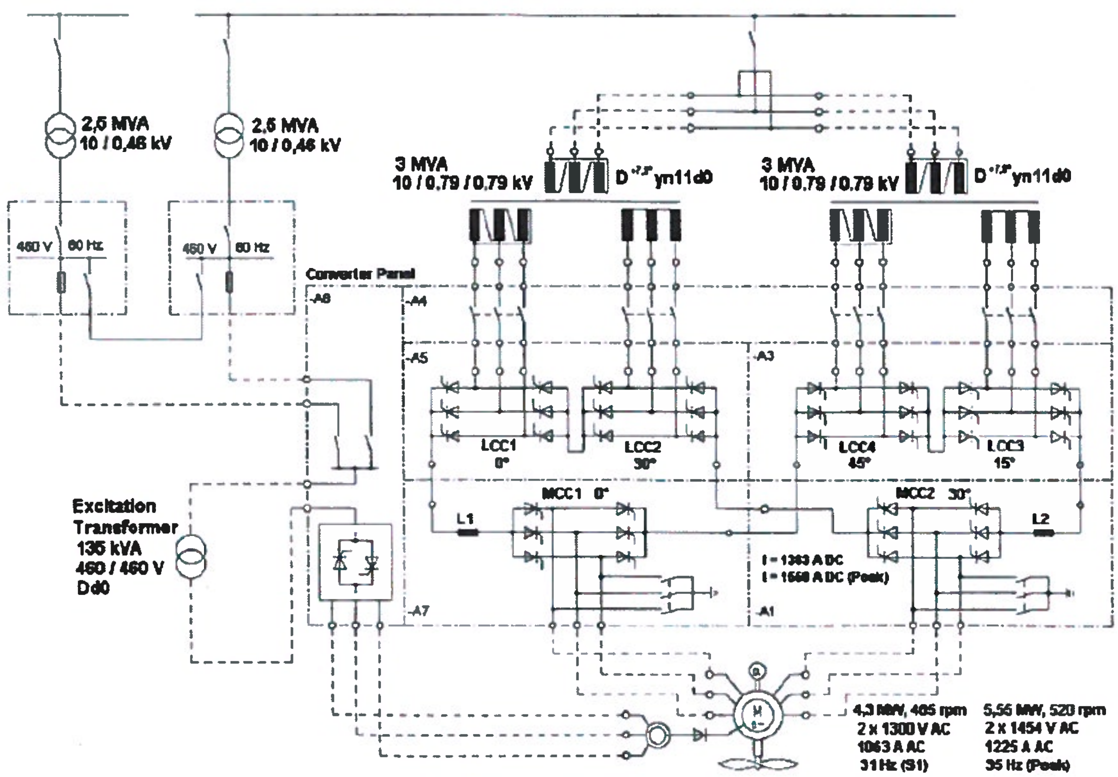
The main components of the converter are the line-commutated converter (LCC), the smoothing choke for the DC link and the motor-commutated converter (MCC).

The LCC is a fully controlled 3-phase thyristor bridge on the network side. The LCC is operated as a controlled rectifier and is used for setting the speed of the motor via the intermediate DC current and voltage.

The MCC is used for converting the DC link voltage into AC of the required voltage and frequency. The MCC consists of a fully controlled thyristor bridge and is commutated by the motor voltage. The drive system can be compared to an externally excited DC drive with its rotor having been repositioned into the stator and with its commutator being formed by the inverter - the MCC.

The pulses are formed automatically by detecting the zero crossings of the motor voltage. For reduction of harmonics and torque pulsations in the air gap, the six-phase synchronous machine is fed in 12-pulse mode by 2 inverters which are operated with a phase shift of 30°. The four line commutated converters are fed by 2 double deck transformers with a phase shift winding of 7.5° on the high voltage side. The connection with clockwise and counterclockwise rotary field produces a phase shift of 15°.

For the 24-pulse operation, special symmetrization of the current in the DC link is unnecessary due to series connection of all thyristor bridges (Punga connection), so that only one common current flows in the converter. Due to the exact 24-pulse system, a THD of 6% at rated data is achieved without any additional filtering.



Data of the Synchro-Converter

All functions of drive control, process regulation, drive regulation, set value processing and monitoring are performed by the multiprocessor system Logidyn D. The control functions of the MCC and LCC run on the processor unit CCU096 and the functions of the superordinated control and monitoring tasks run on the control unit MCU032 in multitasking mode.

The control and monitoring tasks are freely programmable on the CAD system „LogiCAD" on a personal computer. The logical structures are programmed and documented graphically. All currently existing settings and values of the digital controllers can be shown on a personal computer; telediagnostics via satellite is possible with the use of an additional PC and supplementary software.

Synchroconverter

Data of the Synchro-Converter

- 4 controlled rectifiers for 24-pulse network operation
- 2 inverter bridges for 12-pulse motor operation
- 2 integrated DC link chokes
- Series connected (Punga connection) with common circuit
- Closed circuit air cooling with 4 integrated air/water heat exchangers
- Control and regulation system with internal diagnostic system, which detects malfunctions and signals them to the automatic vessel management system (AVM) via a serial link.

Pipelaying Vessel "SOLITAIRE"

The Transformers

Cast-resin transformers with coils of high electrical, thermal and dynamic strength were chosen due to their many advantages:

- Moisture proof: The complete embedding of the windings in epoxy resin prevents moisture from penetrating into the windings and causing thermal breakdowns. This insulation offers maximum protection against an aggressive salty and moist environment.
- Immediate switch-on: Owing to the insulation materials used, the transformers can be immediately switched on without predrying, even after extended periods of idleness.
- Impulse strength: In contrast to conventional dry-type transformers, castresin transformers are resistant to impulse voltage according to IEC76 and VDE 0111.
- Short-circuit strength: The dynamic short-circuit strength is considerably higher than for conventional dry-type transformers.
- Free from partial discharges: No partial discharges of more than 20 pC in the windings, thus an increased life of the transformers.
- Resistant against temperature fluctuations: The glass-fibre reinforced epoxy-resin laminates are resistant even against extreme temperature fluctuations.
- High overload capacity: Owing to the high heating time constants and the high insulation material classes, cast-resin transformers can be overloaded considerably longer than any other transformer.
- Flameproof: The insulation materials used are flameproof against electrical arcs and are self-extinguishing (more than 90% of the coil materials are glass and copper).

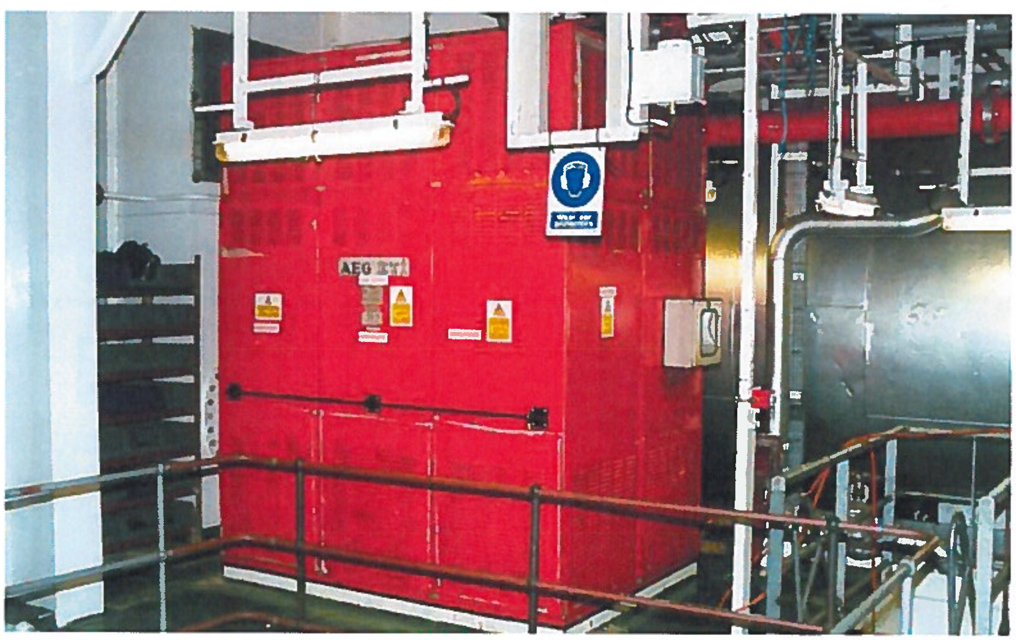
Propulsion Transformer Data

- Power 3000 kVA (peak load 3400 kVA)
- 2 secondary windings, vector group D+7.5° y11d0
- Phase shift 15° el. between the 4 associated secondary systems for 24-pulse operation
- Secondary voltage 790 V
- Cast resin transformers
- Enclosure IP23, natural air cooling

Supply Transformer Data

- Power 2000 - 3500 kVA
- Vector groups Dyn11 and Dd0
- Secondary voltage 460 V
- Cast resin transformers
- Enclosure IP23, natural air cooling

Propulsion transformer



The 10 kV Medium Voltage Switchboard

The center of the 10kV energy and distribution system consists of the two main switchboards MS1 and MS2, which are equipped with vacuum circuit breakers and are normally operated together.

The generator panels and the coupling breaker panels are equipped with the microprocessor controlled Generator Management Module GMM10. The GMM10's monitor, protect, control and synchronize both the generators and the busbar. Each transformer panel is equipped with a Transformer Protection Module TPM10. The GMM10 and TPM10 communicate via an internal bus system. Differential protection for all generators and transformers is included. Any malfunction is indicated by an internal diagnostic system, which is connected by an external data bus to the automation system of the ship. The ship's mains is controlled by the integrated Power Management System:

- 8 generator panels for generators 8 MVA
- 8 panels, each with 2 transformers for thruster drive 6 MVA (6.8 MVA)
- 12 transformer panels for 460 V distributions 2.0-3.5 MVA
- 2 panels for earthing-transformers
- 2 spare panels
- 2 synchronisation panels
- 2 panels for coupling-breakers

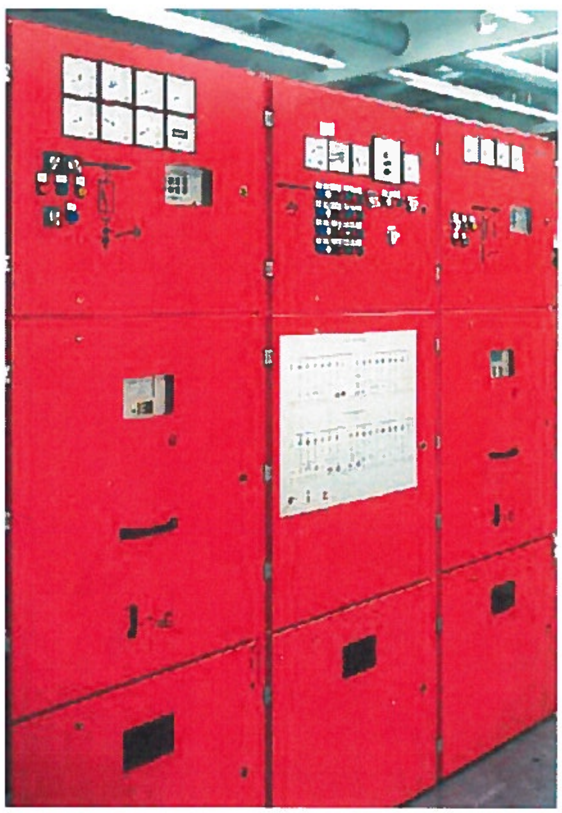
Characteristic Features of the Switchboard Panels of Type WBB

- Air insulated switchboard panels, metal-enclosed, metal-clad with single busbar
- Vacuum circuit breaker mounted on plug-in unit
- Cable connection compartment accessible through separate door
- High operating safety due to completely clad busbar compartment even with the breaker in test position
- Protection, monitoring and control by the microprocessor-controlled protection system GMM10 / TPM10
- Check of circuit breakers and copper busbars via comparative resistance measurement

Definition and Insulation Coordination

The complete high voltage system of the "Solitaire" was simulated on a computer. In this process, the main data for the earthing concept and the insulation coordination were investigated in order to confirm possible voltage peaks which may result from switching or faults of machines or cables.

One result of the simulation was the mounting of surge voltage arresters in critical circuits for protection of machines and transformers.



Switchboard: 10 kV High Voltage

Pipelaying Vessel "SOLITAIRE"

Equipment Delivered by SAM Electronics

- 8 azimuth thruster drives:
  - 8 synchronous motors 4.3 MW 465 rpm (5.5 MW 520 rpm peak load)
  - 8 synchro-converters 24/12-pulse incl. control and monitoring system
  - 16 cast resin transformers
  - 8 excitation transformers
- 8 diesel generators 8 MVA, 10 kV, 60 Hz, 514 rpm

- High voltage switchboard 10 kV
  - 36 panels
  - Protection system
  - Earthing transformers and resistors
  - UPS
- 12 cast resin transformers for low voltage supply
- 4 air chokes for short circuit damping in low voltage switchboards

- 16 inch radar
- Doppler speed log
- Echo sounder
- D-GPS
- Decca
- Loran-C
- Radio direction finder
- Rate-of-return indicator
- Radar beacon
- Weatherfax receiver
- Weather satellite system (NCAA)
- Meteo equipment
- GMDSS radio station
- Radio station for public purposes
- VHF network for internal communication
- Helicopter communication
- Automatic telephone exchange
- Public address and general alarm network
- UHF trunking system
- Talk back system
- Sound powered telephone network
- Audio entertainment (radio broadcast, C.D., cassette)
- Video entertainment (satellite TV receiver, off air broadcast, VHS)
- C.C.T.V. security and observation system

SAM Electronics GmbH
Drives and Special Systems
Behringstrasse 120
22763 Hamburg · Germany

Phone: +49 (0)40 - 88 25 - 27 20
Fax +49 (0)40 - 88 25 - 41 02
DSS@sam-electronics.de
www.sam-electronics.de

Equipment

A HEEREMA GROUP COMPANY

Thialf, the largest Deepwater Construction Vessel operated by Heerema Marine Contractors (HMC), is capable of a tandem lift of 14,200 mT. The dual cranes provide for depth reach lowering capability as well as heavy lift capacity to set topsides. This multi-functional dynamic positioned DCV is tailored for the installation of foundations, moorings, SPARs, TLPs and integrated topsides.

Accommodation / helicopter deck
The living quarters are equipped to accommodate 685 men. All quarters have heating and air conditioning facilities. The helicopter deck is suitable for a Boeing Chinook 234 (21 mT take-off weight).

Life-saving / fire-fighting
Life-saving and fire-fighting equipment according to the latest Class and NMO requirements.

Mooring system
12 Delta Flipper anchors of 22.5 mT each, on 3 1/8 inch wire ropes of 2,400 meters (8,000 ft) long.
Minimum breaking strength 480 mT.

Diving system
Containerized saturation diving system with diving bell can be made available.

Ballast system
Ballast pump capacity 20,800 cubic meters/hour.

Deck load / transit speed
- Deck load capacity 15 mT/square meter
- Total deck load capacity 12,000 mT

Thialf

Main hoist lifting height
95 m (312 ft) above work deck for each crane. Lowering depth of auxiliary hoists 460 m (1,500 ft) below work deck at minimum radius.

Main hoist deepwater mode
Main hoist: 900 mT with hook at 850 meters water depth up to 128 meters above the water line. Special main hoist block: 1,025 mT at 847 meters water depth. Deep water blocks: 414 mT at 2,741 meters water depth (all based on main hoist at minimal radius and 26.6 meters operating draft).

Dynamic positioning system
The Thialf is equipped with a Class III Dynamic Positioning system with the following characteristics:

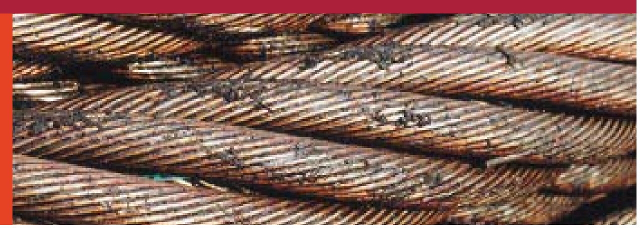
Thrusters
6 x 5,500 kW - 360 degrees azimuth, total thrust 420 mT

Modes of Operation
- Manual
- Joy-stick
- Auto-pilot
- Full DP mode
- Position mooring

Special DP functions
- Heavy lift
- Follow target
- External force compensation

Position reference systems
- 2 x Satellite DGPS with 5 arials
- 1 x Mechanical taut wire (300m)
- 1 x Artemis
- 2 x Acoustic SSBL/LBL
- 1 x Fan-beam laser

Transit speed with 1 tug
Max. 7.0 knot at 12.5m draft



Dimensions

Length overall	206.6 m	661 ft
Length of vessel	165.3 m	542 ft
Breadth	83.4 m	290 ft
Depth to work deck	49.5 m	162 ft
Draft	11.5 - 31.6 m	43 - 104 ft
GRT	136,709 t	-
NRT	41,012 t	-

Portside and starboard crane	Load	Outreach
Main hoist	7,100 mT	up to 31.2 m (102 ft)
Auxiliary hoist	907 mT	36.0 - 79.2 m (120 - 260 ft)
Whip hoist	200 mT	41.0 - 129.5 m (134 - 425 ft)

Support Equipment

HMC operates a large variety of marine equipment:
- Anchor handling tugs / supply vessels
- Cargo barges
- Cargo / launch barges
- Offshore pile driving hammers

Anchor handling tugs / supply vessels

	Length	Breadth	Depth (work deck)	Max. loading capacity	Loading area	Summer draft	Bollard pull
Husky	60.5 m (198 ft)	15.0 m (49 ft)	7.0 m (23 ft)	-	-	6.2 m (20 ft)	160 mT
Retriever	60.5 m (198 ft)	15.0 m (49 ft)	7.0 m (23 ft)	-	-	6.2 m (20 ft)	160 mT

Cargo barges

	Length	Breadth	Depth	Max. loading capacity	Max. launching capacity
H-302	91.4 m (300 ft)	27.4 m (90 ft)	5.5 m (18 ft)	8,579 mT	-
H-404	122.0 m (400 ft)	36.6 m (120 ft)	7.6 m (25 ft)	21,750 mT	-

Cargo / launch barges

	Length	Breadth	Depth	Max. loading capacity	Max. launching capacity
H-122	122.0 m (400 ft)	30.5 m (100 ft)	7.6 m (25 ft)	17,294 mT	5,500 mT
MWB-403	122.0 m (400 ft)	31.9 m(105 ft)	7.6 m (25 ft)	16,322 mT	6,800 mT
H-541	165.0 m (540 ft)	42.0 m (138 ft)	10.7 m (35 ft)	41,718 mT	20,500 mT
H-627	176.8 m (580 ft)	48.8 (160 ft)	11.0 m (36 ft)	52,481 mT	26,000 mT
H-851	260.0 m (853 ft)	63.0 m (207 ft)	15.0 m (49 ft)	130,514 mT	60,000 mT

Heerema Marine Contractors U.S., Inc.
17154 Butte Creek
Houston, Texas 77090
U.S.A.

Tel.: +1 281 880 16 00
Fax: +1 281 893 83 95

Heerema Marine Contractors Nigeria Ltd.
Westminster House, plot 1601
Adeola Hopewell Street, Victoria Island
P.O. Box 51579, Falomo, Lagos
Nigeria

Tel.: +234 [0]1 462 66 81
Fax: +234 [0]1 461 73 14

Heerema Marine Contractors
Mexico S. de R.L. de C.V.
Av. México No. 45, 2° Piso
Col. Condesa, Del. Cuauhtémoc
C.P. 06100, México, D.F.

Tel.: +52 55 528 615 02 / +52 55 528 604 32
Fax: +52 55 528 615 02

www.heerema.com

MARINE
CONTRACTORS

Heerema Marine Contractors Nederland B.V.
Vondellaan 55
2332 AA Leiden
The Netherlands

Mailing address:
Heerema Marine Contractors Nederland B.V.
P.O. Box 9321
2300 PH Leiden
The Netherlands

Tel.: +31 [0]71 579 90 00
Fax: +31 [0]71 579 90 99

E-mail: info@hmc-heerema.com

April 2007

Calamity Jane

Calamity Jane is a versatile vessel optimised for pipeline trenching, the flooding, gauging and testing (FGT) of pipelines, offshore lifts and installation of subsea structures, survey activities and other operations in support of Allseas' pipelaying vessels *Solitaire*, *Audacia* and *Lorelay*.

Her slender ship-shape and efficient propulsion system combine to facilitate a high transit speed and excellent workability, while precise manoeuvring on full dynamic positioning (DP) allows*Calamity Jane* to operate safely in congested areas. She is also fitted with survey equipment, several cranes and lifting appliances, and equipment for FGT and mattress installation.
In addition to supporting the Allseas fleet,*Calamity Jane* can operate as an independent trenching unit. For this purpose, she is equipped with Allseas' mechanical trencher *Digging Donald*.

Calamity Jane

- **Length overall**
  151 m (495 ft)
- **Length between perpendiculars**
  117.2 m (384 ft)
- **Breadth**
  20.2 m (67 ft)
- **Maximum speed**
  11 knots
- **Accommodation**
  72 persons
- **Total installed power**
  15,086 kW
- **Dynamic positioning system**
  NMD Class 2 / LR DP (AA), Alstom Cegelec 902 Duplex system
- **Cranes / lifting equipment**
  General purpose crane:
  26 t (57 kips) at 31 m (103 ft)
  Trencher handling frame:
  200 t (441 kips) up to 197 m water depth (385 ft)
  A-frame:
  35 t (77 kips) at waterline; 20 t (44 kips) at 1,570 m (5,151 ft); 5 t (11 kips) at 3,100 m (10,170 ft)
  Knuckle boom crane:
  10 t (22 kips) at 3.5 m (12 ft)

Sedco Express		
The SEDCO EXPRESS is a Sedco Forex Xpress 2000 design dynamic positioned semi-submersible drilling unit capable of operating in moderate environments and water depths up to 7,500 ft using 18¾in 10,000 psi BOP and 21in OD marine riser.		
Rig Type	5th Generation Deepwater	
Design	SFXpress 2000, 4 columns, self-propelled	
Builder	DCN Brest, France	
Year Built	2000	
Classification	+A1, E , Column Stabilized Drilling Unit, +AMS, +DPS3, +ACCU	
Flag	Liberia	
Accommodation	184 berths	
Helideck	Rated for S61-N, Super Puma and E-225C helicopter	
Moonpool	26 ft x 134 ft	
Station Keeping	Dynamically Positioned	
Max Drill Depth	35,000 ft / 10,668 m	
Max Water Depth	7,500 ft / 2,286 m	
Operating Conditions	Wind 70 knots; wave period 10 sec; current 3.1 knots (station keeping)	
Storm Conditions	Wind 100 knots; wave period 12 sec; current 5.8 knots (station keeping)	

Technical Dimensions

Length	349 ft	106 m
Breadth	226 ft	69 m
Depth	111 ft	34 m
Operating Draft	65 ft	20 m
Ocean Transit Draft	30 ft	9 m
VDL - Operating	6,612 st	6,000 mt

Capacities

Liquid Mud	10,818 bbls	60,738 cu ft	1,719 cu m
Drill Water	9,812 bbls	55,089 cu ft	1,559 cu m

Potable Water	3,730 bbls	20,942 cu ft	593 cu m
Fuel Oil	9,812 bbls	55,089 cu ft	1,559 cu m
Bulk Mud		11,477 cu ft	325 cu m
Bulk Cement		11,477 cu ft	325 cu m
Sack Material	10,000 sacks		

Drilling Equipment

Derrick	Joseph Paris Tri-Act Derrick; 190 ft; 2057 kips GNC
Drawworks	Hitec / Dreco 6800 hp Active Heave Compensating, 680 mt with 14 lines
Motion Compensator	(NA: drawworks is Active Heave Compensating)
Top Drive	Canrig 1275E, 51400 ft.lbs continuous, 680 mt
Rotary	BJ Varco RST 60½in, hydraulically operated
Pipe Handling	2 x Varco PRS-5R; 2 x auxiliary porch hoists; 2 x MOS Catwalk Machines; 2 x Pipe Deck Handlers; 1 x MOS Riser Gantry Crane
Mud Pumps	3 x National 14-P-220, 7500 psi, 2200 hp
Shale Shakers	6 x Derrick Flo Line 2000/2L48-90F-3TA Linear Motion; 3 x Brandt Single Tandem Scalping Shakers
Desander	1 x Fluid Systems Mod DSR4H, 2000 gpm
Desilter	1 x Derrick FloLine 2000, 20x4
Mud Cleaner	N/A
BOP	Cameron Type TL 18¾in 10K (1 x double + 1 x extended double); Cameron HC with Vetco H4 profile connector
LMRP	1 x Cameron Type DL Dual, 18¾in 5K; Cameron Collet connector 18¾in 10K
Diverter	Hydrill FS 21-500, 59½in, 500 psi, 12in overboard line
Control System	Cameron Multiplex Control System
Riser	Vetco MR6E 21in x 65ft jts, 4in ID Choke & Kill
Riser Tensioners	10 (4 dual + 2 single) x Retsco 200 kips
Guideline Tensioners	N/A
Podline Tensioners	N/A
Choke & Kill	3-1/16in 10,000 psi manifold with 2 x Swaco Hydraulic chokes, 2 x WOM manual chokes
Cementing	Dowell 15K cementing unit (third party services)

Machinery

Main Power	6 x Caterpillar 3616 driving 6 x Kato C183-2382 AC generators; 4.4 MW continuous output
Emergency Power	1 x Caterpillar 3512, 1200 hp driving 910 kW AC generator
Power Distribution	SCR, 11kV AC Alstom
Deck Cranes	2 x KENZ, Pedestal Crane; DHC 65/3500 OS. 65 mt @ 60 ft
Thrusters	4 x 7 MW Kamewa Mermaid, azimuthal thrusters, fixed pitch
Propulsion	See Thrusters

Mooring Equipment

Winches	2 x BLM Offshore Windlasses, brake capacity 265 mt
Wire/Chain	2 x 3,280 ft x 2½in wire rope
Anchors	2 x 15 mt LWT

TIDEWATER- 280’ Anchor Handling Towing supply Vessel - <u>RICHARD M CURRENCE</u>

(Will be used to set the trees)

Tidewater

RICHARD M CURRENCE

Characteristics

Length, Overall..............	280.3 ft	85.4 m
Beam.........................	69.0 ft	21.0 m
Depth........................	26.0 ft	7.9 m
Maximum Draft................	22.3 ft	6.8 m
Light Draft..................	15.6 ft	4.7 m
Freeboard....................	4.0 ft	1.2 m
Deadweight...................	2,877.0 lt	2,923.0 t
Clear Deck Space.............	128 x 57 ft	39.0 x 17.4 m
Deck Strength................	2,049.0 lb/ft^2	10.0 t/m^2
Minimum Height...............	100.3 ft	30.6 m

Capacities

Deck Cargo...................	1,791 lt	1,819.7 t
Cargo Water..................	326,200 gal	1,234.7 t
Fuel oil.....................	403,550 gal	1,301.2 t
Potable Water................	115,680 gal	437.9 t
Lube oil.....................	6,700 gal	23.4 t
Bulk Tanks (3) Total.........	8,370 ft^3	237.0 m^3
Drilling Fluid (22 lbs/gal)...	8,338 bbl	1,325.9 m^3
Walk-In Cooler...............	823 ft^3	23.3 m^3
Walk-in Freezer..............	752 ft^3	21.3 m^3

Machinery

Main Engines...............(4)	EMD 16-265 H7		
Horsepower..................	26400		
Gears......................(2)	Reintjes DLG 4447U		
Propellers.................(2)	FIXED PITCH		
Kort Nozzles...............(2)			
Rudders....................(2)	Ulstein		
Secondary Generators.......(1)	350 kW	480 V	60 hZ
Driven by...................	CAT 3408 DITA		
Emergency Generators.......(1)	99 kW	480 V	60 hZ
Driven by...................	CAT 3404 DIT		
Bow Thruster...............(2)	Brunvoll, 1 tunnel, 1DD		
Driven by...................	GE 752 Motor		
Thrust (Max)................	14 st		12.8 t
Stern Thruster.............(1)	TUNNEL (Brunvoll)		
Driven by...................	GE 752 Motor		
Thrust (Max)................	13 st		11.8 t

Performance

(Assuming Fair Weather)

Speed VS Fuel Consumption

Maximum.....................	about 16 knots	about 795 gph
Cruising....................	about 13 knots	about 344 gph
Economical..................	about 10 knots	about 285 gph
Standby (Generator Only)....	0 knots	about 10 gph
Range @ 13.0 knots...........	about 15,250 nm	
Bollard Pull.................	238 st	216.0 t

Transfer Rates

Cargo Water....	660 gpm @ 295 ft	150.0 t/h @ 90.0 m
Fuel Oil.......	660 gpm @ 295 ft	127.7 t/h @ 90.0 m
Bulk...........	28 cfm @ 295 ft	75.0 t/h @ 90.0 m
Drilling Fluid.	660 gpm @ 200 ft	287.0 t/h @ 61.0 m

Registration

Flag: VANUATU Home Port: PORT VILA
Official Number... 1538 Call Sign.. YJUC8
Builder.... YANTAI RAFFLES Hull Number.. 119
Year Built.. 2005 Tonnage.. 4,544 GITCT 1,363 NITCT
ABS ABS,+A1,+AMS,AH,OSV,+DP2,+ACCU,AH,TS,SOLAFFV 1 Rea

Tow and Anchor Handling

Winch........................	Electric, Dbl-Drum w/secondard winch (3rd Drum)
Model.......................	SL 600 WX 1BSL600WX Rolls Royce
Line Pull...................	1,323,000 lbs
Capacity....................	19,000 ft of 3.25 in
Pennant Reels..............(2)	11,000 ft of 3.25
Tugger.....................(2)	Rolls Royce
Line Pull...................	33,000 lbs
Capstan....................(2)	Rolls Royce
Line Pull...................	33,000 lbs
Stern Roller.................	Rolls Royce, 3 Part, 13' Diameter
SWL..........................	750
Tow Pins.....................	3 Karmfork 240 MT
Shark Jaw....................	3 Karmfork 750 MT
Chain Lockers (number).......	4
Capacity....................	13,500 ft of 3.25 in

Vessel Mooring

Windlass.....................	Rolls Royce LBFG 22
Anchors....................(2)	8300 lbs ea.
Chain (Per Side).............	1,350 ft of 2.00 in

Accommodations

Staterooms...................	(14) - 1 Man (18) - 2 Men
Other........................	Office (1); Change Room (1); Day Room (2)
Total Certified to Carry......	50
Hospital.....................	Yes
Galley Seating...............	30
Air Conditioning/Heating......	Yes
Special Features.............	Elevator

Electronics

Radar(s).....................	3
Radio(s).....................	VHF - 3 SSB - 2
SATCOM.......................	yes
Depth Sounder................	2
Magnetic Compass.............	1
Gyro Compass.................	3
DGPS.........................	2
FAX Weather Receiver.........	1
GMDSS........................	1
Auto Pilot...................	1

Special Equipment

Joystick Controls............	Yes
Dynamic Positioning..........	DP2
Crane........................	Yes
Crane Rating................	11,000 lbs @ 52 ft

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Tidewater
RICHARD M CURRENCE

Crane Rating................	11,000 lbs @ 52 ft
Stabilization System..........	Passive
Aux Rescue Boat...............	Solas Compliant
Welding Machine...............	2
A-Frame 300T SWL	
Incinerator (1)	
Rov Deck (1)	
Pop up Crane (1)	
Tank Cleaning	

TIDEWATER- 280' Anchor Handling Towing supply Vessel – JOHN P LABORDE

(Supply vessel)

Tidewater

JOHN P LABORDE

Characteristics

Length, Overall...............	280.3 ft	85.4 m
Beam.........................	68.9 ft	21.0 m
Depth........................	26.2 ft	8.0 m
Maximum Draft................	22.3 ft	6.8 m
Light Draft..................	15.4 ft	4.7 m
Freeboard....................	4.0 ft	1.2 m
Deadweight...................	3,056.0 lt	3,104.9 t
Clear Deck Space.............	128 x 57 ft	39.0 x 17.4 m
Deck Strength................	2,049.0 lb/ft²	10.0 t/m²
Minimum Height...............	100.3 ft	30.6 m

Capacities

Deck Cargo..................	1,791 lt	1,819.7 t
Cargo Water.................	326,200 gal	1,234.7 t
Fuel Oil....................	403,550 gal	1,301.2 t
Potable Water...............	115,680 gal	437.9 t
Lube Oil....................	6,700 gal	23.4 t
Bulk Tanks (3) Total........	8,370 ft³	237.0 m³
Drilling Fluid (22 lbs/gal)...	8,338 bbl	1,325.9 m³
Walk-In Cooler..............	823 ft³	23.3 m³
Walk-in Freezer.............	752 ft³	21.3 m³

Machinery

Main Engines...............(4)	4 X EMD 16-265 H7	
Horsepower..................	26400	
Gears......................(2)	Reintjes DLG 4447U	
Propellers.................(2)	FIXED PITCH	
Kort Nozzles...............(2)		
Rudders....................(2)	Ulstein	
Driven by..................	EMD 16-265H7	
Secondary Generators.......(1)	350 kW 480 V 60 hZ	
Driven by..................	CAT 3408 DITA	
Emergency Generators.......(1)	99 kW 480 V 60 hZ	
Driven by..................	CAT 3404 DIT	
Bow Thruster...............(2)	Brunvoll, Tunnel, 1DD	
Driven by..................	GE 752 Motor	
Thrust (Max)................	14 st	12.8 t
Stern Thruster.............(1)	TUNNEL (Brunvoll)	
Driven by..................	GE 752 Motor	
Thrust (Max)................	13 st	11.8 t

Performance

(Assuming Fair Weather)

Speed VS Fuel Consumption

Maximum....................	about 16 knots	about 795 gph
Cruising...................	about 13 knots	about 344 gph
Economical.................	about 10 knots	about 285 gph
Standby (Generator Only)....	0 knots	about 10 gph
Range @ 13.0 knots...........	about 15,250 nm	
Bollard Pull.................	238 st	216.0 t

Transfer Rates

Cargo Water....	660 gpm @ 295 ft	150.0 t/h @ 90.0 m
Fuel Oil.......	660 gpm @ 295 ft	127.7 t/h @ 90.0 m
Bulk...........	28 cfm @ 295 ft	75.0 t/h @ 90.0 m
Drilling Fluid.	660 gpm @ 200 ft	287.0 t/h @ 61.0 m

Registration

Flag: VANUATU   Home Port: PORT VILA

Official Number... 1392   Call Sign.. YJSJ6

Builder.... YANTAI RAFFLES   Hull Number.. 118

Year Built.. 2004 Tonnage.. 4,544 GITCT 1,363 NITCT

ABS ABS,+A1,+AMS,AH,OSV,+DP2,+ACCU,AH,TS,SOLAFFV 1 Rea

Tow and Anchor Handling

Winch........................	Brattvag Electric, Dbl. Drum w/secondary winch (3r
Model......................	SL 600 WX 1BSL600WX, Rolls Royce
Line Pull..................	1,323,000 lbs
Capacity...................	19,000 ft of 3.25 in
Pennant Reels..............(2)	11,000 ft of 3.25
Tugger.....................(2)	Rolls Royce
Line Pull..................	33,000 lbs
Capstan....................(2)	Rolls Royce
Line Pull..................	33,000 lbs
Stern Roller.................	Rolls Royce, 3 part, 13' Diameter
SWL..........................	750
Tow Pins.....................	3 Karmfork 240MT
Shark Jaw....................	3 Karmfork 750MT
Chain Lockers (number)........	2
Capacity...................	6,750 ft of 3.25 in

Vessel Mooring

Windlass.....................	Rolls Royce LBFG22
Anchors....................(2)	8300 lbs ea.
Chain (Per Side).............	1,350 ft of 2.00 in

Accommodations

Staterooms...................	(14) - 1 Man (18) - 2 Men
Other........................	Office (1); Change Room (1); Day Room (2)
Total Certified to Carry......	50
Hospital.....................	Yes
Galley Seating...............	30
Air Conditioning/Heating......	Yes

Electronics

Radar(s).....................	3
Radio(s).....................	VHF - 3 SSB - 2
SATCOM.......................	yes
Depth Sounder................	2
Magnetic Compass.............	1
Gyro Compass.................	3
DGPS.........................	2
FAX Weather Receiver..........	1
GMDSS........................	1
Auto Pilot...................	1

Special Equipment

Joystick Controls.............	Yes
Dynamic Positioning...........	DP2
Crane........................	Yes
Crane Rating................	11,000 lbs @ 52 ft
Crane Rating................	11,000 lbs @ 52 ft

11/8/2010 10:30:40AM *Page 1 of 2*

Tidewater

JOHN P LABORDE

Stabilization System..........	Passive
Rescue Boat..................	Solas Complaint
Welding Machine...............	2
Elevator (1)	
Incinerator (1)	
Rov Deck (1)	
Pop up Crane (1)	
Tank Cleaning	

BEEMAR – "Busy Bee Class – 210' " Platform Supply Vessel - <u>WORKER BEE</u>

(Supply vessel)

BUSY BEE CLASS Platform Supply Vessel

DP2 • 2,700 DWT • 6,300 BBLS Liquid Mud • 4,000 BHP

M/V Busy Bee • M/V Worker Bee • M/V Honey Bee • M/V Bayou Bee • M/V Bee Sting

MAIN PARTICULARS

LENGTH OVERALL	210.00 ft	64.01 m
LENGTH BP	197.33 ft	60.15 m
BEAM	56.00 ft	17.07 m
DEPTH	18.00 ft	5.49 m
LIGHT DRAFT	5.50 ft	1.68 m
LOADED DRAFT	14.92 ft	4.55 m
SUMMER FREEBOARD	3.08 ft	0.94 m
LIGHTSHIP	1,150 Lt	1,168 Mt

CAPACITIES

FUEL OIL	115,000 USG	435.3 m³
LIQUID MUD (6 tanks)	6,300 BBLS	1,001.6 m³
DRY BULK (6 tanks)	6,000 ft³	169.9 m³
DRILL WATER	245,000 USG	927.4 m³
FRESH WATER	26,000 USG	98.4 m³
LUBE OIL	450 USG	1.7 m³
GEAR OIL	450 USG	1.7 m³
HYDRAULIC OIL	450 USG	1.7 m³
SEWAGE	1,600 USG	6.1 m³
DIRTY OIL	800 USG	3.0 m³
OILY BILGE	800 USG	3.0 m³
DEADWEIGHT at 14' 11" draft	2,700 Lt	2,743 Mt

CARGO DECK

MAX. DECK CARGO CAPACITY	1,700 Lt	1,727.3 Mt
STRENGTH	540 lb/ft²	2.6 Mt/m²
LENGTH (deck boards)	150 ft	45.7 m
WIDTH (max between rails)	47 ft	14.3 m
CLEAR AREA	7,050 ft²	655.0 m²

MACHINERY

MAIN ENGINES	2 x Cummins QSK60
BRAKE HORSEPOWER	2000 BHP ea. @1800 rpm
REDUCTION GEARS	2 x Twin Disc MG 5600
GEAR RATIO	5.76:1
PROPELLERS	NIBRAL
DIAMETER & MAX PITCH	81" x 68"
RUDDERS	Becker High-Lift Rudders
SERVICE GENERATOR	3 x 300 kW @ 1800 RPM, 480VAC, 3o, 60 Hz
GENERATOR DRIVES	3 x Cummins QSM11
EMERGENCY GENERATOR	Cummins - 85 KW
BOW THRUSTER	2 x 750 BHP Schottel - Controllable Pitch
BOW THRUSTER DRIVE ENGINE	2 x Cummins QSK19
STERN THRUSTER	1 x 350 BHP Schottel
STERN THRUSTER DRIVE ENGINE	1 x Variable Speed Electric Drive
BULK MUD - AIR COMP	2 x LeRoi Electric Driven 150 BHP
LIQUID MUD PUMPS	Discharge 2 x 200 HP Circulation 2 x 50 HP

PERFORMANCE

MAXIMUM SPEED	11.5 knots
CRUISING SPEED	10 knots
ECONOMICAL SPEED	8 knots
MAXIMUM FUEL CONSUMPTION	14.9 MT/3,936 USG per day
CRUISING FUEL CONSUMPTION	9.6 MT/2,536 USG per day
ECONOMY FUEL CONSUMPTION	3 MT/792 USG per day

DISCHARGE RATES	GPM @ ft	m³/hr @ m
FUEL OIL	425 @ 185	97 @ 56
WATER	525 @ 185	119 @ 56
LIQUID MUD	500 @ 185	114 @ 56
DRY BULK	2 x 735 ft³/hr 80psi	20 6-bar

ACCOMMODATIONS

CABINS	8
BERTHS	22
OFFSHORE WORKERS	16

ELECTRONICS & CONTROLS

DYNAMIC POSITIONING (ABS DPS 2)	Beier Radio IVCS 2002
DEPTH RECORDER	Furuno FE-700
VESSEL CONTROL	Sentinel
DGPS	Leica MX 525 C-Nav 1000 Cyscan
GYRO	Yokogawa CM29008
MAIN ENGINE CONTROLS	Sentinel
RADAR	Furuno FAR 2117
RADIO SYSTEM	Furuno RC 1825A-3
STEERING	Sentinel
PUBLIC ADDRESS SYSTEM	Bogden GS 250
VHF	ICOM M504
LOUDHAILER	Furuno LH 3000
SPEED LOG	Furuno DS-80

SPECIAL EQUIPMENT

ANCHOR WINDLASS	Electro Hydraulic
FiFi MONITOR	(1) Stang @ 1900GPM
FiFi PUMP	Crane Deming
FUEL OIL METER W/ PRINTER	Smith Meter
LIFE RAFTS	Four 25 man inflatable liferafts
RESCUE BOAT	SOLAS

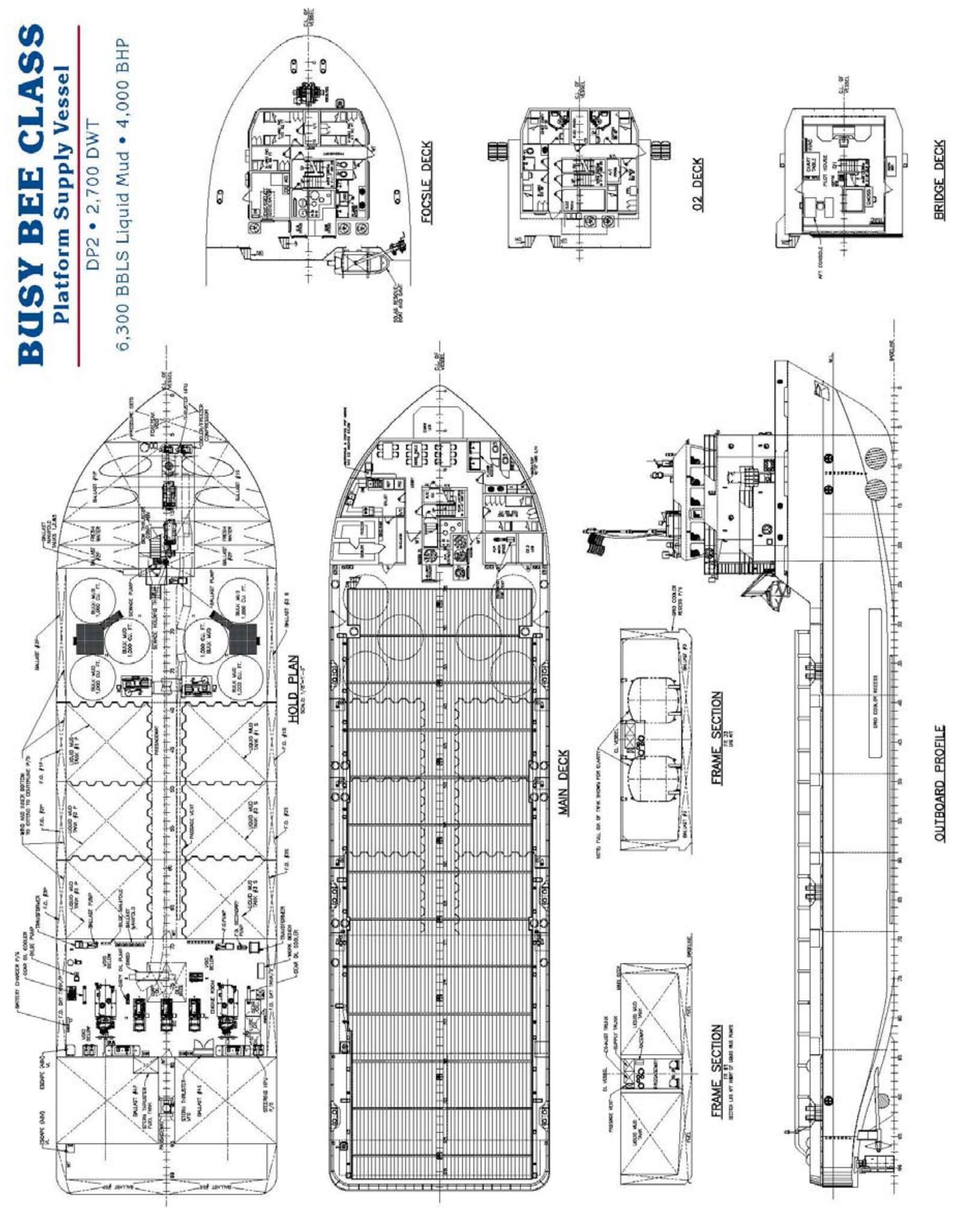
DOCUMENTATION

CLASS	ABS +A1, +AMS, Ocean Service, +DPS 2, Circle E
FLAG	US
SOLAS	SOLAS
USCG	SubChapter L O S V
INTERNATIONAL/US REGISTERED TONNAGE	1,596 GT

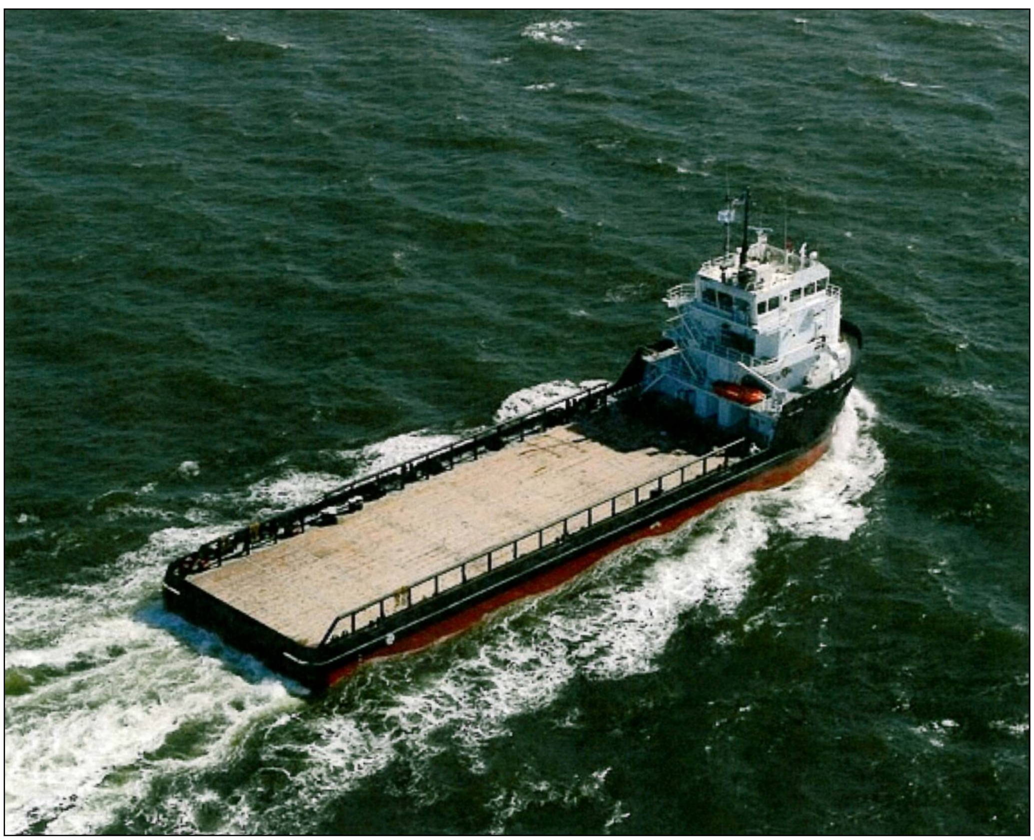
CORPORATE OFFICE AND SALES
2500 Wilcrest, Suite 300 • Houston, Texas 77042
Phone: 713-954-4810 • Fax: 713-954-4811

FLEET OPERATIONS OFFICE
200 Woodland Drive • Post Office Box 160 • Broussard, Louisiana 70518
Phone: 337-837-9770 • Fax: 337-837-9771
www.beemarllc.com

BEEMAR


BUSY BEE CLASS
Platform Supply Vessel
DP2 • 2,700 DWT
6,300 BBLS Liquid Mud • 4,000 BHP
FOCSLE DECK
02 DECK
BRIDGE DECK
HOLD PLAN
MAIN DECK
FRAME SECTION
FRAME SECTION
OUTBOARD PROFILE


WORKER BEE



1.1 BEEMAR – "Bumble Bee Class – 234' " Platform Supply Vessel – BEE HIVE (Supply vessel)

BUMBLE BEE CLASS Platform Supply Vessel

DP2 • 3,000 DWT • 9,000 BBLS Liquid Mud • 4,000 BHP

M/V Bumble Bee • M/V Queen Bee • M/V Bee Hive

MAIN PARTICULARS

LENGTH OVERALL	234.00 ft	71.32 m
LENGTH BP	221.33 ft	67.46 m
BEAM	56.00 ft	17.07 m
DEPTH	18.00 ft	5.49 m
LIGHT DRAFT	5.50 ft	1.68 m
LOADED DRAFT	14.88 ft	4.53 m
SUMMER FREEBOARD	3.13 ft	0.95 m
LIGHTSHIP	1,250 Lt	1,270 Mt

CAPACITIES

FUEL OIL	158,000 USG	598.1 m3
LIQUID MUD (8 tanks)	9,000 BBLS	1,430.9 m^3
DRY BULK (6 tanks)	6,000 ft^3	169.9 m^3
DRILL WATER	245,000 USG	927.4 m^3
FRESH WATER	26,000 USG	98.4 m^3
LUBE OIL	450 USG	1.7 m^3
GEAR OIL	450 USG	1.7 m^3
HYDRAULIC OIL	450 USG	1.7 m^3
SEWAGE	1,600 USG	6.1 m^3
DIRTY OIL	800 USG	3.0 m^3
OILY BILGE	800 USG	3.0 m^3
DEADWEIGHT at 14' 11" draft	3,000 Lt	3,048.2 Mt

CARGO DECK

MAX. DECK CARGO CAPACITY	2,000 Lt	2,032.1 Mt
STRENGTH	540 lb/ft^2	2.6 Mt/m^2
LENGTH (deck boards)	175 ft	53.3 m
WIDTH (max between rails)	47 ft	14.3 m
CLEAR AREA	8,225 ft^2	762 m^2

MACHINERY

MAIN ENGINES	2 x Cummins QSK60
BRAKE HORSEPOWER	2000 BHP ea. @1800 rpm
REDUCTION GEARS	2 x Twin Disc MG 5600
GEAR RATIO	5.76:1
PROPELLERS	NIBRAL
DIAMETER & MAX PITCH	81" x 68"
RUDDERS	2 x Becker High-Lift Rudders
SERVICE GENERATOR	3 x 300 kW @ 1800 RPM, 480 VAC, 3o, 60 Hz
GENERATOR DRIVES	3 x Cummins QSM11
EMERGENCY GENERATOR	Cummins - 85 KW
BOW THRUSTER	2 x 750 BHP Schottel - Controllable Pitch
BOW THRUSTER DRIVE ENGINE	2 x Cummins QSK19
STERN THRUSTER	1 x 350 BHP Schottel
STERN THRUSTER DRIVE ENGINE	1 x 350 Variable Speed Electric Motor
BULK MUD - AIR COMP.	2 x LeRoi Electric Driven 150 BHP
LIQUID MUD PUMPS	Discharge 2 x 200 HP Electric Drive Circulation 4 x 50 HP Electric Drive

PERFORMANCE

MAXIMUM SPEED	11.5 knots
CRUISING SPEED	10 knots
ECONOMICAL SPEED	8 knots
MAXIMUM FUEL CONSUMPTION	14.9 MT/3,936 USG per day
CRUISING FUEL CONSUMPTION	9.6 MT/2,536 USG per day
ECONOMY FUEL CONSUMPTION	3 MT/792 USG per day

DISCHARGE RATES

DISCHARGE RATES	GPM @ ft	m^3/hr @ m
FUEL OIL	425 @ 185	97 @ 56
WATER	525 @ 185	119 @ 56
LIQUID MUD	500 @ 185	114 @ 56
DRY BULK	2 x 735 f^3/hr 80psi	20 6-bar

ACCOMMODATIONS

CABINS	8
BERTHS	22
OFFSHORE WORKERS	16

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LOUDHAILER	Furuno LH 3000
SPEED LOG	Furuno DS-80

SPECIAL EQUIPMENT

ANCHOR WINDLASS	Electro Hydraulic
FiFi MONITOR	(1) Stang @ 1900GPM
FiFi PUMP	Crane Deming
FUEL OIL METER W/ PRINTER	Smith Meter
LIFE RAFTS	Four 25 Man Inflatable Liferafts
RESCUE BOAT	SOLAS with 40 HP Outboard Motor

DOCUMENTATION

CLASS	ABS +A1, +AMS, Ocean Service, +DPS 2, Circle E
FLAG	US
SOLAS	SOLAS
USCG	SubChapter L O S V
INTERNATIONAL/US REGISTERED TONNAGE	> 1,600 GT

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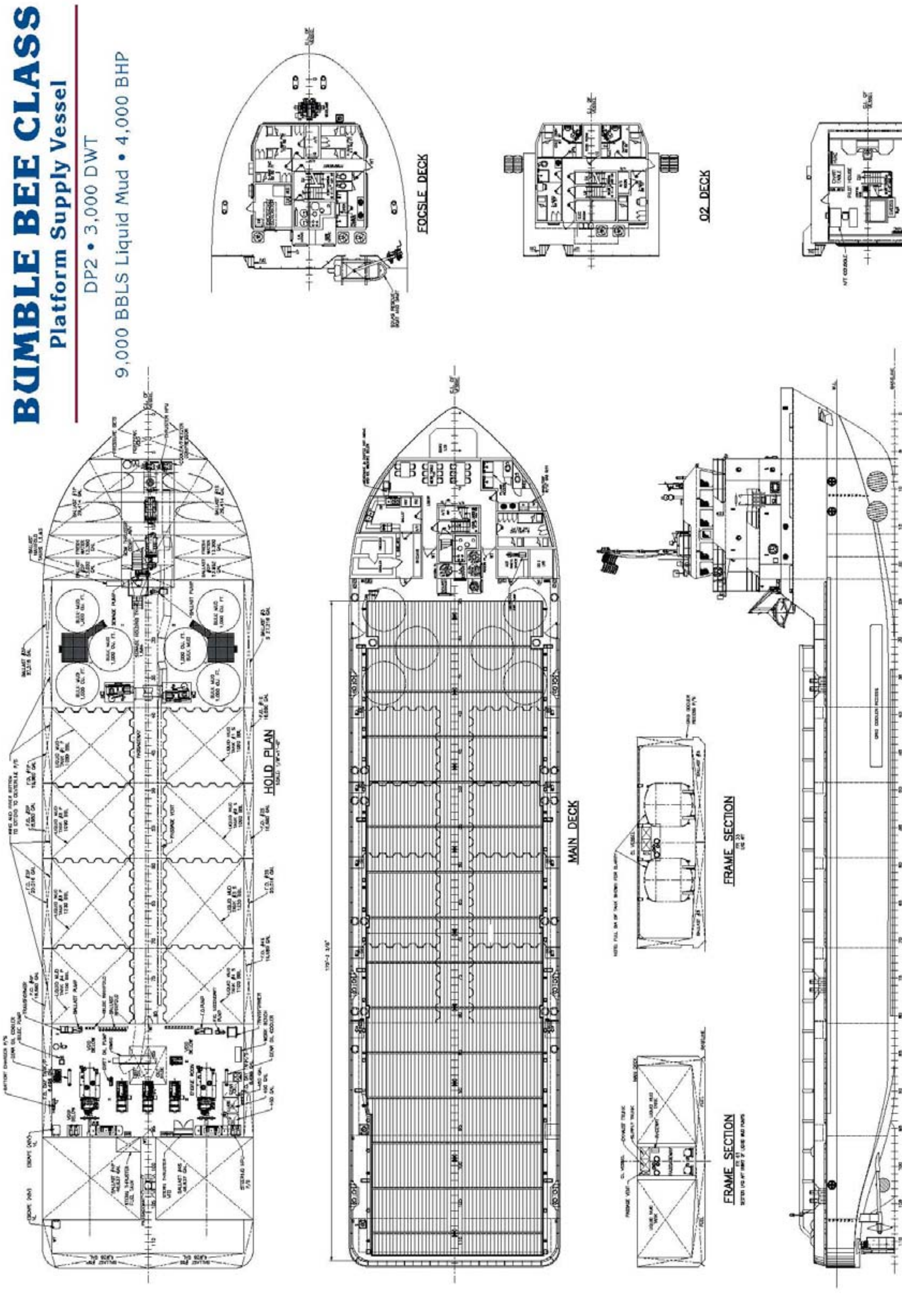
BUMBLE BEE CLASS
Platform Supply Vessel
DP2 • 3,000 DWT
9,000 BBLS Liquid Mud • 4,000 BHP
FOCSLE DECK
02 DECK
BRIDGE DECK
HOLD PLAN
MAIN DECK
FRAME SECTION
FRAME SECTION
OUTBOARD PROFILE


BUMBLE BEE


BUMBLE BEE

M/V Highland Rover

Ship Type: Multi purpose offshore vessel
Year Built: 1998
Length x Breadth: 72 m X 16 m
Gross Tonnage: 2186 t
Dead Weight: 3200 t
Speed recorded (Max/Average): 10.4/9.1 knots
Flag: Malta
Call Sign: 9HA2877
IMO: 9161338, MMSI: 256530000

Appendix B

Biological Data – List of Israeli Birds

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
STRUTHIONIFORMES														
Struthionidae														
Ostrich	*Struthio camelus*	x	x	x	x	x	x	x	x	x	x	x	x	Extinct since 1920s
GAVIIFORMES														
Gaviidae														
Red-throated Loon	*Gavia stellata*	E			E								E	4 records, last on 2001
Black-throated Loon	*Gavia arctica*	v	v	v								v	v	Occasional WV
PODICIPEDIFORMES														
Podicipedidae														
Horned Grebe	*Podiceps auritus*			E	E	E	E	E						3 records (1909, 1981, 1993)
Black-necked Grebe	*Podiceps nigricollis*	F	F	U	U	U	r	r	U	U	U	F	F	PM, WV, non-breeding SV, formerly bred
Little Grebe	*Tachybaptus ruficollis*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV, SV
Great Crested Grebe	*Podiceps cristatus*	F	U	U	U	fr	fr	fr	fr	U	U	F	F	PM, WV, non-breeding SV, formerly bred
Red-necked Grebe	*Podiceps grisegena*										E		E	4 records, last on 1996
PROCELLARIIFORMES														
Diomedeidae														
Shy Albatross	*Thalassarche cauta*		E											1 record (1981)
Procellariidae														
Atlantic Petrel	*Pterodroma incerta*				E	E								2 records (1982, 1989)
Fea's Petrel	*Pterodroma feae*		E											1 record (1963)
Soft-plumaged Petrel	*Pterodroma mollis*			E										1 record (1997)
Cory's Shearwater	*Calonectris diomedea*	r	r	r	U	U	r	r	r	r	r	r	r	PM, WV, wanderer
Streaked Shearwater	*Calonectris leucomelas*		E			E	E	E	E	E				4 records (1992, 1993, 2003, 2008)
Flesh-footed Shearwater	*Puffinus carneipes*								E					1 record (1980)
Sooty Shearwater	*Puffinus griseus*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	PM, WV
Great Shearwater	*Puffinus gravis*	E	E											3 records (1976, 1985, 1995)
Little Shearwater	*Puffinus assimilis*	E												2 records (1988, 1996)
Audubon's Shearwater	*Puffinus lherminieri*					E	E						E	4 records (1985, 1989, 1992, 1999)
Balearic Shearwater	*Puffinus mauretanicus*	E		E										2 records (1982, 2002)
Yelkouan Shearwater	*Puffinus yelkouan*	F	F	F	fr	fr	fr	fr	fr	fr	U	F	F	PM, WV
Hydrobatidae														
European Storm-Petrel	*Hydrobates pelagicus*	E	E							E		E	E	5 records, last on 1986
Wilson's Storm-Petrel	*Oceanites oceanicus*							E						1 record (1983)
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	r	r	r								r	r	Irruptive WV
Madeiran Storm-Petrel	*Oceanodroma castro*							E						1 record (1983)
Swinhoe's Storm-Petrel	*Oceanodroma monorhis*	E			E					E				4 records, last on 2004

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
PELECANIFORMES														
Phaethontidae														
Red-billed Tropicbird	*Phaethon aethereus*			v	v	v	v	v	v			v		Occasional at the Gulf of Eilat
Sulidae														
Northern Gannet	*Morus bassanus*	U	U	U	U	U	E	E	E	E	E	U	U	WV
Brown Booby	*Sula leucogaster*	r	r	r	r	r	r	r	r	r	r	r	r	Locally rare at Eilat
Masked Booby	*Sula dactylatra*							E						1 record (2004)
Phalacrocoracidae														
European Shag	*Phalacrocorax aristotelis*	E	E	E	E	E	E	E	E	E	E	E	E	1 record (2005-6)
Great Cormorant	*Phalacrocorax carbo*	C	C	C	U	U	r	r	r	U	F	C	C	WV, PM, non-breeding SV
Pygmy Cormorant	*Phalacrocorax pygmeus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV
Fregatidae														
Lesser Frigatebird	*Fregrata ariel*					E							E	2 records (1997, 1999)
Anhingidae														
African Darter	*Anhinga rufa*					E								WV till the 50's, now straggler (reported 2004)
Pelecanidae														
White Pelican	*Pelecanus onocrotalus*	F	F	C	C	C	fr	fr	fr	C	C	C	F	WV, PM, non-breeding SV
Dalmatian Pelican	*Pelecanus crispus*	E	E	E	E						E	E	E	8 records, last on 2004
Pink-backed Pelican	*Pelecanus rufescens*			E	E	E	E	E	E					7 records, last on 2001
CICONIFORMES														
Ardeidae														
Great Bittern	*Botaurus stellaris*	U	U	U	fr	fr					fr	U	U	WV, PM
Little Bittern	*Ixobrychus minutus*	v	v	U	U	U	fr	fr	U	U	U	r	v	WV, PM, SV
Black-crowned Night Heron	*Nycticorax nycticorax*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV, SV
Mangrove Heron	*Butorides striatus*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	Local breeder at the gulf of Eilat
Intermediate Egret	*Mesophoyx intermedia*										E			1 record (2004)
Cattle Egret	*Bubulcus ibis*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
Squacco Heron	*Ardeola ralloides*	fr	fr	U	F	F	U	U	F	F	F	U	fr	PM, WV, SV
Little Egret	*Egretta garzetta*	C	C	C	C	C	F	F	C	C	C	C	C	Resident, PM, WV, SV
Western Reef Heron	*Egretta gularis*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	non-breedibg visitor (local at Eilat)
Great Egret	*Casmerodius albus*	F	F	F	F	U	r	r	r	U	F	F	F	PM, WV, non-breeding SV
Grey Heron	*Ardea cinerea*	C	C	C	C	U	U	U	C	C	C	C	C	PM, WV, non-breeding SV
Purple Heron	*Ardea purpurea*	fr	U	F	F	F	fr	fr	F	F	F	U	fr	PM, WV, SV
Goliath Heron	*Ardea goliath*			E	E					E	E			6 records, last on 1993
Black Heron	*Egretta ardesiaca*										E			1 record (1982)
Black-headed Heron	*Ardea melanocephala*										E	E	E	1 record (1987)

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Ciconiidae														
Marabou Stork	*Leptoptilos crumeniferus*				E	E								2 records (1951, 1957)
Yellow-billed Stork	*Mycteria ibis*		v	v	v	v	v	v	v	v	v			Occasional, last on 1997
White Stork	*Ciconia ciconia*	U	C	C	C	C	fr	fr	C	C	C	C	U	PM, WV, SV (rare breeder)
Black Stork	*Ciconia nigra*	U	F	C	C	U	U	U	U	C	C	U	U	PM, WV, OS
Glossy Ibis	*Plegadis falcinellus*	U	U	F	F	F	U	U	F	F	U	U	U	(Resident), PM, WV, SV
Northern Bald Ibis	*Geronticus eremita*			E	E	E			E	E				Occasional
Eurasian Spoonbill	*Platalea leucorodia*	F	F	F	F	U	fr	fr	U	F	F	F	F	PM, WV, non-breeding SV
PHOENICOPTERIFORMES														
Phoenicopteridae														
Greater Flamingo	*Phoenicopterus ruber*	U	U	U	U	U	fr	fr	fr	U	U	U	U	PM, WV, present yearound at Eilat, non-breeding
Lesser Flamingo	*Phoenicopterus minor*			E	E	E	E							1 record (2006)
ANSERIFORMES														
Anatidae														
Mute Swan	*Cygnus olor*	r	r	r	r							r	r	WV (irruptive)
Whooper Swan	*Cygnus cygnus*	E	E	E									E	4 records, last on 2002
Tundra Swan	*Cygnus columbianus*	v	v	v								v	v	Occasional WV
Greater White-fronted Goose	*Anser albifrons*	r	r	r	r						r	r	r	PM, WV
Lesser White-fronted Goose	*Anser erythropus*	E	E			E							E	5 records, last on 1992
Greylag Goose	*Anser anser*	r	r	r	r							r	r	PM, WV
Bean Goose	*Anser fabalis*			E										1 record (2007)
Red-breasted Goose	*Branta ruficollis*	E	E									E	E	Irregular WV
Lesser Whistling Duck	*Dendrocygna javanica*	E	E	E								E	E	1 record (1966), possibly an escape
Egyptian Goose	*Alopochen aegyptiacus*		E			E	E	E	E	E	E			Accidental till 80's. Recent records are of a feral populations
Common Shelduck	*Tadorna tadorna*	U	U	U	U	r	v	v	r	r	U	U	U	PM, WV, OS
Ruddy Shelduck	*Tadorna ferruginea*	fr	fr	fr	r	r	r	r	r	r	r	fr	fr	PM, WV, non-breeding SV (formerly bred)
Mallard	*Anas platyrhynchos*	C	C	C	C	U	U	U	U	C	C	C	C	Resident, SV, PM, WV
Gadwall	*Anas strepera*	U	U	U	fr	r	r	r	r	r	U	U	U	PM, WV, OS
Northern Pintail	*Anas acuta*	F	F	F	F	U	v	v	U	F	F	F	F	PM, WV, OS
Northern Shoveler	*Anas clypeata*	C	C	C	C	C	U	r	U	C	C	C	C	PM, WV, OS
Eurasian Wigeon	*Anas penelope*	F	F	F	F	U	U	v	v	U	F	F	F	PM, WV, OS
Common Teal	*Anas crecca*	C	C	C	C	F	r	r	F	C	C	C	C	PM, WV, OS
Cape Teal	*Anas capensis*					E	E	E	E	E	E			3 records (1978, 1982, 1984)
Red-billed Teal	*Anas erythrorhyncha*						E	E						1 record (1958), possibly an escape
Garganey	*Anas querquedula*	r	U	F	F	F	fr	fr	F	C	F	F	r	PM, WV, SV (very rare breeder)
Marbled Duck	*Marmaronetta angustirostris*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	Resident (local)
Common Pochard	*Aythya ferina*	C	C	C	F	U	v	v	v	U	F	C	C	PM, WV, OS

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Red-crested Pochard	*Netta rufina*	fr	fr	fr	fr							fr	fr	PM, WV
Southern Pochard	*Netta erythropthalma*					E								1 record (1998)
Ferruginous Duck	*Aythya nyroca*	U	U	U	U	fr	fr	fr	fr	U	U	U	U	PM, WV, SV
Greater Scaup	*Aythya marila*	v	v								v	v	v	Occasional WV
Tufted Duck	*Aythya fuligula*	C	C	C	C	U	v	v	v	U	C	C	C	PM, WV, OS
Common Eider	*Somateria mollissima*											E	E	2 records (1942, 1979)
Velvet Scoter	*Melanitta fusca*	E										E	E	7 records, last on 2008
Long-tailed Duck	*Clangula hyemalis*	E											E	6 records, last on 1986
Common Goldeneye	*Bucephala clangula*	v	v	v							v	v	v	Occasional WV
Smew	*Mergellus albellus*	v	v	v							v	v	v	Occasional WV
Goosander	*Mergus merganser*	E												2 records (1925, 2004)
Red-breasted Merganser	*Mergus serrator*	r	r	r	r	r						r	r	PM, WV
White-headed Duck	*Oxyura leucocephala*	U	U	U	U						U	U	U	WV
ACCIPITRIFORMES														
Accipitridae														
Lammergeier	*Gypaetus barbatus*	v	v	v		v						v	v	Occasional, resident population extinct
Eurasian Griffon Vulture	*Gyps fulvus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV
Cinereous Vulture	*Aegypius monachus*	r	r	r	v	v	v	v	v	r	r	r	r	PM, WV, OS (formerly bred)
Lappet-faced Vulture	*Torgos tracheliotus*					E					E			Occasional visitor, resident population extinct
Egyptian Vulture	*Neophron percnopterus*	v	U	F	F	F	U	U	F	F	U	v	v	PM, WV, SV
White-tailed Eagle	*Haliaeetus albicilla*	r	r	r						r	r	r	r	PM, WV, formerly bred and re-introduced
Golden Eagle	*Aquila chrysaetos*	r	r	r	r	r	r	r	r	r	r	r	r	Resident
Eastern Imperial Eagle	*Aquila heliaca*	U	U	fr	fr	fr				fr	fr	U	U	PM, WV
Lesser Spotted Eagle	*Aquila pomarina*	r	r	F	C	F			fr	C	C	U	r	PM, WV
Greater Spotted Eagle	*Aquila clanga*	U	U	U	U	v	v	v	v	v	U	U	U	PM, WV, OS (former resident)
Steppe Eagle	*Aquila nipalensis*	fr	C	C	C	F					C	C	fr	PM, WV
Tawny Eagle	*Aquila rapax*	E	E	E								E	E	3-5 records, last on 2001
Verreaux's Eagle	*Aquila verreauxii*	v	v	v	v	v	v	v	v	v	v	v	v	Occasional visitor
Bateleur	*Terathopius ecaudatus*		E	E	E	E								7 records, last on 2008
Short-toed Eagle	*Circaetus gallicus*	v	F	C	C	C	F	F	C	C	C	U	v	PM, WV, SV
Booted Eagle	*Hieraaetus pennatus*	v	v	F	F	F				F	F	U	v	PM, WV
Bonelli's Eagle	*Hieraaetus fasciatus*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	Resident, PM, WV
Red Kite	*Milvus milvus*	E	E	E						E	E	E	E	Irregular PM, WV, last on 1992
Black Kite	*Milvus migrans*	F	F	C	C	C	U	U	F	F	F	F	F	PM, WV, SV (rare breeder)
Marsh Harrier	*Circus aeruginosus*	F	F	F	F	F	v	v	U	F	F	F	F	PM, WV, non-breeding SV

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
														(formerly bred)
Black-winged Kite	*Elanus caeruleus*	E	E	E	E				E			E	E	8 records, last on 2005
Hen Harrier	*Circus cyaneus*	U	U	U	U						U	U	U	PM, WV
Montagu's Harrier	*Circus pygargus*	v	v	U	U			U	U	U	U	v	v	PM, WV
Pallid Harrier	*Circus macrourus*	fr	fr	F	F	U			U	F	F	U	fr	PM, WV, occasionally OS
Rough-legged Buzzard	*Buteo lagopus*	E											E	2 records (1984, 1985)
Long-legged Buzzard	*Buteo rufinus*	F	F	F	U	U	U	U	U	U	U	F	F	Resident, PM, WV
Common Buzzard	*Buteo buteo*	F	C	C	C	C	U	r	r	U	F	F	F	PM, WV, occasional SV (very rare breeder)
European Honey Buzzard	*Pernis apivorus*				C	C	C		C	C	F	U		PM
Crested Honey Buzzard	*Pernis ptilorhynchus*	E	E	E	fr	fr			r	r	r			PM
Eurasian Sparrowhawk	*Accipiter nisus*	F	F	F	F	F	r	r	r	r	F	F	F	PM, WV, SV
Shikra	*Accipiter badius*				E							E		2 records (1987, 2005)
Levant Sparrowhawk	*Accipiter brevipes*			U	C	C				C	C			PM
Northern Goshawk	*Accipiter gentilis*	fr	fr	fr	r	r				r	r	fr	fr	PM, WV
Dark Chanting-Goshawk	*Melierax metabates*				E									1 record (1979)
Pandionidae														
Osprey	*Pandion haliaetus*	U	U	U	U	fr	fr	fr	U	U	U	U	U	PM, WV
FALCONIFORMES														
Falconidae														
Common Kestrel	*Falco tinnunculus*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
Lesser Kestrel	*Falco naumanni*	r	U	F	F	F	F	F	F	F	U	r	r	PM, WV, SV
Red-footed Falcon	*Falco vespertinus*				U	U	fr		U	F	F	U		PM
Eurasian Hobby	*Falco subbuteo*			U	F	F	F	F	F	F	U	U		PM, SV
Eleonora's Falcon	*Falco eleonorae*				fr	fr	fr			fr	fr	fr		PM
Sooty Falcon	*Falco concolor*				r	r	U	U	U	U	U	r		(PM), SV
Peregrine Falcon	*Falco peregrinus*	U	U	U	U	U	r	v	fr	U	U	U	U	PM, WV, non-breeding SV, formerly bred
Barbary Falcon	*Falco pelegrinus*	U	U	U	U	U	U	U	U	U	U	U	U	Resident
Merlin	*Falco columbarius*	U	U	fr	fr						fr	U	U	PM, WV
Saker Falcon	*Falco cherrug*	r	r	r	v	v				v	v	r	r	(PM), WV
Lanner Falcon	*Falco biarmicus*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	Resident, PM, WV
GALLIFORMES														
Phasianidae														
Black Francolin	*Francolinus francolinus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local)
Chukar	*Alectoris chukar*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Sand Partridge	*Ammoperdix heyi*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Common Quail	*Coturnix coturnix*	U	F	C	C	C	fr	fr	fr	C	C	U	U	PM, WV,SV

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GRUIFORMES														
Rallidae														
Corncrake	*Crex crex*			U	U	U	fr		fr	fr	fr			PM
Water Rail	*Rallus aquaticus*	F	F	F	F	U	r	r	U	F	F	F	F	PM, WV, OS (very rare breeder / Resident)
Spotted Crake	*Porzana porzana*	fr	fr	U	U	U			U	U	U	fr	fr	PM, WV
Little Crake	*Porzana parva*	r	U	F	F	U	r	v	U	U	U	U	r	PM, WV, non-breeding SV
Baillon's Crake	*Porzana pusilla*	v	fr	U	U	U	r	r	fr	fr	fr	r	v	PM, WV, non-breeding SV (formerly bred)
Common Moorhen	*Gallinula chloropus*	C	C	C	F	F	F	F	F	F	C	C	C	Resident, PM, WV, (SV)
Common Coot	*Fulica atra*	C	C	C	C	C	F	F	F	F	C	C	C	(Resident), PM, WV, SV (rare breeder)
Purple Swamp-hen	*Porphyrio porphyrio*	v	v	v	v	v	v	v	v	v	v	v	v	Occasional WV, very rare breeder
Gruidae														
Common Crane	*Grus grus*	C	C	C	C	U				U	C	C	C	PM, WV
Demoiselle Crane	*Anthropoides virgo*			v	v	v					v	v	v	PM
Otididae														
Great Bustard	*Otis tarda*	E	E									E		6 records, last on 2008
Macqueen's Bustard	*Chlamydotis maqueenii*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	Resident
Little Bustard	*Tetrax tetrax*	r	r	v								r	r	PM, WV
CHARADRIIFORMES														
Rostratulidae														
Painted Snipe	*Rostratula benghalensis*	E		v	v	v	v	v	v	v	v	E	E	Occasional visitor, recorded breeding
Haematopodidae														
Eurasian Oystercatcher	*Haematopus ostralegus*	v	r	fr	fr	fr	fr	fr	fr	fr	fr	v	v	PM (WV)
Recurvirostridae														
Pied Avocet	*Recurvirostra avosetta*	U	U	F	F	F	fr	fr	F	F	F	U	U	PM, WV, SV (very rare breeder)
Black-winged Stilt	*Himantopus himantopus*	C	C	F	F	F	F	F	F	F	F	C	C	Resident, PM, WV, SV
Dromadidae														
Crab Plover	*Dromas ardeola*						E	E						3 records (1987, 1997)
Burhinidae														
Stone-curlew	*Burhinus oedicnemus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV, SV
Glareolidae														
Cream-coloured Courser	*Cursorius cursor*	U	U	U	U	U	U	U	U	U	U	U	U	(Resident), PM, WV, SV
Collard Pratincole	*Glareola pratincola*			F	C	C	U	fr	F	F	F	U		PM, SV
Black-winged Pratincole	*Glareola nordmanni*			fr	fr	fr	fr			U	U	U		PM
Oriental Pratincole	*Glareola maldivarum*										E			1 record (1999)
Charadriidae														
Little Ringed Plover	*Charadrius dubius*	v	U	F	F	F	F	F	F	F	F	F	v	PM, WV, SV (rare breeder)

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Common Ringed Plover	*Charadrius hiaticula*	F	F	C	C	C	fr	fr	C	C	C	C	F	PM, WV, non-breeding SV
Kentish Plover	*Charadrius alexandrinus*	F	F	F	F	F	U	U	F	F	F	F	F	Resident, PM, WV
Kittlitz's Plover	*Charadrius pecuarius*	v	v								v	v	v	Occasional visitor (irruptive)
Lesser Sand Plover	*Charadrius mongolus*				E									Straggler
Greater Sand Plover	*Charadrius leschenaultii*	U	F	F	F	U	fr	fr	U	F	F	F	U	PM, WV, non-breeding SV
Caspian Plover	*Charadrius asiaticus*		v	r	r	r	v	v	v	v				PM
Grey Plover	*Pluvialis squatarola*	U	U	F	F	F	fr	fr	F	F	F	F	U	PM, WV, non-breeding SV
Eurasian Golden Plover	*Pluvialis apricaria*	F	F	U	U	U				U	U	F	F	PM, WV
American Golden Plover	*Pluvialis dominica*											E	E	1 record (2008)
Pacific Golden Plover	*Pluvialis fulva*			v	v	v	v	v	r	r	r	r		PM
Eurasian Dotterel	*Charadrius morinellus*	fr	fr	r	r						r	fr	fr	PM, WV
Black-headed Lapwing	*Vanellus tectus*													1 record (1869)
Northern Lapwing	*Vanellus vanellus*	C	C	C	F	F	r	r	r	F	F	C	C	PM, WV, non-breeding SV (formerly bred)
Spur-winged Lapwing	*Vanellus spinosus*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV, (SV)
Red-wattled Lapwing	*Vanellus indicus*	E	E								E		E	2 records (1991-92, 2001)
Sociable Lapwing	*Vanellus gregarius*	fr	fr	fr	r	r				r	r	fr	fr	PM, WV
White-tailed Lapwing	*Vanellus leucurus*	r	r	fr	fr	r	r	r	r	fr	fr	fr	r	PM, WV
Scolopacidae														
Great Knot	*Calidris tenuirostris*										E	E		2 records (1985, 1991)
Red Knot	*Calidris canutus*	E	E	v	v	v	v	v	v	r	r	E	E	PM (WV)
Sanderling	*Calidris alba*	U	U	F	F	F	U	U	U	F	F	F	U	PM, WV
Dunlin	*Calidris alpina*	U	U	C	C	C	U	U	C	C	C	C	U	PM, WV
Curlew Sandpiper	*Calidris ferruginea*	v			F	F	U	U	F	F	U	v	v	PM, WV
Semipalmated Sandpiper	*Calidris pusilla*					E								1 record (1989)
Red-necked Stint	*Calidris ruficollis*				E									1 record (2003)
Baird's Sandpiper	*Calidris bairdii*										E			1 record (1998)
White-rumped Sandpiper	*Calidris fuscicollis*				E					E				1 record (2004)
Temminck's Stint	*Calidris temminckii*	U	U	F	F	F	U	U	F	F	F	F	U	PM, WV
Little Stint	*Calidris minuta*	F	C	C	C	C	F	C	C	C	C	C	F	PM, WV
Long-toed Stint	*Calidris subminuta*								E		E			2 records (1991, 2004)
Pectoral Sandpiper	*Calidris melanotos*			E		E			E	E				7 records, last on 2008
Broad-billed Sandpiper	*Limicola falcinellus*				U	U	U	fr	U	U	U			PM
Ruff	*Philomachus pugnax*	U	F	C	C	C	U	U	C	C	C	F	U	PM, WV, OS
Great Snipe	*Gallinago media*			v	v	v	v			v	v	v		PM
Common Snipe	*Gallinago gallinago*	F	C	C	C	C	U	U	U	C	C	C	F	PM, WV
Jack Snipe	*Lymnocryptes minimus*	U	U	U	U	U					U	U	U	PM, WV
Pin-tailed Snipe	*Gallinago stenura*										E	E	E	6 recoeds, last on 2003
Eurasian Woodcock	*Scolopax rusticola*	F	F	U	U						U	F	F	PM, WV

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Long-billed Dowitcher	*Limnodromus scolopaceus*							E	E					1 record (1984)
Black-tailed Godwit	*Limosa limosa*	F	F	F	F	F	U	U	U	F	F	F	F	PM, WV
Bar-tailed Godwit	*Limosa lapponica*	v		fr	fr	fr	fr		fr	fr	fr	v	v	PM, WV
Eurasian Curlew	*Numenius arquata*	fr	U	U	U	U	r	r	U	U	U	U	fr	PM, WV, non-breeding SV
Whimbrel	*Numenius phaeopus*	r	r	fr	fr	fr	r	r	fr	fr	fr	r	r	PM, WV, non-breeding SV
Slender-billed Curlew	*Numenius tenuirostris*										E			1 record (1917)
Wood Sandpiper	*Tringa glareola*	fr	U	C	C	C	C	C	C	C	C	F	fr	PM, WV
Green Sandpiper	*Tringa ochropus*	F	C	C	C	C	F	F	C	C	C	C	F	PM, WV
Common Redshank	*Tringa totanus*	F	C	C	C	U	U	C	C	C	C	C	F	PM, WV, non-breeding SV
Spotted Redshank	*Tringa erythropus*	F	F	F	F	F	U	F	F	F	F	F	F	PM, WV
Common Greenshank	*Tringa nebularia*	U	F	F	F	F	F	U	F	F	F	F	U	PM, WV
Marsh Sandpiper	*Tringa stagnatilis*	U	U	F	F	F		U	F	F	F	F	U	PM, WV
Lesser Yellowlegs	*Tringa flavipes*						E							1 record (1977)
Terek Sandpiper	*Xenus cinereus*			r	r	r	r	fr	fr	r				PM
Common Sandpiper	*Actitis hypoleucos*	U	U	C	C	C	F	C	C	C	C	U	U	PM, WV
Ruddy Turnstone	*Arenaria interpres*	U	U	F	F	F	F	F	F	F	F	U	U	PM, WV
Red Phalarope	*Phalaropus fulicaria*	v		v	v	v	v	v		v	v	v	v	Occasional PM, WV
Red-necked Phalarope	*Phalaropus lobatus*			r	fr	fr	fr	fr	r	r	fr	r		PM, (OS)
Stercorariidae														
South Polar Skua	*Catharus maccormicki*						E							2 records (1983, 1992)
Great Skua	*Stercorarius skua*			E		E						E		4 records, last on 1969
Pomarine Skua	*Stercorarius pomarinus*	r	r	U	U	U	U	U	U	U	U	U	r	PM, WV, (non-breeding SV)
Parasitic Skua	*Stercorarius parasiticus*	U	U	U	U	F	F	F	F	F	U	U	U	PM, WV, (non-breeding SV)
Long-tailed Skua	*Stercorarius longicaudus*			fr	fr	fr	fr	fr	fr	fr	fr			PM, (OS)
Laridae														
Grey-headed Gull	*Larus cirrocephalus*			E	E	E			E	E				3 records (all from 1989)
Brown-headed Gull	*Larus brunnicephalus*					E								1 record (1985)
Black-headed Gull	*Larus ridibundus*	C	C	C	C	C	U	U	U	C	C	C	C	PM, WV, SV
Slender-billed Gull	*Larus genei*	F	F	F	F	F	F	F	F	F	F	F	F	PM, WV, non-breeding SV
Common Gull	*Larus canus*	fr	fr	fr								fr	fr	PM, WV
Mediterranean Gull	*Larus melanocephalus*	fr	fr	r	r	r	r	r	r		r	fr	fr	PM, WV, OS
Audouin's Gull	*Larus audouinii*	v	v	v	v	v	v	v	v	v	v	v	v	Occasional
Great Black-backed Gull	*Larus marinus*	v	v	v	E	E				E	v	E	v	Occasional PM, WV
Lesser Black-backed Gull	*Larus fuscus*	F	F	C	C	C	U	U	C	C	C	F	F	PM, WV, non-breeding SV
Herring Gull	*Larus argentatus*	E												1 record (1987)

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Yellow-legged Gull	*Larus michahellis*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (rare), PM, WV
Armenian Gull	*Larus armenicus*	C	C	C	C	F	U	U	F	F	C	C	C	PM, WV, non-breeding SV
Caspian Gull	*Larus cachinnans*	F	F	F	U	fr	r	r	F	F	F	F	F	WV, PM
Pallas's Gull	*Larus ichthyaetus*	F	F	F	U	U							F	PM, WV
Little Gull	*Larus minutus*	F	U	U	U	U	r	r	r	U	U	U	F	PM, WV, non-breeding SV
Black-legged Kittiwake	*Rissa tridactyla*	fr	fr	r	r						r	r	r	(PM), WV
Sabine's Gull	*Larus sabini*						E	E	E					2 records (1989, 1992)
Glaucous Gull	*Larus hyperboreus*				E									1 record (1914)
Sooty Gull	*Larus hemprichii*				E	E	E				E	E		5 records (1983, 1989-92, 1998)
White-eyed Gull	*Larus leucophthalmus*	U	U	U	U	F	F	F	F	U	U	U	U	Local, non-breeding at the gulf of Eilat
Franklin's Gull	*Larus pipixcan*						E	E						2 records (2003, 2006)
Sternidae														
Saunders's Tern	*Sterna saundersi*				E	E	E	E						Straggler
Little Tern	*Sterna albifrons*	E			F	F	F	F	F	F	F		E	PM, SV (Fr breeding)
Sandwich Tern	*Sterna sandvicensis*	F	F	F	U	U	fr	fr	fr	U	F	F	F	PM, WV, non-breeding SV
Gull-Billed Tern	*Sterna nilotica*			fr	F	F	fr	fr	F	F	fr			PM
Common Tern	*Sterna hirundo*			F	C	C	C	C	C	C	F		v	PS, SV
Arctic Tern	*Sterna paradisaea*					v	r	r	v					Non-breeding SV at the Gulf of Eilat, Straggler at Med
Roseate Tern	*Sterna dougallii*								E	E		E		3 records (1982, 1987, 1989)
Caspian Tern	*Sterna caspia*	U	U	U	U	U	U	U	U	U	U	U	U	Local at the gulf of Eilat, very rare elsewhere
Greater Crested Tern	*Sterna bergii*			v	v	v	v	v	E			E	E	Occasional visitor
Lesser Crested Tern	*Sterna bengalensis*			fr	fr	fr	fr	fr	fr	fr				Non-breeding SV at the Gulf of Eilat, Straggler at Med.
Sooty Tern	*Sterna fuscata*							E	E					4 records (1980, 1981, 1988)
Bridled Tern	*Sterna anaethetus*						fr	fr	fr					Non-breeding SV at Eilat, straggler at Med.
White-cheeked Tern	*Sterna repressa*				fr	fr	fr	fr	fr					Non-breeding SV at Eilat, Occasional at Med
Black Tern	*Chlidonias niger*				fr	fr	fr	fr	fr	fr	fr			PM, non-breeding SV (formerly bred)
White-winged Tern	*Chlidonias leucopterus*				F	C	C	F	C	C	F	F		PM, non-breeding SV (rare)
Whiskered Tern	*Chlidonias hybridus*	U	U	U	F	F	F	U	F	F	U	U	U	PM, WV (local), non-breeding SV
Rynchopidae														
African Skimmer	*Rynchops flavirostris*							E						1 record (1934)
PTEROCLIDIFORMES														
Pteroclididae														
Black-bellied Sandgrouse	*Pterocles orientalis*	U	U	U	U	U	U	U	U	U	U	U	U	Resident, WV
Pin-tailed Sandgrouse	*Pterocles alchata*	U	U	U	U	U	U	U	U	U	U	U	U	Resident, WV
Spotted Sandgrouse	*Pterocles senegallus*	U	U	U	U	U	U	U	U	U	U	U	U	Resident

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Crowned Sandgrouse	*Pterocles coronatus*	U	U	U	U	U	U	U	U	U	U	U	U	Resident
Lichtenstein's Sandgrouse	*Pterocles lichtensteinii*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (local)
COLUMBIFORMES														
Columbidae														
Rock Dove	*Columba livia*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Stock Dove	*Columba oenas*	F	F	F							F	F	F	PM, WV
Wood Pigeon	*Columba palumbus*	F	F	fr							fr	F	F	PM, WV (local)
African Collared Dove	*Streptopelia roseogrisea*	E	E	E								E	E	Occasional
Eurasian Collared Dove	*Streptopelia decaocto*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
European Turtle Dove	*Streptopelia turtur*			F	C	C	C	C	C	C	F	U		PM, SV (rare in winter)
Oriental Turtle Dove	*Streptopelia orientalis*									E	E			4 records, last on 2007
Laughing Dove	*Streptopelia senegalensis*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Namaqua Dove	*Oena capensis*	fr	fr	U	U	U	U	U	U	U	U	fr	fr	(Resident), SV (local)
CUCULIFORMES														
Cuculidae														
Diederik Cuckoo	*Chrysococcyx caprius*			E										1 record (1994)
Common Cuckoo	*Cuculus canorus*		U	U	U	U	U	U	U	U	U	U		PM, SV
Oriental Cuckoo	*Cuculus saturatus*								E					1 record (1985)
Great Spotted Cuckoo	*Clamator glandarius*	v	U	F	F	F	F	F	F	F	U	U	v	PM, WV, SV
STRIGIFORMES														
Tytonidae														
Barn Owl	*Tyto alba*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Strgidae														
Tawny Owl	*Strix aluco*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (local)
Hume's Owl	*Strix butleri*	U	U	U	U	U	U	U	U	U	U	U	U	Resident
Eurasian Eagle Owl	*Bubo bubo*	U	U	U	U	U	U	U	U	U	U	U	U	Resident
Brown Fish Owl	*Bubo zeylonensis*	x	x	x	x	x	x	x	x	x	x	x	x	Extinct, last recorded 1975
Long-eared Owl	*Asio otus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV
Short-eared Owl	*Asio flammeus*	fr	fr	fr	fr	fr	r	r	r	r	fr	fr	fr	PM, WV, SV
Little Owl	*Athene noctua*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Eurasian Scops Owl	*Otus scops*	r	U	U	F	F	F	F	F	F	U	U	r	PM, WV, SV
Pallid Scops Owl	*Otus brucei*	fr	fr	r								r	fr	WV, recorded breeding in the past
CAPRIMULGIFORMES														
Caprimulgidae														
European Nightjar	*Caprimulgus europaeus*	r	r	U	F	F	U	r	r	F	F	U	r	PM, WV, SV (recorded breeding)
Egyptian Nightjar	*Caprimulgus aegyptius*		v	r	r	r	v		v	v	v			PM, recorded breeding
Nubian Nightjar	*Caprimulgus nubicus*	r	r	r	r	r	r	r	r	r	r	r	r	Resident (local), SV
APODIFORMES														

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Apodidae														
Common Swift	*Apus apus*	F	C	C	C	C	C	C	C	C	C	U	U	PM, WV, SV
Pallid Swift	*Apus pallidus*	U	C	C	C	C	C	C	C	F	F	fr	fr	PM, WV, SV
Alpine Swift	*Tachymarptis melba*	U	C	C	C	F	F	F	C	C	C	C	U	PM, WV, SV
Little Swift	*Apus affinis*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local), PM, (SV)
CORACIIFORMES														
Alcedinidae														
Common Kingfisher	*Alcedo atthis*	F	F	F	U	U	r	U	F	F	F	F	F	PM, WV, non-breeding SV
White-throated Kingfisher	*Halcyon smyrnensis*	F	F	F	F	F	F	F	F	F	F	F	F	Resident
Pied Kingfisher	*Ceryle rudis*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Meropidae														
European Bee-eater	*Merops apiaster*			F	C	C	C	C	C	C	C	U		PM, SV
Blue-cheeked Bee-eater	*Merops persicus*			fr	U	U	fr	fr	U	U	fr	fr		PM, SV
Little Green Bee-eater	*Merops orientalis*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local)
PSITTACIFORMES														
Psittacidae														
Rose-ringed Parakeet	*Psittacula krameri*	C	C	C	C	C	C	C	C	C	C	C	C	Resident -introduced
Black-hooded Parakeet	*Nandayus nenday*	U	U	U	U	U	U	U	U	U	U	U	U	Resident -introduced (local)
Monk Parakeet	*Myiopsitta monachus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident -introduced
CORACIIFORMES														
Coraciidae														
European Roller	*Coracias garrulus*			F	F	F	F	F	F	F	U	U		PM, SV
Upopidae														
Eurasian Hoopoe	*Upupa epops*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV, (SV)
PICIFORMES														
Picidae														
Syrian Woodpecker	*Dendrocopos syriacus*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Eurasian Wryneck	*Jynx torquilla*	r	U	F	F	U	v	v	U	F	F	U	r	PM, WV, occasional SV, recorded breeding
PASSERIFORMES														
Alaudidae														
Common Skylark	*Alauda arvensis*	C	C	C	F						C	C	C	PM, WV
Oriental Skylark	*Alauda gulgula*	fr	fr	fr	fr	r				r	fr	fr	fr	PM, WV
Crested Lark	*Galerida cristata*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Woodlark	*Lullula arborea*	F	F	F	fr	fr	fr	fr	fr	fr	F	F	F	PM, WV, SV (local)
Greater Short-toed Lark	*Calandrella brachydactyla*	fr	C	C	C	U	U	U	C	C	C	U	fr	PM, WV, SV
Hume's Short-toed Lark	*Calandrella acutirostris*		E											1 record (1986)
Lesser Short-toed Lark	*Calandrella rufescens*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local), PM, WV

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Desert Lark	*Ammomanes deserti*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Bar-tailed Lark	*Ammomanes cincturus*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (local), (SV)
Dunn's Lark	*Eremalauda dunni*	v	v	v	v	v	v	v	v	v	v	v	v	Irruptive nomadic visitor and casual breeder, usually absent
Black-crowned Sparrow-lark	*Eremopterix nigriceps*	v	v	v	v	v	v					v		Occsional visitor
Chestnut-headed Sparrow-Lark	*Eremopterix signata*					E								1 record (1983)
Calandra Lark	*Melanocorypha calandra*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local), WV, (SV)
Bimaculated Lark	*Melanocorypha bimaculata*	v	r	U	U	fr	fr	fr	fr	r	r	r	v	PM (irruptive), WV, SV
Thick-billed Lark	*Ramphocoris clotbey*	E	v	r	r	v						E		Nomadic & occsional breeder
Horned Lark	*Eremophila alpestris*	U	U	U	U	U	U	U	U	U	U	U	U	Resident, SV(local)
Temminck's (Horned) Lark	*Eremophila bilopha*	U	U	U	U	U	U	U	U	U	U	U	U	Resident, SV, PM
Hoopoe Lark	*Alaemon alaudipes*	r	r	r	r	r	r	r	r	r	r	r	r	Resident (local), very rare in recent years
Hirundinidae														
Sand Martin	*Riparia riparia*	r	F	C	C	C	F	F	C	C	C	U	r	PM, WV, non-breeding SV (formerly bred)
Plain Martin	*Riparia paludicola*					E								3 records (1986, 1989, 2003)
Eurasian Crag Martin	*Ptyonoprogne rupestris*	F	F	F	U	r	r	r	r	r	U	F	F	PM, WV, SV (local)
Rock Martin	*Ptyonoprogne fuligula*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, (PM), (WV)
Ethiopian Swallow	*Hirundo aethiopica*					E								1 record (1991)
Barn Swallow	*Hirundo rustica*	C	C	C	C	C	C	C	C	C	C	C	C	Resident (local), PM, WV, SV
Red-rumped Swallow	*Hirundo daurica*	v	F	F	F	F	F	F	F	F	F	F	v	PM, WV, SV
Common House Martin	*Delichon urbica*	r	C	C	C	C	F	F	C	C	C	C	r	PM, WV, SV
Motacillidae														
Tawny Pipit	*Anthus campestris*	fr	F	F	F	F	U	fr	F	F	F	F	fr	PM, SV, WV
Long-billed Pipit	*Anthus similis*	U	U	U	U	U	U	U	U	U	U	U	U	Resident
Richard's Pipit	*Anthus richardi*	r	r	fr	fr	r	v			r	U	U	r	PM, WV
Blyth's Pipit	*Anthus godlewskii*									E		E		4 records, last on 2008
Water Pipit	*Anthus spinoletta*	C	C	C	fr	fr					fr	C	C	PM, WV
Buff-bellied Pipit	*Anthus rubescens*	fr	fr	fr	r						r	fr	fr	PM, WV
Meadow Pipit	*Anthus pratensis*	C	C	C	U						U	C	C	PM, WV
Tree Pipit	*Anthus trivialis*	r	C	C	C	C	U			C	C	C	r	PM, WV
Olive-backed Pipit	*Anthus hodgsoni*	r	r	r	v						r	r	r	PM, WV
Red-throated Pipit	*Anthus cervinus*	F	C	C	C	C	F			C	C	C	F	PM, WV
White Wagtail	*Motacilla alba*	C	C	C	C	U	fr	fr	fr	U	C	C	C	PM, WV, SV
Yellow Wagtail	*Motacilla flava*	v	C	C	C	C	U	U	C	C	C	C	v	PM, SV
Citrine Wagtail	*Motacilla citreola*	U	U	U	U	U	U		U	U	U	U	U	PM, WV
Grey Wagtail	*Motacilla cinerea*	F	F	F	F	F			F	F	F	F	F	PM, WV
Pycnonotidae														

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Spectacled Bulbul	*Pycnonotus xanthopygos*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Bombycillidae														
Bohemian Waxwing	*Bombycilla garrulus*	E										E	E	3 record (1966-67, 1978)
Grey Hypocolius	*Hypocolius ampelinus*	E	E	E	E							E	E	Occasional PM
Troglodytidae														
Wren	*Troglodytes troglodytes*	U	U	U	U	U	U	U	U	U	U	U	U	Resident, WV
Prunellidae														
Dunnock	*Prunella modularis*	U	U	U	U						U	U	U	PM, WV
Alpine Accentor	*Prunella collaris*	v	v	v								v	v	WV
Radde's Accentor	*Prunella ocularis*	v	v	v							v	v	v	WV
Black-throated Accentor	*Prunella atrogularis*	E	E	E										1 record (1982)
Turdidae														
European Robin	*Erithacus rubecula*	C	C	C	U	r	r	r	r	r	C	C	C	PM, WV, OS
Common Nightingale	*Luscinia megarhynchos*			F	C	F	F	F	F	F	U			PM, SV
Thrush Nightingale	*Luscinia luscinia*			U	U	F	U		U	F	U	U		PM
Rufous Bush Robin	*Cercotrichas galactotes*			U	F	F	F	F	F	F				PM, SV
Black Bush Robin	*Cercotrichas podobe*			r	r	r	r							PM
Bluethroat	*Luscinia svecica*	C	C	C	F					fr	C	C	C	PM, WV
Red-flanked Bluetail	*Tarsiger cyanurus*	E										E	E	1 record (1996)
White-throated Robin	*Irania gutturalis*				r	r	r	r	v	v				PM, SV (local at Hermon)
Common Redstart	*Phoenicurus phoenicurus*	v	U	C	C	C	U		U	C	C	F	v	PM, WV
Black Redstart	*Phoenicurus ochruros*	C	C	C	fr	fr	fr	fr	fr	fr	fr	C	C	PM, WV, SV (local)
Eversmann's Redstart	*Phoenicurus erythronota*											E		1 record (1988)
Blackstart	*Cercomela melanura*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Whinchat	*Saxicola rubetra*			U	fr	fr	U		U	fr	fr	fr		PM
European Stonechat	*Saxicola rubicola*	C	C	C	U						U	C	C	PM, WV
Pied Bushchat	*Saxicola caprata*	E									E			6 records, last on 2002
Northern Wheatear	*Oenanthe oenanthe*	r	r	C	C	C	fr	fr	fr	C	C	F	r	PM, WV, SM (local)
Isabelline Wheatear	*Oenanthe isabellina*	fr	fr	C	C	fr	U	U	F	C	C	C	fr	Resident, PM, WV, SV
Desert Wheatear	*Oenanthe deserti*	U	U	U	U	U	U	U	U	U	U	U	U	Resident, PM, WV
Black-eared Wheatear	*Oenanthe hispanica*		F	C	C	C	C	C	C	C	C	F		PM, SV
Pied Wheatear	*Oenanthe pleschanka*			r	r	v				v	r	v		PM
Variable Wheatear	*Oenanthe picata*		E											1 record (1986)
Cyprus Wheatear	*Oenanthe cypriaca*		fr	fr	fr					v	v	v		PM
Finsch's Wheatear	*Oenanthe finschii*	F	F	F	v	v	v	v	v		U	F	F	PM, WV, SV (local)
Mourning Wheatear	*Oenanthe lugens*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Hooded Wheatear	*Oenanthe monacha*	U	U	U	U	U	U	U	U	U	U	U	U	Resident

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White-crowned Wheatear	*Oenanthe leucopyga*	F	F	F	F	F	F	F	F	F	F	F	F	Resident
Black Wheatear	*Oenanthe leucura*												E	1 record (1982)
Kurdish Wheatear	*Oenanthe xanthoprymna*	v	v	v	v					v	v	v	v	occasional WV & PM
Red-tailed Wheatear	*Oenanthe chrysopygia*				E									1 record (1990)
Red-rumped Wheatear	*Oenanthe moesta*	v	v	v	v	v	v	v	v	v	v	v	v	Casual resident breeder
Blue Rock-Thrush	*Monticola solitarius*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV
Rufous-tailed Rock-Thrush	*Monticola saxatilis*			fr	fr	fr	r	r	r	fr	fr	fr		PM, SV (local)
Song Thrush	*Turdus philomelos*	C	C	C	C						fr	C	C	PM, WV
Redwing	*Turdus iliacus*	U	U	U	r							U	U	PM, WV (rare in some years)
Mistle Thrush	*Turdus viscivorus*	fr	fr	fr	r							fr	fr	PM, WV (rare in some years)
Fieldfare	*Turdus pilaris*	U	U	U	r						r	U	U	PM, WV (rare in some years)
Common Blackbird	*Turdus merula*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
Ring Ouzel	*Turdus torquatus*	v	v	v	v						v	r	r	PM, WV (irregular)
Dark-throated Thrush	*Turdus ruficollis*	E	E									E	E	Occasional PM, WV
Dusky Thrush	*Turdus naumanni*											E		1 record (1982)
Eye-browed Thrush	*Turdus obscurus*										E	E		2 records (1996. 2007)
Sylviidae														
Cetti's Warbler	*Cettia cetti*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV
Zitting Cisticola	*Cisticola juncidis*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, (PM)
Graceful Prinia	*Prinia gracilis*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Scrub Warbler	*Scotocerca inquieta*	F	F	F	F	F	F	F	F	F	F	F	F	Resident
Common Grasshopper Warbler	*Locustella naevia*			E					E	E				8 records, last on 1992
Pallas's Grasshopper Warbler	*Locustella certhiola*		E											1 record (1983)
River Warbler	*Locustella fluviatilis*		v	v	r	fr	r		v	r	r	v		PM
Savi's Warbler	*Locustella luscinioides*	r	F	F	F	U	U	U	F	F	F	r	r	PM, WV, SB
Sedge Warbler	*Acrocephalus schoenobaenus*	U	C	C	C	C	U	U	fr	C	C	C		PM, WV
Moustached Warbler	*Acrocephalus melanopogon*	F	F	F	U	fr	fr	fr	fr	fr	U	F	F	PM, WV, SB
Blyth's Reed Warbler	*Acrocephalus dumetorum*					E				E	E			Occasional
Paddyfield Warbler	*Acrocephalus agricola*			E							E	E		Occasional
Marsh Warbler	*Acrocephalus palustris*				fr	fr	fr		U	U	U	U		PM
Great Reed Warbler	*Acrocephalus arundinaceus*	v	U	F	F	F	U	r	U	F	F	U	v	
Clamorous Reed Warbler	*Acrocephalus stentoreus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local), PM
Eurasian Reed Warbler	*Acrocephalus scirpaceus*	r	U	C	C	C	C	C	C	C	C	U	r	PM, WV, SV
Oriental Great Reed Warbler	*Acrocephalus orientalis*		E	E	E	E								2 records (1988, 1990)
Basra Reed Warbler	*Acrocephalus griseldis*			v	v	v	v	v		v				Occasional
Icterine Warbler	*Hippolais icterina*				r	fr	r		r	fr	r			PM
Olive-tree Warbler	*Hippolais olivetorum*				fr	U	fr	fr	f	r				PM, SV

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
									r					
Upcher's Warbler	*Hippolais languida*				r	U	U	U	r					PM (irregular), SV (local)
Eastern Olivaceous Warbler	*Hippolais pallida*			F	C	C	C	C	C	F	U			PM, SV
Booted Warbler	*Hippolais caligata*	E	E	E	E	E			E	E	E	E	E	Occasional
Sykes's Warbler	*Hippolais rama*	E	E	E	E	E			E	E	E	E	E	Occasional
Garden Warbler	*Sylvia borin*				U	F	U		U	F	fr	fr		PM
Barred Warbler	*Sylvia nisoria*				U	U	r		r	r	r			PM
Blackcap	*Sylvia atricapilla*	U	F	C	C	C	F	F	F	C	C	C	U	PM, WV, SV
Eastern Orphean Warbler	*Sylvia hortensis*		U	F	F	F	F	F	F	F	U			PM, SV
Arabian Warbler	*Sylvia leucomelaena*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (local)
Lesser Whitethroat	*Sylvia curruca*	v	C	C	C	C	F	F	C	C	C	C	v	PM, WV (local), SV
Sardinian Warbler	*Sylvia melanocephala*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV, (SV)
Ménétries's Warbler	*Sylvia mystacea*	E	E	r	r						v	v	E	PM, WV
Cyprus Warbler	*Sylvia melanothorax*	fr	U	U	r						r	U	fr	PM, WV
Rüppell's Warbler	*Sylvia rueppelli*		U	F	F	U			r	r	r			PM
Common Whitethroat	*Sylvia communis*		F	C	C	C	F	F	F	F	F	U		PM, SV
Spectacled Warbler	*Sylvia conspicillata*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local), (PM), WV
Subalpine Warbler	*Sylvia cantillans*		r	fr	fr	r			v	v	v			PM
Asian Desert Warbler	*Sylvia nana*	U	U	U	fr						fr	U	U	PM, WV
Willow Warbler	*Phylloscopus trochilus*		U	U	F	F	U		C	C	C	C	U	PM
Wood Warbler	*Phylloscopus sibilatrix*			U	F	F			U	U	U			PM
Balkan (Eastern Bonelli's) Warbler	*Phylloscopus orientalis*		U	F	F	U	fr	fr	U	fr	fr	fr		PM, SV (irregular breeder)
Chiffchaff	*Phylloscopus collybita*	C	C	C	fr	U					C	C	C	PM, WV
Dusky Warbler	*Phylloscopus fuscatus*			E							E			3 records (1989, 1997)
Radde's Warbler	*Phylloscopus schwarzi*										E			2 record (1982, 1991)
Mountain Chiffchaff	*Phylloscopus sindianus*										E			1 record (1983)
Green Warbler	*Phylloscopus trochiloides nitidus*					E			E		E			3 records (1987, 2004, 2008)
Yellow-browed Warbler	*Phylloscopus inornatus*	r	r	r	v						r	r	r	WV, PM
Hume's Leaf Warbler	*Phylloscopus humei*	v	v	v	v						v	v	v	WV, PM
Pallas's Warbler	*Phylloscopus proregulus*		E	E	E						E			3 records (1991, 1992, 1998)
Goldcrest	*Regulus regulus*	r	r	r								r	r	(PM), WV (irregular)
Muscicapidae														
Red-breasted Flycatcher	*Ficedula parva*	E	E	v	r	r				r	fr	fr	E	PM (WV)
Spotted Flycatcher	*Muscicapa striata*			U	C	C	F	F	F	C	C	C	U	PM, SV
Pied Flycatcher	*Ficedula hypoleuca*			F	F	F			r	r	r			PM
Collared Flycatcher	*Ficedula albicollis*			F	F	F			r	fr	fr			PM
Semi-collared Flycatcher	*Ficedula semitorquata*			fr	fr	r				r	r	r		PM
Tmaliidae														

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Arabian Babbler	*Turdoides squamiceps*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Paridae														
Bearded Reedling	*Panurus biarmicus*	v	v	v	v						v	v	v	WV (irregular), last recorded on 1995
Great Tit	*Parus major*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Coal Tit	*Parus ater*	E	E											Occasional WV
Sombre Tit	*Parus lugubris*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local at Hermon)
Sittidae														
Western Rock Nuthatch	*Sitta neumayer*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (local at Hermon)
Tichodromadidae														
Wallcreeper	*Tichodroma muraria*	r	r	r	v							v	r	WV
Remizidae														
Eurasian Penduline Tit	*Remiz pendulinus*	U	U	U	U	r	v	v	v	v	U	U	U	PM, WV, (OS)
Nectariniidae														
Palestine Sunbird	*Nectarinia osea*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Oriolidae														
Eurasian Golden Oriole	*Oriolus oriolus*				U	U	U	v	U	U	U	U		PM, (SV)
Laniidae														
Red-backed Shrike	*Lanius collurio*				F	F	F	F	C	C	C	U		PM, SV (local)
Isabelline Shrike	*Lanius isabellinus*	r	r	r	r	v	v	v		r	fr	fr	r	PM, WV
Woodchat Shrike	*Lanius senator*	r	U	F	F	F	F	F	F	F	U			PM, SV
Masked Shrike	*Lanius nubicus*			C	C	C	F	F	F	C	C	U	E	PM, SV
Long-tailed Shrike	*Lanius schach*	E	E									E	E	1 record (1982-83)
Southern Grey Shrike	*Lanius excubitor*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, PM, WV
Lesser Grey Shrike	*Lanius minor*				U	U	v	v	U	U	U	U		PM, (non-breeding SV)
Corvidae														
Eurasian Jay	*Garrulus glandarius*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Western Jackdaw	*Corvus monedula*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Red-billed Chough	*Pyrrhocorax pyrrhocorax*					E	E							1 record (1972)
Alpine Chough	*Pyrrhocorax graculus*	r	r	r	r	v	v	v	v	v	v	v	r	WV (local wanderer at Hermon)
Rook	*Corvus frugilegus*	F	F	U	r	r	r	r	r	r	U	F	F	(PM), WV, OS (irregular)
Hooded Crow	*Corvus corone cornix*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Common Raven	*Corvus corax*	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	fr	Resident
Brown-necked Raven	*Corvus ruficollis*	F	F	F	F	F	F	F	F	F	F	F	F	Resident
House Crow	*Corvus splendens*	F	F	F	F	F	F	F	F	F	F	F	F	Resident - Introduced (local)
Sturnidae														
Common Myna	*Acridotheres tristis*	C	C	C	C	C	C	C	C	C	C	C	C	Invasive, spreading rapidly
Vinous-breasted Myna	*Acridotheres burmannicus*	F	F	F	F	F	F	F	F	F	F	F	F	Invasive.
Corvidae														
Fan-tailed Raven	*Corvus rhipdurus*	U	U	U	U	U	U	U	U	U	U	U	U	Resident (local)

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Sturnidae														
Tristram's Starling	*Onychognathus tristramii*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, (nomadic)
Common Starling	*Sturnus vulgaris*	C	C	C	U	v	v	v	v	v	F	C	C	(PM), WV, non-breeding SV
Rose-Coloured Starling	*Sturnus roseus*	E	E	E	r	fr	r		r	r	r	r		PM (WV)
Passeridae														
House Sparrow	*Passer domesticus*	C	C	C	C	C	C	C	C	C	C	C	C	Resident
Spanish Sparrow	*Passer hispaniolensis*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
Eurasian Tree Sparrow	*Passer montanus*	E	E	E								E	E	Occasional WV
Dead Sea Sparrow	*Passer moabiticus*	F	F	F	F	F	F	F	F	F	F	F	F	Resident and dispersal (local)
Rock Sparrow	*Petronia petronia*	F	F	F	F	F	F	F	F	F	F	F	F	Resident (local)
Estrildidae														
Indian Silverbill	*Euodice malabarica*	F	F	F	F	F	F	F	F	F	F	F	F	Resident, spreading
Passeridae														
Chestnut-shouldered Sparrow	*Petronia xanthocollis*			E		E						E		2-3 records (1982, 2001-2)
Pale Rockfinch	*Petronia brachydactyla*		fr	fr	fr	fr	fr	r	v	v				PM, SV (local, irregular)
Fringillidae														
Common Chaffinch	*Fringilla coelebs*	C	C	C	F	v	v	v	v	v	F	C	C	PM, WV, (OS)
Brambling	*Fringilla montifringilla*	F	F	F	fr						fr	F	F	PM, WV (irregular)
Common Linnet	*Carduelis cannabina*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
European Goldfinch	*Carduelis carduelis*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
European Greenfinch	*Carduelis chloris*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, PM, WV
Eurasian Siskin	*Carduelis spinus*	F	F	F	F						fr	F	F	PM, WV (irregular)
European Serin	*Serinus serinus*	C	C	C	F	F	F	F	F	F	F	C	C	Resident (local), PM, WV
Syrian Serin	*Serinus syriacus*	U	U	U	F	F	F	F	F	F	F	U	U	PM, WV (local), SV (local)
Red-Fronted Serin	*Serinus pusillus*	r	r	r								r	r	PM, WV (local)
Common Crossbill	*Loxia curvirostra*	v	v	v	v	v	v	v	v	v	v	v	v	WV (irregular), OS, occasionally breeds
Hawfinch	*Coccothraustes coccothraustes*	U	U	U	fr							U	U	PM, WV (local, irregular)
Common Rosefinch	*Carpodacus erythrinus*	v	v	r	r	r			r	r	r	r	v	PM, WV
Sinai Rosefinch	*Carpodacus synoicus*	U	U	U	U	U	U	U	U	U	U	U	U	resident (local), WV
Trumpeter Finch	*Bucanetes githagineus*	C	C	C	C	C	C	C	C	C	C	C	C	Resident & dispersal
Crimson-winged Finch	*Rhodopechys sanguinea*			F	F	F	F	F	F	F	U	U	U	SV (WV) (local at Hermon)
Desert Finch	*Rhodospiza obsoleta*	C	C	C	C	C	C	C	C	C	C	C	C	Resident, (PM), WV, (SV)
Emberizidae														
Corn Bunting	*Emberiza calandra*	C	C	C	C	C	C	C	C	C	C	C	C	(Resident), WV, SV
Reed Bunting	*Emberiza schoeniclus*	F	F	F	E	E	E	E	E	E	F	F	F	PM, WV, SV
Little Bunting	*Emberiza pusilla*	E	E	E	E						v	v	v	PM (WV)
Rustic Bunting	*Emberiza rustica*		E	E	E						v	v	v	PM
Ortolan Bunting	*Emberiza hortulana*			U	C	C	r	r	C	C	C	U	U	PM, SV (local)
Cretzschmar's Bunting	*Emberiza caesia*		F	C	C	C	F	F	C	C	F			PM, SV
Yellowhammer	*Emberiza citrinella*	U	U	U								U	U	WV

English Name	Latin Name	J	F	M	A	M	J	J	A	S	O	N	D	Status
Pine Bunting	*Emberiza leucocephalos*	r	r	r								r	r	WV (local)
Cinereous Bunting	*Emberiza cineracea*			fr	fr	r			r	r				PM
Red-headed Bunting	*Emberiza bruniceps*					E								1 record (1979)
Black-headed Bunting	*Emberiza melanocephala*				U	F	F	F	U	U	U			PM, SV (local)
Yellow-breasted Bunting	*Emberiza aureola*					E				E	E	E		Occasional PM
Rock Bunting	*Emberiza cia*	F	F	F	U	U	U	U	U	U	F	F	F	Resident (local), WV
Mountain Bunting	*Emberiza striolata*	U	U	U	U	U	U	U	U	U	U	U	U	Resident & dispersive (localy common)
Total species: 532														

Legend	
X	Extinct
E	Extremly Rare
V	Very Rare
R	Rare
FR	Fairly Rare
U	Uncommon
F	Fairly Common
C	Common

Passage Migrant	PM
Summer Visitor	SV
Winter Visitor	WV
Summer Breeding	SB
Over-Summering	OS