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Technical Assistance to Support the Government of Lebanon's Preparation of Exploiting and Producing Offshore Oil and Gas Resources

Strategic Environmental Assessment (SEA) for Exploration and Production Activities Offshore Lebanon

SEA Report
VOLUME 2 - Baseline Conditions

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Republic of Lebanon
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Strategic Environmental Assessment (SEA) for Exploration and Production Activities Offshore Lebanon

SEA Report - Volume 2 - Baseline Conditions

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1. INTRODUCTION

This Volume provides an overview of available data and information related to the environment and socio-economic conditions in Lebanon relevant to offshore E&P activities. An integral process in the SEA is data collection and assessment which provides the foundation upon which the SEA and impact assessment is built. To the extent possible, this volume establishes existing conditions for various environmental and socio-economic factors as well as their likely evolution with time without offshore petroleum activities in Lebanon.

It is noted throughout the process that data availability in Lebanon is challenging, and although a relatively large amount of studies and surveys exist, there is still a significant amount of baseline information that need to be established in Lebanon, preferably prior to starting petroleum activities.

A summary of baseline conditions and their likely evolution without petroleum activities described in this volume is presented in **Appendix A.**

A map presenting socio-economic sensitive sites as identified in the draft National Oil Spill Contingency Plan is provided in **Appendix B**.

2. PHYSICAL ENVIRONMENT

2.1 GEOGRAPHIC FEATURES OF THE MEDITERRANEAN BASIN OFF THE LEBANESE COAST

On the margins of land masses, marine waters are very shallow and overlay an underwater extension of continental lands called the continental shelf (defined by Law 163/2011 under the United Nations Convention on the Law of Seas). On global scale, the slopes generally range from 0 m depth from the shore to depth ranging between 100-200 m (Figure 2-1). At the outer edge of the shelf, there is an abrupt steeping of the sea floor to become the continental slope with different depth ranges for different parts of the world. The continental slope then descends precipitously until the bottom becomes the flat, extensive sediment covered plain. The area beyond the continental slope is referred to in this SEA as the deep-sea plain. In Lebanon, the continental slope reaches a depth of approximately 1600-1700m before the sea floor stretches into the deep-sea plain with approximate depth ranges from 1600m to 2100m (Figure 2-2).

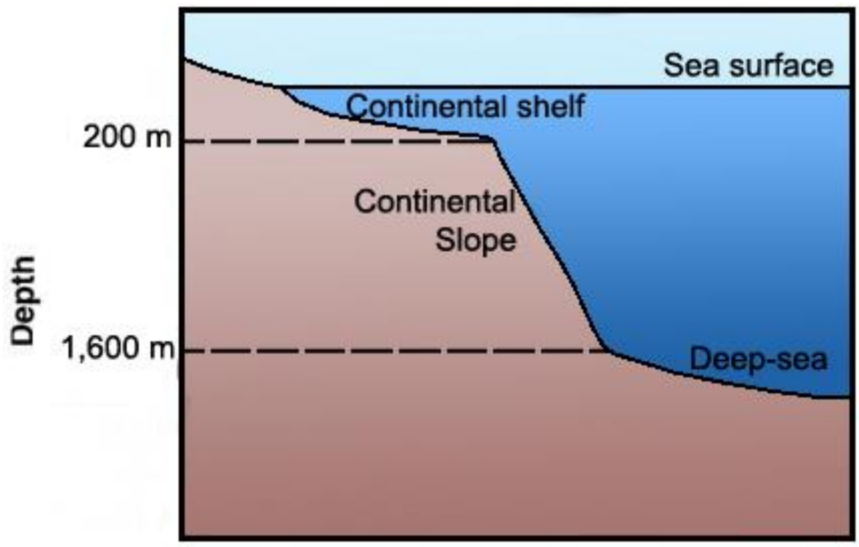


Figure 2-1 Diagrammatic cross section of the sea basin off the coast of Lebanon (Not to scale; large vertical exaggeration and approximation of depth values)
(Source: Nybakken James, (2001), Marine Biology an ecological approach. Addison Waesley Longman, Inc. Fifth Edition. 516p.)

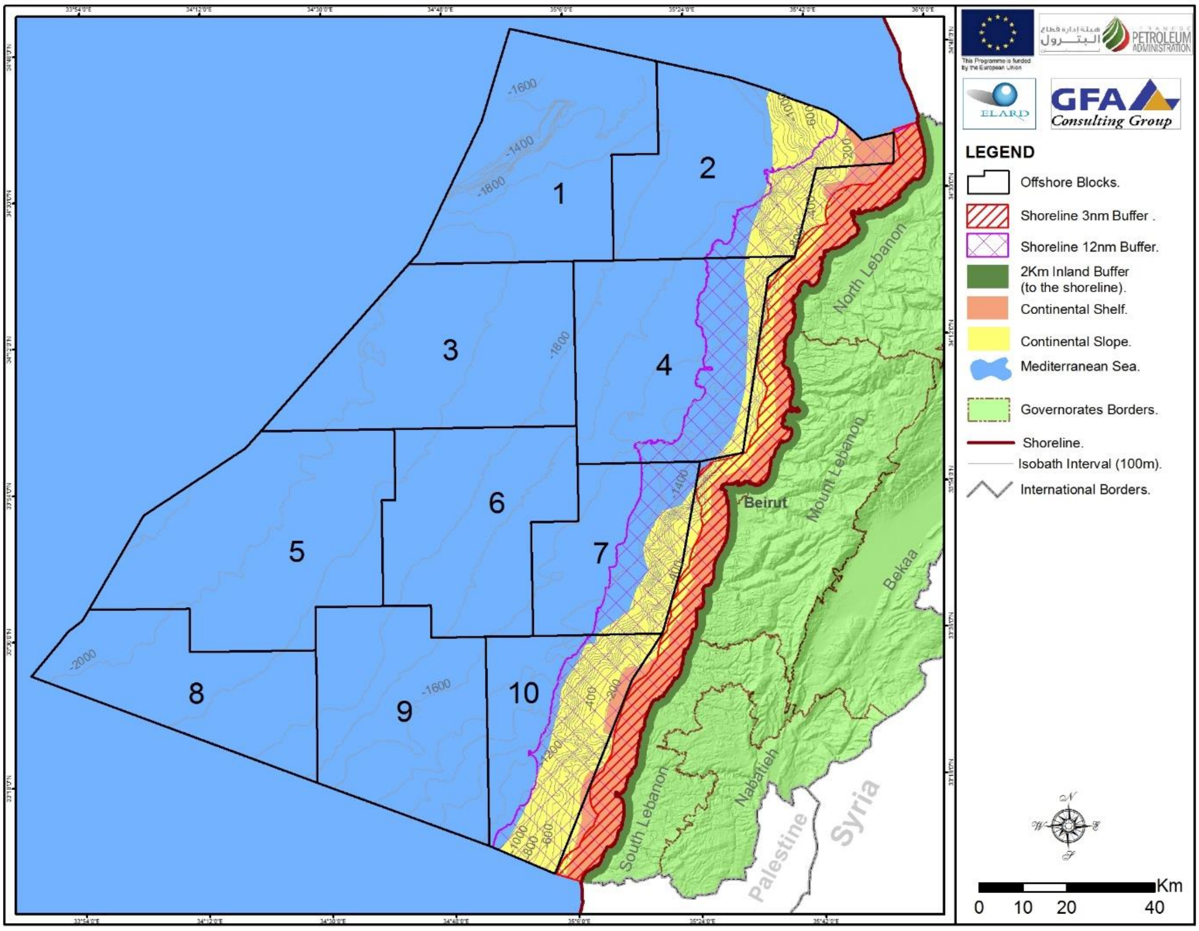


Figure 2-2 Geographic features of the sea basin off the coast of Lebanon

Continental shelves are one of the most productive parts of marine environments. Although they comprise only 7-8% of the surface area of the world oceans and seas, they provide 15-30% of marine primary production. From a biological standpoint, continental shelves are extremely important because they are much shallower than the rest of the ocean/sea basins. This allows enough light to penetrate in the water column for primary production and to reach the sea floor further allowing plant growth. This is indispensable for many animals, including most fishery species, since bottom habitats are generally safer than open water habitats due to the complexity of the shallow natural environment. Any habitat that combines food availability with safety attracts the majority of life forms.

In this area, nutrients supporting the rich and diverse marine life come from both the land and the sea where river and stream runoff is an extremely important source of nutrients and sediments. Wind, tides, and waves serve to keep nutrients in the euphotic layer of the water column while the continental slopes, through their canyons and general geo-morphology return nutrients that had settled into the deep-sea plains (refer to section 0 related to The East Levantine Canyon Area).

Given the extensive anthropogenic pressures exerted on the Lebanese coastal zone (due to urbanization, industrial activities, shipping, fishing, tourism, etc.) including the continental shelf, it is imperative that all precautionary measures be taken to protect and conserve this biome due to its importance to human food security and overall marine ecosystem productivity and equilibrium.

In parallel, the continental slopes present highly localized biodiversity (localized on the slopes) which is fundamental to the production of valuable fisheries, energy, and mineral resources, and performs critical ecological services (nutrient cycling, carbon sequestration, nursery and habitat support).

Even though minimal research activities have taken place on the continental slope and its canyons off the Lebanese coast, serious conservation actions are required to preserve the functions and services provided by these deep-sea environments that science is just starting to understand. Recent surveys in Lebanese Canyons down to a depth of 1,000 m undertaken by IUCN and partners through the OCEANA project with the Ministry of Environment and CNRS confirm the ecological importance of these habitats.

As for the **deep-sea plains**, our knowledge of their biodiversity remains extremely low. They are characterized by the absence of light (absence of photosynthesis), mild to non-existent currents and very specialized biodiversity that can survive in dark, cold, high-pressure environments. Even though more research is being carried out in the Mediterranean, there is no total biodiversity census (i.e., the biodiversity of all forms of life) of any deep-sea region. Scientists nevertheless highlight the presence of clear differences in knowledge of the deep-sea Mediterranean biota due to the fragmented spatial coverage of investigations, which is short of reflecting "*the true species richness*".

2.2 BATHYMETRY

A bathymetric survey of the Lebanese Exclusive Economic Zone (EEZ) was conducted in 2003 by the SHALIMAR bathymetric cruise (MOPWT – DGLMT, 2017) (Figure 2-3).

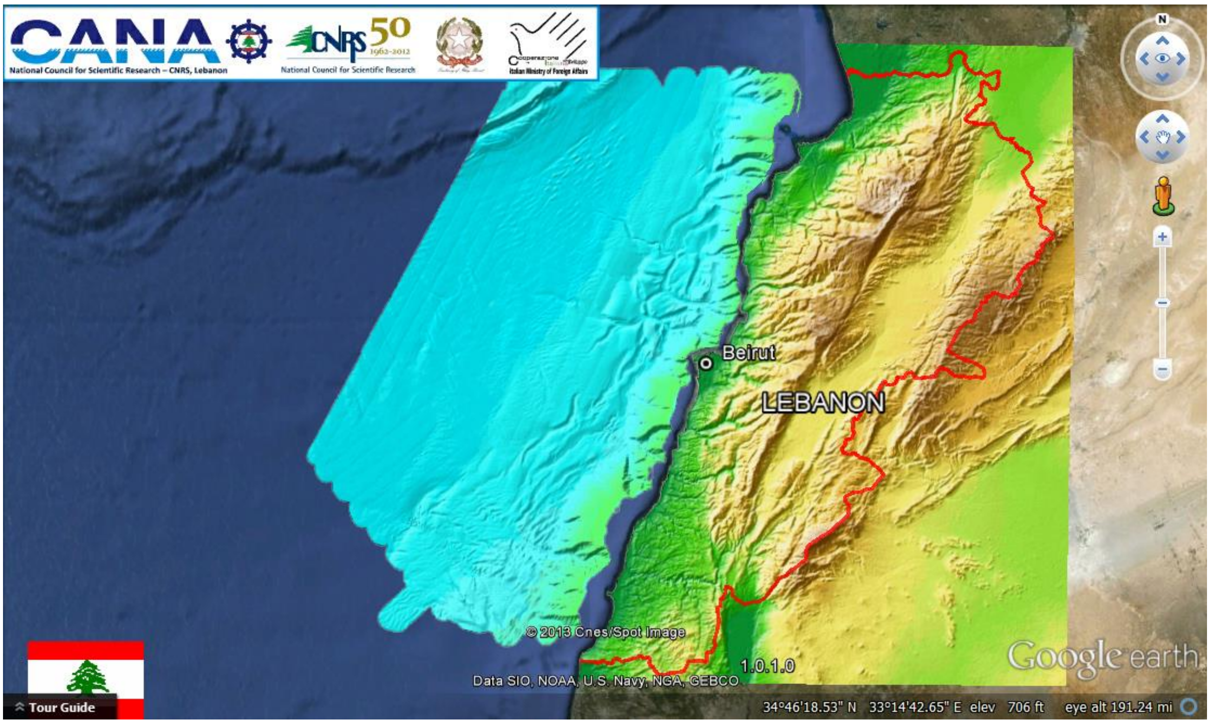


Figure 2-3 SHALIMAR Map

According to the survey, the water depth off the coast increases westward to 2000 m in the abyssal plain of the Levant basin (MOPWT – DGLMT, 2017).

The Lebanese continental shelf itself is relatively narrow, and is considered, as for all continental shelves around the world, the most productive part of Lebanese waters where most fishing activities are concentrated. It can be divided into 3 main parts: 1) the widest part (18 Km) and falls between Enfeh and Akkar; 2) falls between Enfeh and Ras Beirut where the coastal plain is very narrow or almost non-existent (in this part, the continental shelf does not extend to more than 3 Km; and 3) extends from Ras Beirut till Naquoura where the continental shelf widens up again reaching 7 Km (Figure 2-3). Between Beirut and Batroun, the shelf is extremely narrow and the margin exhibits its steepest slope, with the water depth dropping from 100 to 1500 m in less than 5 km in some areas (MOPWT – DGLMT, 2017).

The bathymetry of shallower waters (0-200 meters depth) between the coast and up to 10 km seaward is in the surveying process. Once complete this will connect the inland geomorphology with the seabed relief already mapped during the bathymetric cruise SHALIMAR survey (MOPWT – DGLMT, 2017).

Even though several bathymetrical maps have been produced on localized scales and for specific objectives like ports and private marina construction, such maps are not readily available since they are scattered in several ministries and private entities. Developing such information into one cohesive bathymetrical map will require intensive human and financial resource investment.

The East Levantine Canyon Area (ELCA)

Deep canyons characterize the continental slope of the Lebanese coast. Almost 518 large submarine canyons have been identified in the Mediterranean Sea and are considered as key structures for its ecosystem functioning. Submarine canyons are steep-walled, sinuous valleys, with V-shaped cross sections and relief comparable even to the largest of land canyons. Tributaries are found in most of the canyons and rock outcrops abound on their walls. Because they play a fundamental role in "Deep Oceans-Shelf Exchanges", submarine canyons can be defined as "super highways", allowing the energy turnover to speed up by reducing the time and the distances covered by water masses, organic and inorganic sediments, benthonic and nektonic organisms during their active or passive movements from shallow to deeper waters and vice-versa.

Recent interest has focused on the role of submarine canyons in the exchanges between the deep ocean and continental shelf, as well as in the functioning of the benthic and pelagic ecosystems. Mixing rates inside canyons could be as much as 1000 times greater than rates measured in the open ocean, and upwelling associated with canyons enhances local primary productivity with the effects extending up the food chain to include birds and marine mammals. In addition, unique benthic habitats are associated with submarine canyons, particularly the heads of shelf-incising canyons that are characterized by steep bedrock exposures upon which biologically diverse communities may occur. Submarine canyons that extend across the continental shelf and approach the coast are known to intercept organic-matter-rich sediments being transported along the inner shelf zone. This process causes organic-rich material to be supplied and transported down-slope, where it provides nourishment to feed a diverse and abundant macro fauna.

The report "The Mediterranean deep-sea: highly valuable ecosystems in need of protection" published in 2005 by the IUCN and WWF, led the Members of the General Fisheries Commission for the Mediterranean (GFCM) to prohibit the use of towed dredges and trawl net fisheries at depths beyond 1000 m and in areas called "Deep Sea Fisheries Restricted Areas", such as the Lophelia reef off Capo Santa Maria di Leuca, the Nile delta area cold hydrocarbon seeps, and the Eratosthenes Seamount (South of Cyprus). Based on the results of studies completed by the French Agency for Marine Protected Areas and the Spanish Superior Council for Scientific Research (CSIC), in 2009, the GFCM added the submarine canyons of the Gulf of Lion to the list of fisheries restriction zones (Toropova et al., 2010).

The ELCA is featured by its deep canyons all along the Lebanese and Syrian coasts (Würtz M. (ed.), 2012; Elias A., 2007; Fig. 3), several hydrothermal vents (A Shaban, 2013), submarine freshwater springs (Bakalowicz M., 2014; Jihad G., 1998) in addition to its being of particular importance biologically (Figure 2-4) (IUCN 2012; Nader, 2012; Bariche, 2006).

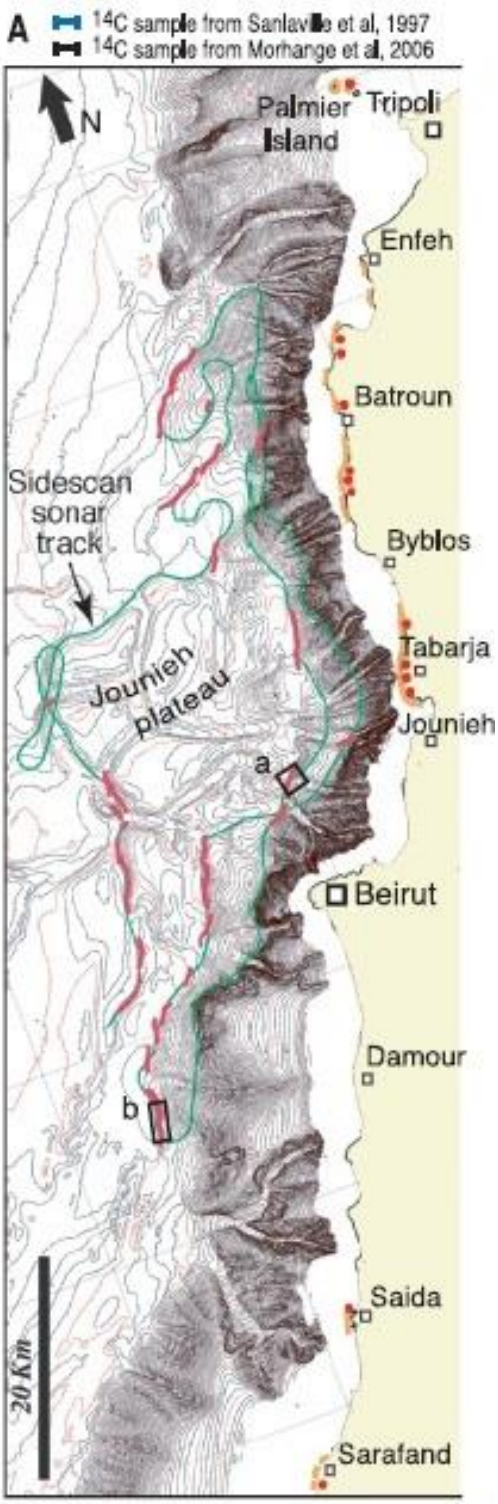


Figure 2-4 Deep sea canyons off the Lebanese Coast
(Adapted from: SINGH Satish, 2003)

2.3 PHYSICAL CHANGE OF THE LEBANESE SHORELINE

A study that aims at detecting erosion, accretion, and sea filling along the coast of Lebanon by comparing the 1962 and 2010 shorelines through GIS and remote sensing is currently underway (MCR-IOE-UOB, 2018). The study is ongoing and the results, once final and published, will help in understanding how such activities affected marine productivity and ecosystem health. Initial results from the study, as displayed in Figure 2-5, show that the shoreline has increased by over 24% from 298 km in 1962 to 371 km in 2010. Beaches have eroded by more than 2.6 Mm² while sea filling has reached a massive 8 Mm² and is expected to increase.

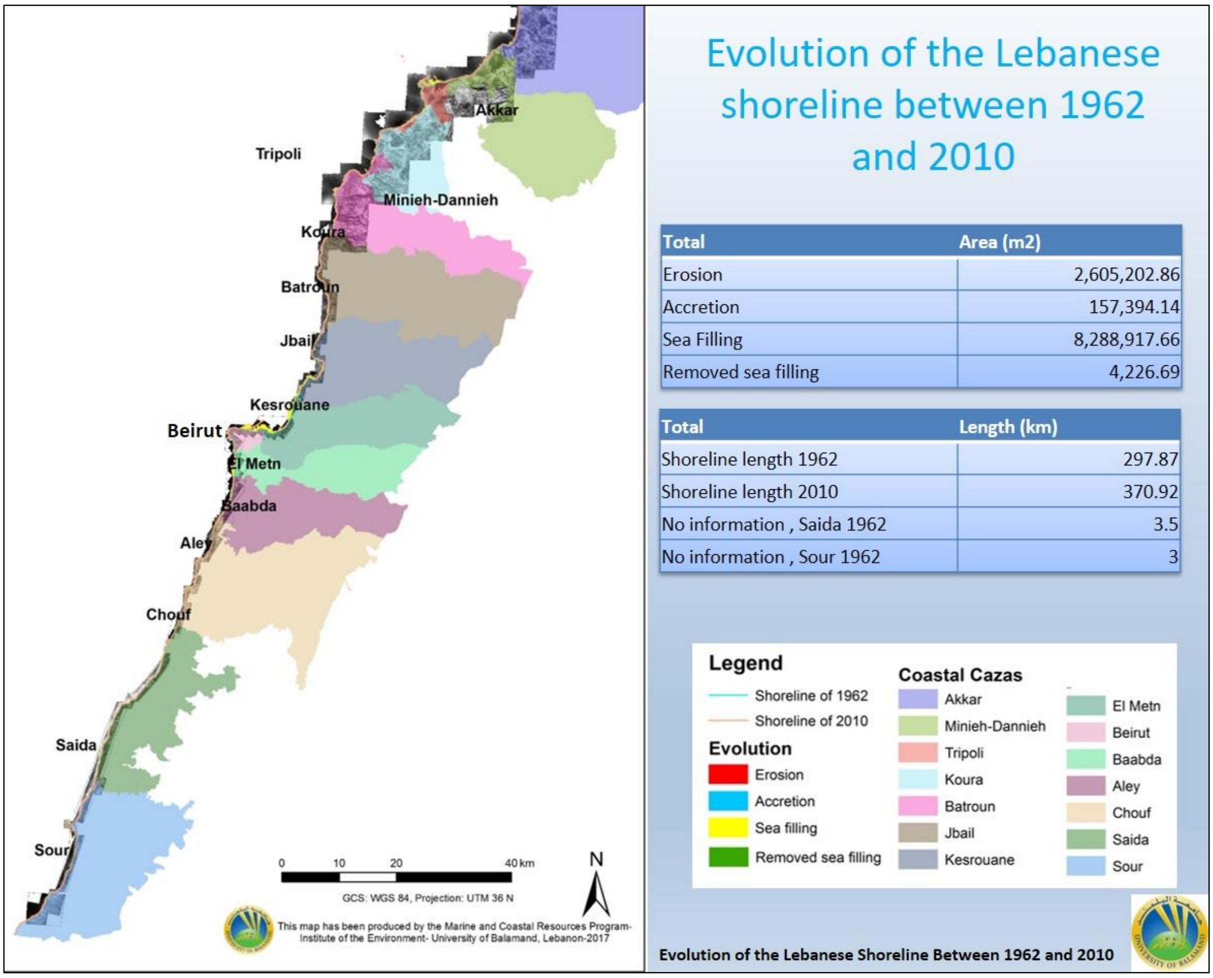


Figure 2-5 Evolution of the Lebanese shoreline between 1962 and 2010 (MCR-IOE-UOB, 2018)

The Lebanese coast is under extreme and increasing anthropogenic pressures that have led, and are leading to the deterioration of the Lebanese shoreline at relatively high rates as expressed by beach erosion and sea filling activities (dumping of material in coastal marine waters to create land. Erosion has most likely caused irreversible damages given that the Lebanese coast is sand starved and beaches do not recover from such losses. In addition, sea filling caused the destruction of subtidal, intertidal and littoral habitats and led to major modifications in coastal dynamics. Waves

2.4 WINDS AND WAVES

It is well reported that waves in the Mediterranean are generated by winds (wind-waves), and therefore they follow the general direction of the prevailing wind. Wave height is proportional to the square of wind velocity with higher wind velocities creating higher waves and generally rougher seas. Mean monthly wave heights vary between 1 and 0.2 meters; yet waves exceeding 5 meters have been recorded (MOPWT – DGLMT, 2017).

In a study that attempted to evaluate the capacity of wave power for producing renewable energy on the Lebanese coast over one year, measurements were taken from three points spread over southern Lebanon, the coast of Beirut, and northern Lebanon. However, reliable data was only obtained from the buoy located off the coast of Beirut. Measurements showed that maximum average monthly wave height reached 1.41 m and that the average significant wave height in Beirut over 12 months (January to December 2003) is greatest in the months of January and February and drops steadily until June while the majority of waves originate and travel from the West to East (Figure 2-6 and Figure 2-7) (Aoun et al., 2013).

Waves are induced by wind blowing over water by three main processes: tangential stress, turbulent airflow that causes shear stresses and pressure fluctuations, and further wave growth resulting from forces on the up-wind face of the wave. Therefore, waves that are more forceful are expected in windier areas, specifically in northern Lebanon, since average offshore winds were found to be strongest with speeds reaching 7 m/sec (Aoun et al., 2013).

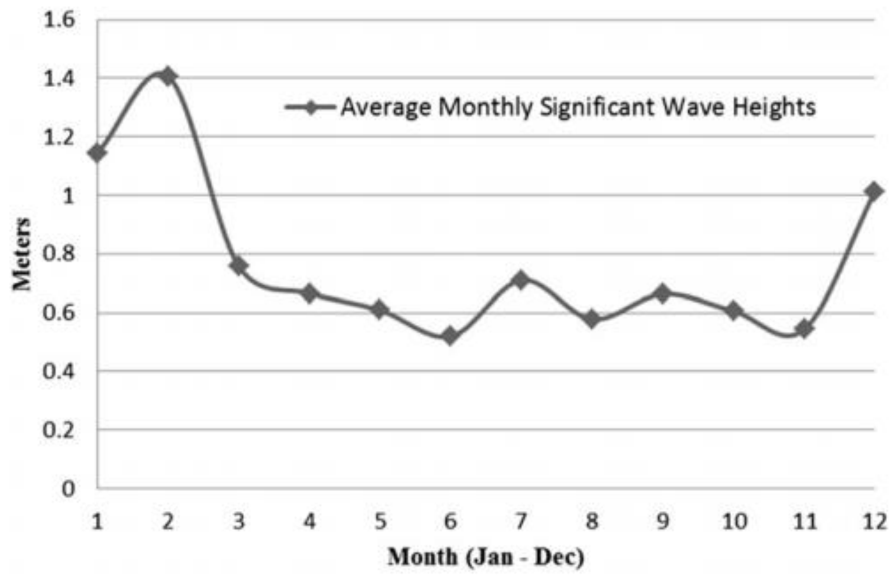


Figure 2-6 Average monthly significant wave heights offshore Beirut (Source: Aoun et al., 2013)

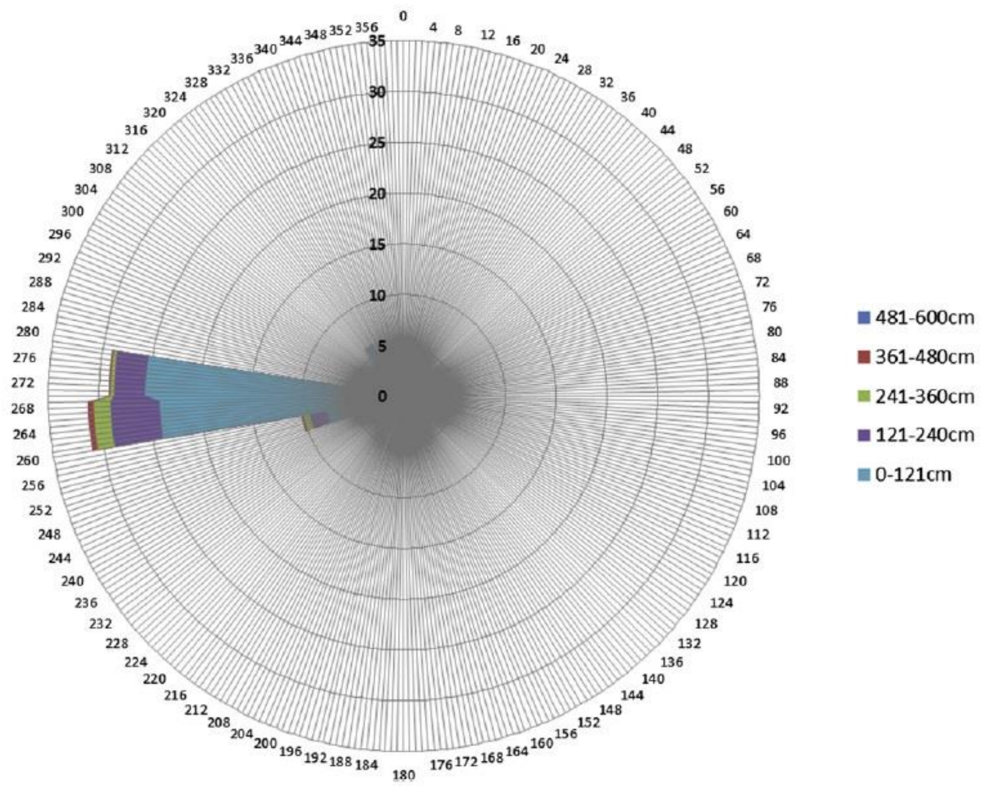


Figure 2-7 Wave rose for year 2003 (Significant Wave Height) offshore Beirut (Source: Aoun et al., 2013)

Based on the data recorded by the Tripoli Environment and Development Observatory (TEDO) between 2012 and 2017, the highest waves in Tripoli, North Lebanon were mostly recorded in the winter season during storm activity reaching around 1.1 m between January and March (TEDO - Tripoli Weather station).

In a study that attempts to evaluate maritime accessibility and protection, wind speed and direction models were generated, in addition to wave height models (

Figure **2-8**, Figure 2-9, Figure 2-10 and Figure 2-11). It can be interpreted from the models that the wind speed pattern differs on the north from the south of the Levantine coast of Lebanon. This could be also witnessed up to 40 km offshore especially during the morning. During the summer this difference is evident during the morning and the afternoon. No violent winds can be observed even during the winter, in which the strongest recorded wind did not exceed 4 on a Beaufort scale of 4 (Safadi, 2016). The generated models show some variations in wind direction patterns although the known predominant winds during the months of May and October are north-westerly, southerly and south-westerly. A noticeable wind direction difference is observed between the northern and southern coast, especially at Tyre which happens to be at the center of directional change (Safadi, 2016).

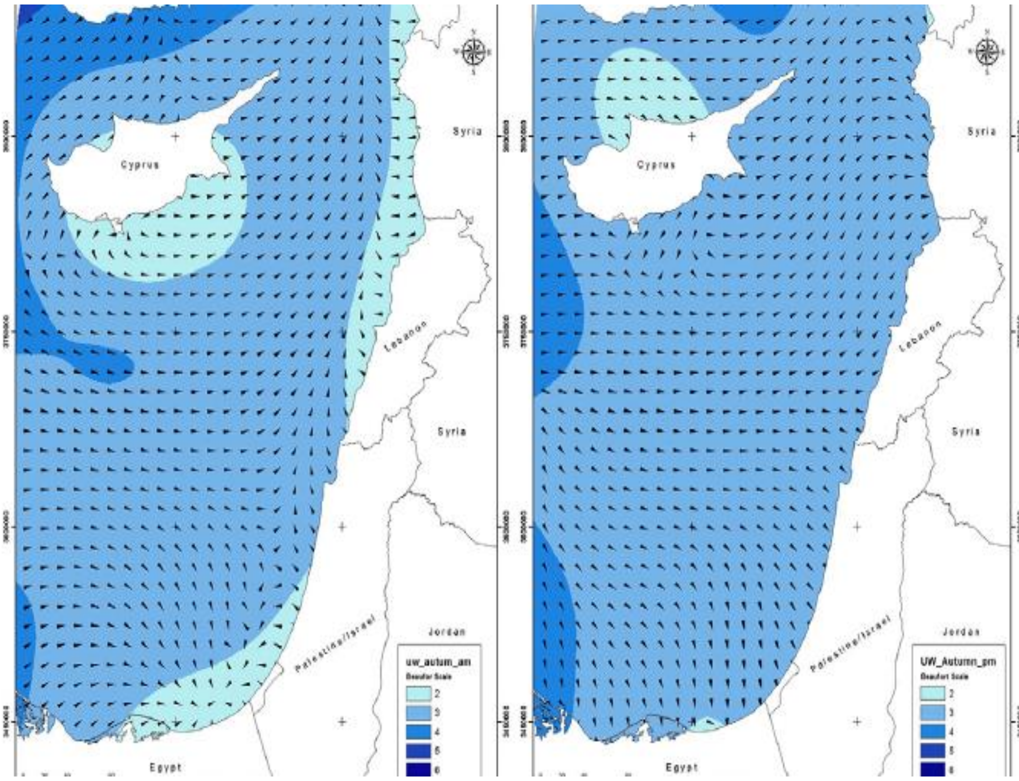


Figure 2-8 Wind Speed and Direction Models for the Autumn in the Morning (left figure) and Autumn in the Afternoon (right figure), (Safadi, 2016)

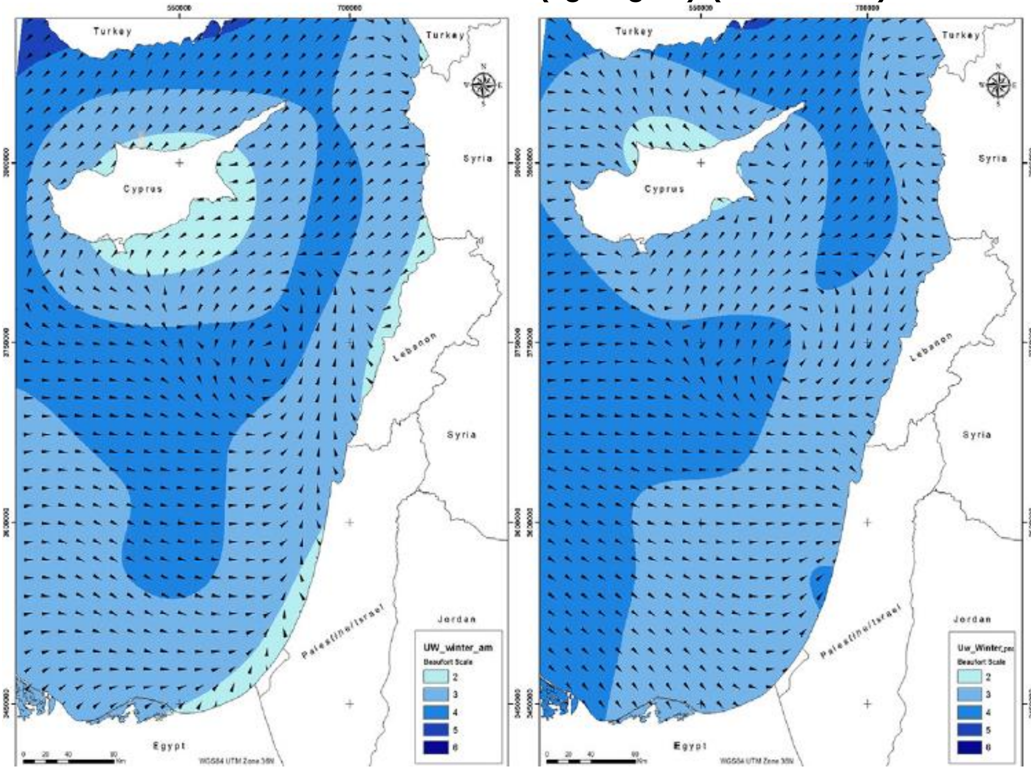


Figure 2-9 Wind Speed and Direction Models for the Winter in the Morning (left figure) and Winter in the Afternoon (right figure), (Safadi, 2016)

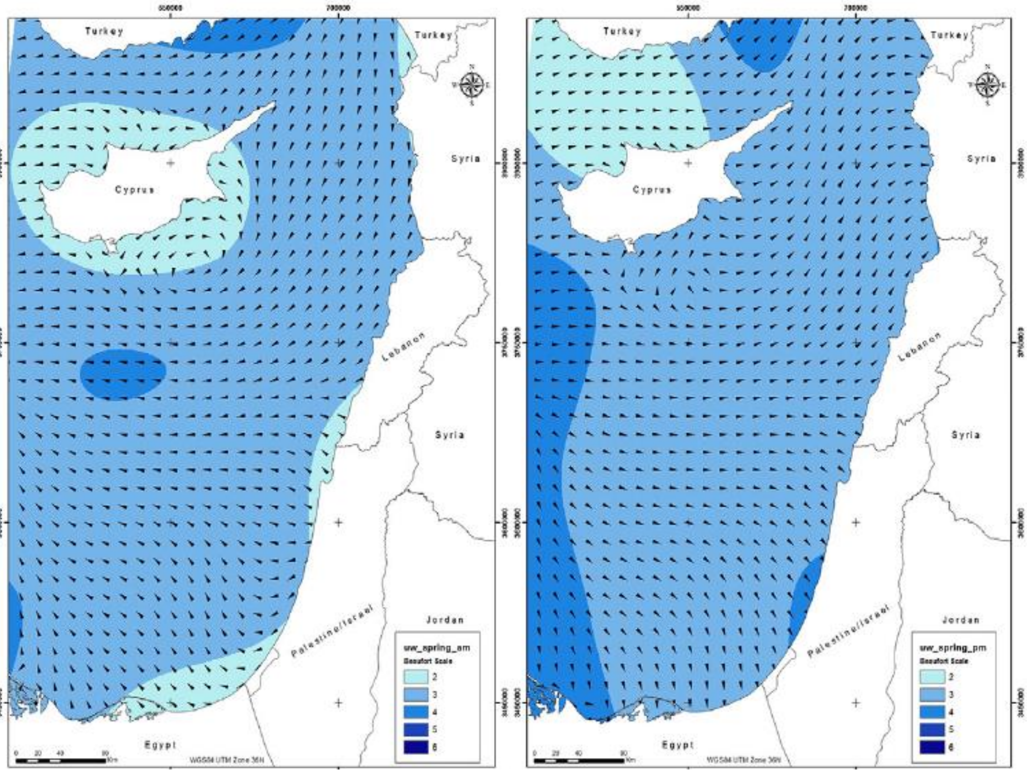


Figure 2-10 Wind Speed and Direction Models for the Spring in the Morning (left figure) and Spring in the Afternoon (right figure)), (Safadi, 2016)

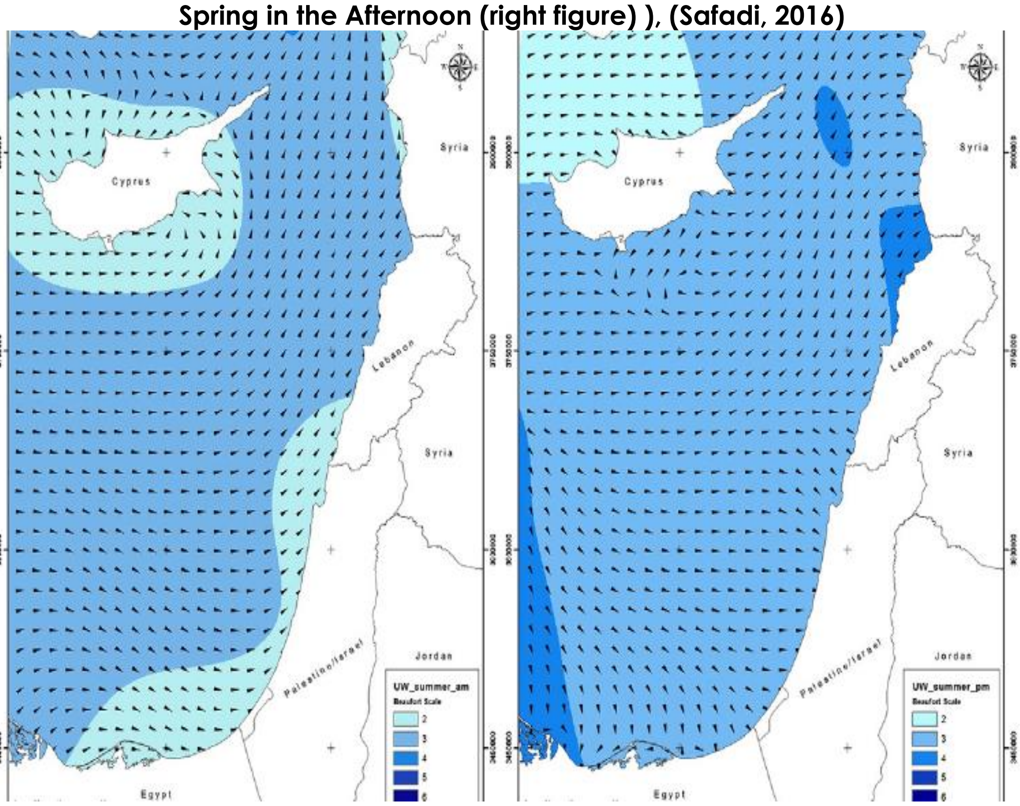


Figure 2-11 Wind Speed and Direction Models for the Summer in the Morning (left figure) and Summer in the Afternoon (right figure)), (Safadi, 2016)

2.5 CURRENTS AND TIDES

The general circulation along the Lebanese coastline is northward in line with the general counter-clockwise gyre of the Eastern Mediterranean. Localized clockwise eddies and small gyres occur as a result of bays, submarine canyons, and headlands (MOPWT – DGLMT, 2017). Tidal activity on the Lebanese coast is weak and ranges between 30 and 40 cm. Nevertheless, this tidal range is essential for the development of vermetid platform. This rocky intertidal ecosystem, like coral reefs, is shaped by the structures of living organisms (Chemello and Silenzi, 2011) and should be protected from any forms of development.

The general East current on the Northern coast of Africa turns North Eastern and North on the coasts of Lebanon and Syria where it becomes weak and variable and affected by winds. The speed of the North current has been recorded to exceed 1 knot during strong Western winds (NG-IA, 2017).

Based on the tidal progression, flood currents in the Mediterranean Sea set East and ebb currents set West. Winds blowing from the West accelerate the flood current, and winds blowing from the East hinder it; whereas the opposite applies for the ebb current (NG-IA, 2017).

The Mediterranean regional seas dynamics (the Adriatic and the Aegean…), and the transport through its straits (Gibraltar and Sicily…) are very important to water circulation in the deep Mediterranean Sea. The Aegean deep water (AeDW) and Adriatic deep water (AdDW) form the Eastern Mediterranean Deep Water (EMDW) while the Tyrrhenian deep water (TDW) and the Gulf of Lions deep waters form the Western Mediterranean Deep Water (WMDW). The EMDW is formed at 1000 to 1500 m depth in the southern Aegean and southern Adriatic, and then it outflows to fill the total depth of the Eastern Mediterranean basin of 4000–5000m (Figure 2-12).

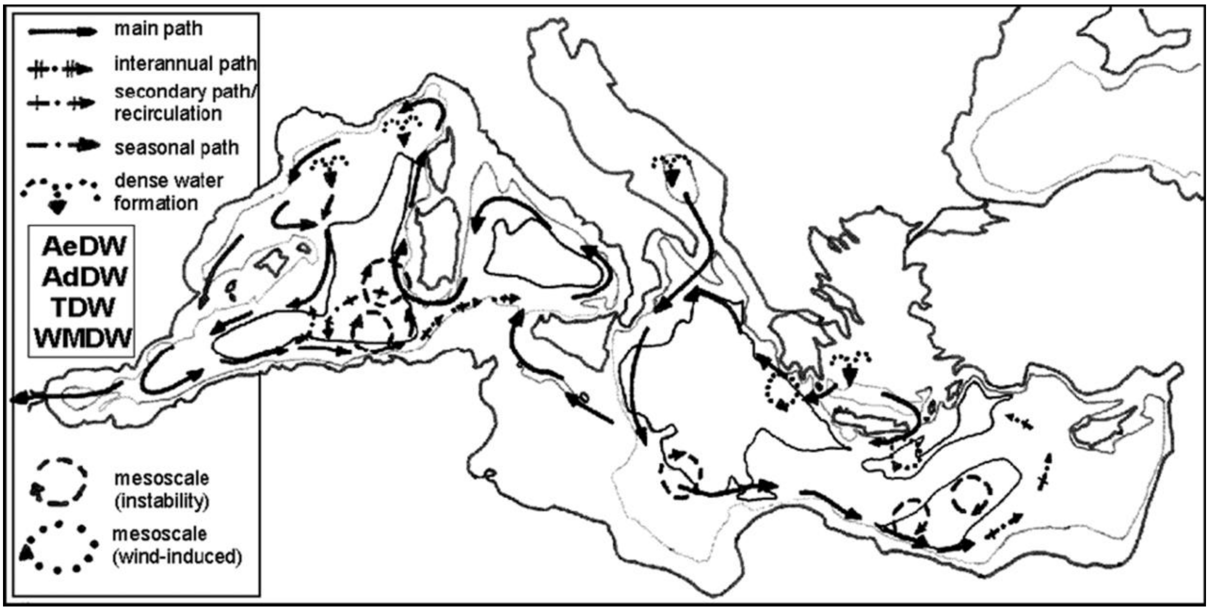


Figure 2-12 Deep-water circulation in the Mediterranean basin, (El-Geziry and Bryden, 2010)

Under the Coriolis force influence, the EMDW flows to the western Mediterranean basin at the deepest point of the Sicily Strait and mainly on the Tunisian side where temperature and salinity slowly decrease with depth indicating a very low static stability.

The deep-waters of the Mediterranean are renewed approximately every 126 years (considering that the upper boundary of the deep regime is of 1200 m).

2.6 GEOLOGY AND RELATED GEOHAZARDS

A brief overview on geology is provided in this section for relevance of introducing the concept of geohazards[1].

Interpretations of the 2D and 3D seismic data acquired within the Levant Basin led to a better understanding of geological domains and structural features onshore and offshore Lebanon.

Based on a recent publication (Ghalayini et al., 2018), Lebanon was subdivided into four domains: the distal Levant Basin, the Lattakia Ridge, the Levant margin, and the onshore (Figure 2-13). The lithological characteristics of the deposited rocks and sediments within the various domains are presented on the chronostratigraphic chart (Figure 2-14) along with the identified potential petroleum system components being the source, reservoir and seal.

[1] A Geohazard is a geological process that poses a threat to people and/or their operations or property. In offshore drilling, a "shallow" geohazard is by definition encountered within the top-hole section of a well (prior to installation of the surface casing). This is typically the first 1000m below the seabed. An unrecognized geohazard can possibly cause a major accident if an operational plan fails to avoid, or mitigate for it.

Lithologies range from sillisiclastics to carbonates in nature depending on the depositional environment and the ongoing regional and tectonic events at the time.

A number of geohazards are associated with offshore exploration activities; these include seismicity, gas hydrates, over pressured zones and submarine landslides.

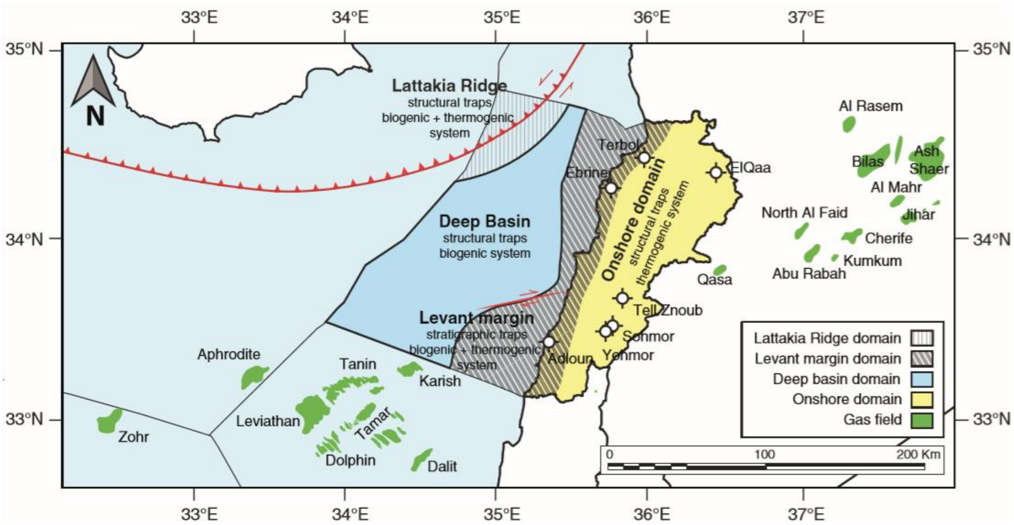


Figure 2-13 Geological Domains of Lebanon (Ghalayini et al., 2018)

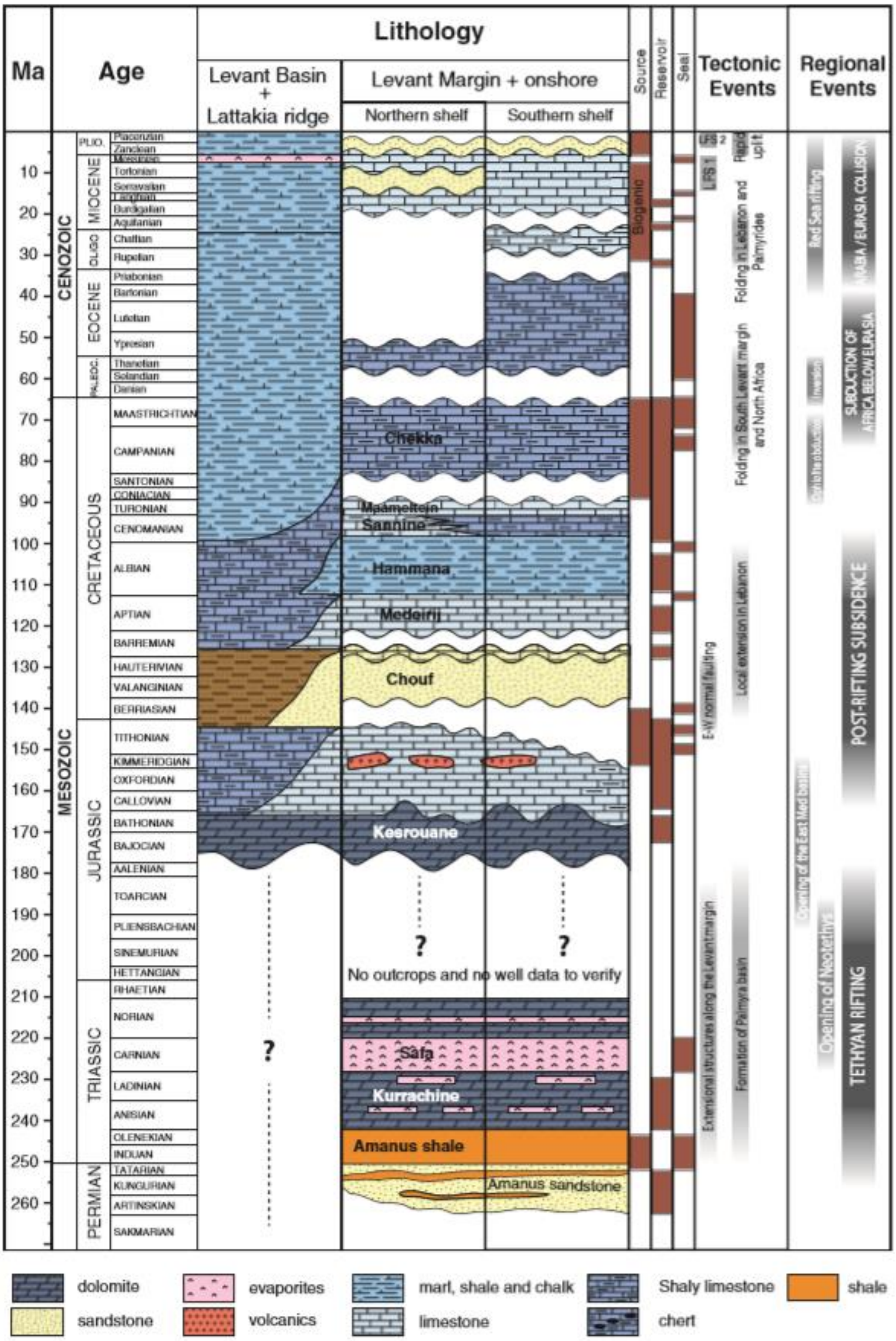


Figure 2-14 Updated Chronostratigraphic Chart of Lebanon (Ghalayini et al., 2018)

2.6.1 *Seismicity (earthquakes)*

Lebanon is located on the eastern coast of the Mediterranean Sea, along the Dead Sea Transform Fault system. The Dead Sea Transform Fault system in Lebanon has several surface expressions such as major fault lineaments (Yammouneh, Roum, Hasbaya, Rachaya and Serghaya faults) and uplifts resulting in mountainous terrain (Mount Lebanon and Anti Lebanon). The fault system also has an active seismic record. Recent work has categorized the Lebanese section of the Dead Sea Transform Fault as being a strong seismic activity zone (Khair *et al.*, 2000). The active structures within and around Lebanon are shown in red on Figure 2-15.

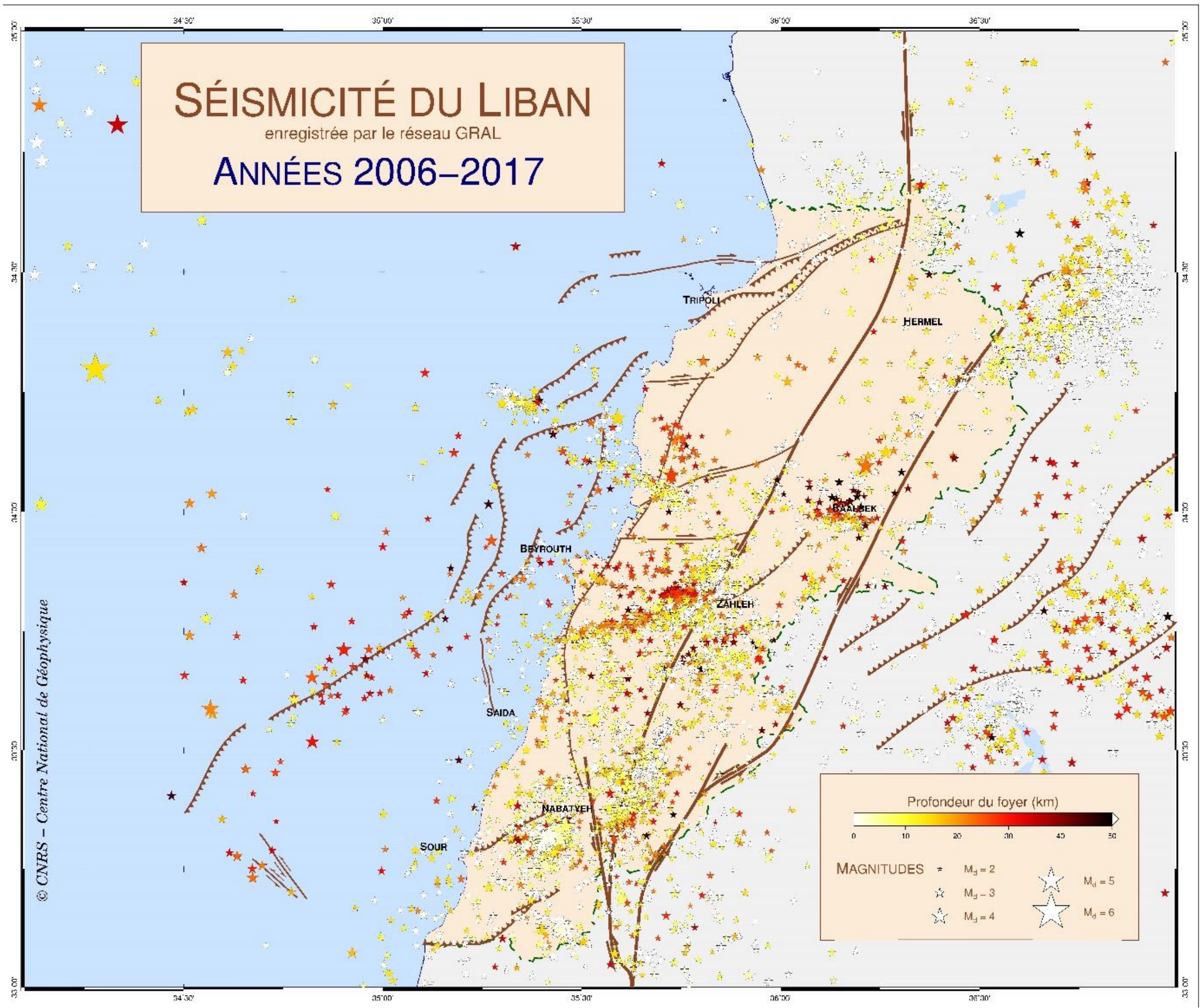


Figure 2-15 Main Structural Elements of Lebanon with Active Ones Shown in Red (CNRS, 2017)

An evaluation study on seismic hazard of Lebanon, carried by Huijer et al., concluded that Lebanon is a country of moderate to high seismic hazard and that the expected Peak Ground Acceleration (PGA) with a 10% probability of exceedance in 50 years varies mostly between 0.20 g and 0.3 g.

A historical seismicity map and a seismic hazard map of Lebanon are presented on Figure 2-16 and Figure 2-17, respectively.

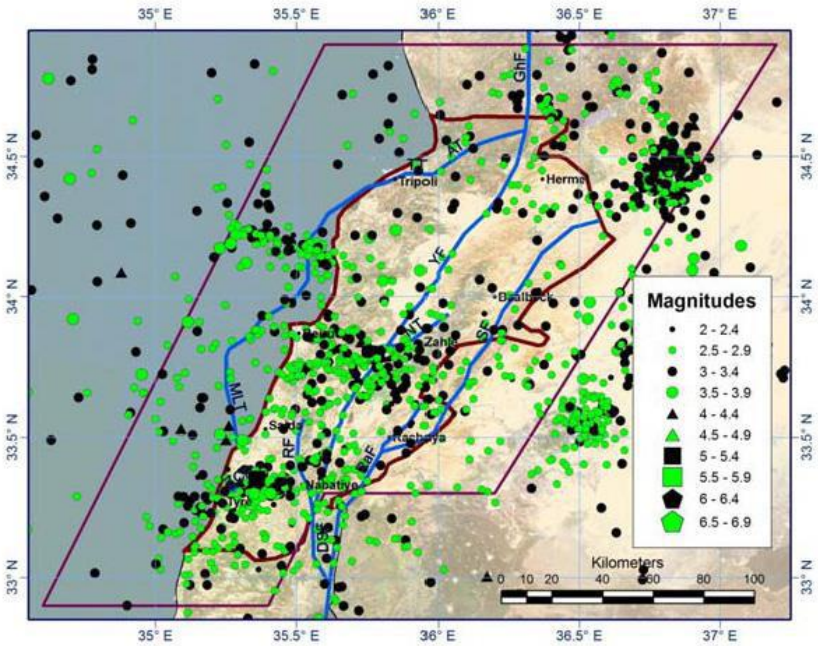


Figure 2-16 Instrumented Earthquake Events in and Around Lebanon between 1998 and 2009 with M ≥ 2 (Figure acquired from original source: Huijer et al., *2011)*

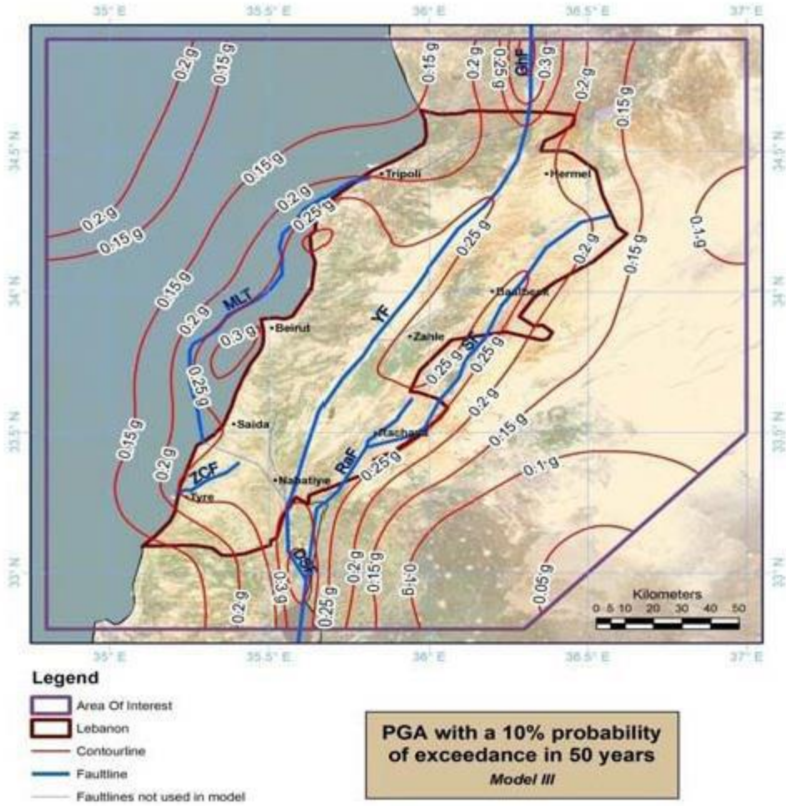


Figure 2-17 Seismic Hazard Map (contouring of Peak Ground Acceleration with a 10% probability of exceedance in 50 years)
(Figure acquired from original source: Huijer et al., 2011)

2.6.2 Gas Hydrates

"Gas hydrates form when methane and water freeze at high pressures and relatively low temperatures. These conditions occur in the shallow part of marine sedimentary sections on many continental margins" (G. Shanmugam, 2012).

These crystalline structures are part of a group of solids known as clathrate and are formed from the mixture of water and low molecular gases at high pressures and low temperatures. Gases likely to combine with water to form hydrates include light alkanes (methane and iso-butane), carbon dioxide, hydrogen sulfide, nitrogen, oxygen and argon.

Gas hydrates are considered as potential hazard, given the impacts they have on the safety of the drilling operations.

The zone or depth at which a methane clathrate naturally exists in the marine environment in the earth's crust is known as a Methane Hydrate Stability Zone (MHSZ) (Praeg et al., 2011).

Modeling of the methane hydrate stability zone (MHSZ) shows it to be present in most of the Mediterranean Sea, albeit in deep waters (>1000 m) due to warm bottom waters (12.5-14°C) and in greater thicknesses (200-500 m) in the geothermally cooler eastern basin.

As observed on the provided map Figure 2-18, the thickness of the stable gas hydrate zone can reach up to 150-200 m offshore Lebanon. It was reported that in the southern part of the Levant Basin, the predicted existence of methane hydrates stability zone (MHSZ) in the seafloor sediments at water depths 1.2 km can have a thickness ranging between 1 and 600 m.

Gas hydrates have been proven by coring at one site in the (eastern) Mediterranean Sea, but their wider extent remains uncertain (Praeg et al., 2011). Comparison of the MHSZ with known or possible zones of gas flux to seabed suggests prospective areas for hydrate occurrence, mainly in the eastern basin. One is the Nile fan, where evidence of the first BSR in the Mediterranean Sea (Praeg et al., 2011) confirms the potential for additional hydrate discoveries.

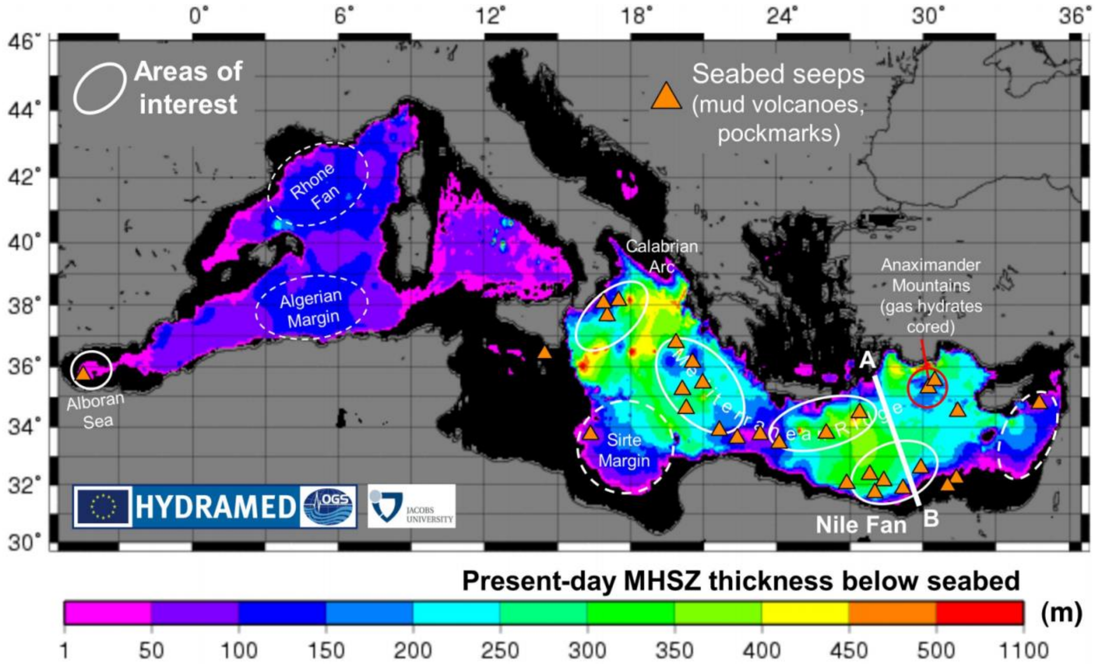


Figure 2-18 Present-day Modeled Methane Hydrate Stability Zone (MHSZ) within the Mediterranean Sea (Praeg et al., 2011)

2.6.3 Over-pressured Zones

Over-pressured zones or surpressures are formations containing fluids with abnormally high pressures. These reservoirs are isolated environments or at least the fluid flow out of the reservoirs is restricted and the total overburden load is partially supported by the pore fluids (Serebryakov et. al, 2002). The generation of Over-pressured zones has been associated with diagenetic reactions, rapid sediment disposition, gas charging and melting of gas hydrates (Garziglia et al., 2008). Drilling into overpressured strata can be hazardous because overpressured fluids escape rapidly, so careful preparation is made in areas of known overpressure.

The Messinian evaporitic layer referred to in the Figure 2-19 is an example of a sealing rock that can hinder the escape of fluids. Recent research, however, have challenged this view by documented evidence of fluid migration pathways and breaching of ascending fluids through evaporites in near-lithostatic overpressure conditions (Bertoni et al., 2015). The Messinian evaporitic is the result of the Messinian Salinity Crisis (MSC) during which a salt body (>1 × 10^6 km^3) accumulated on the Mediterranean seafloor within ~640 k.y. (Gvirtzman et al., 2017). The lithological character if what is thought to be an intra-evaporite highly reflective layers is still debatable. One of the early interpretations suggested that the high reflectivity layers within the salt are overpressurized clastics (Garfunkel, 1984), which create tightly sealed reservoirs and should be seriously considered as a drilling hazard.

Other features that present evidence of overpressured zones are gas chimneys and mud volcanoes. These are discussed in sub-sections below.

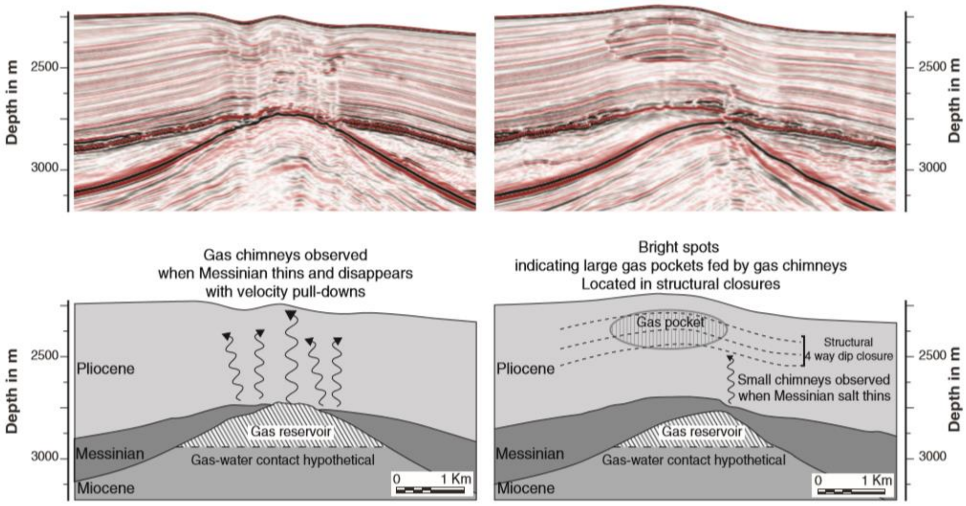


Figure 2-19 Geo-seismic lines showing gas chimneys on top of a Miocene anticline in the Lattakia Ridge domain observed only when the Messinian seal thins or is absent (Ghalayini et al., 2018)

- **Gas Chimneys and Gas Pockets**

Two potential geologic hazards, mud volcanoes and pockmarks, have been documented with increasing frequency since worldwide requirements for offshore hazard, environmental and engineering surveys have become more exacting (Newton, 1980). Mud volcanoes are "plano-conical features exhibiting relief of up to 500 meters on land. Their base diameters range from less than one to over three kilometers." While pockmarks are circular depressions in the silty, alluvial seafloor sediment average 20 meters in diameter and attain depths up to three meters" (Newton, 1980). Analysis of the data collected led to the conclusion that the pockmarks resulted from the escape of either artesian water or gas upwards through the thick alluvial sediment of the sub bottom.

The formation of mud volcanoes has been recently associated with over-pressured zones developed by compaction disequilibrium, hydrocarbon generation and liquefaction processes.

The eastern basins of the Mediterranean Sea are the sectors where mud volcanoes and related fluid expulsion features are the most abundant. The observations summarized in Figure 2-20 show that the vast majority of features occur along the accretionary piles resulting from the convergence/subduction of the African and Eurasian plates (Mascle et al, 2014).

In the southern part of the Levant Basin, The Nile deep turbiditic system displays many fluid-releasing structures on the seabed: mud volcanoes reassembling small cones (100–900 m in diameter), mud pies (5 km in diameter), and pockmarks. These features delineate a belt of apparently very active gas chimneys along the upper continental slope. Pockmarks are erosional depressions formed by fluid expulsion from over-pressured zones via low permeability pathways also known as Fluid Escape Pipe and typically associated either with strongly destabilized sedimentary masses or with gas chimneys. Among the controlling parameters interacting in fluid release are localized overpressured and under-compacted fluid-rich sediments that can act as drilling hazard if not taken into consideration.

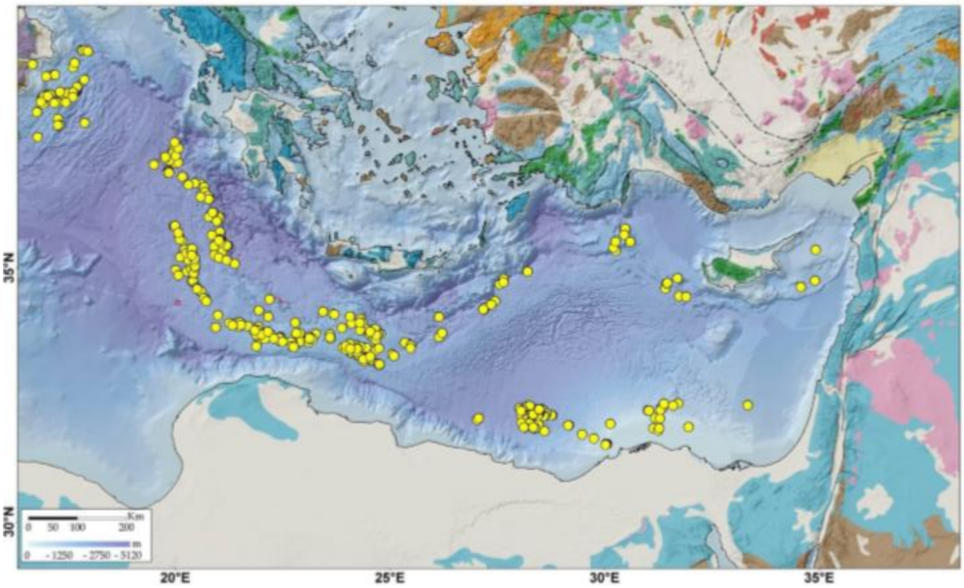


Figure 2-20 Distribution of mud volcanoes and other fluid/mud-releasing structures (yellow dots) in the eastern Mediterranean (Mascle et al., 2014)

2.6.4 Submarine Landslides and coastal slope failures

Submarine slope instability can be defined as a variety of down slope movements of the material composing slope (Ye, 2017).

The major risks related to submarine landslides include destruction of seabed infrastructure, collapse of coastal areas into the sea and landslide-generated tsunamis.

Submarine landslides mapped in the Mediterranean Sea basins, compiled from multiple sources are presented on Figure 2-21 (modified from Urgeles and Camerlenghi, 2013).

Slump deposits associated with submarine landslides along the continental margin of southern part of the Levant Basin have been described by Martinez et al. (2005) using 3D seismic data. The high occurrence of slumping processes along the southern continental margin was possible because of a combination of seismic activity, presence of gas within the sediments, and relative steep slopes (Martinez et al., 2005).

Should similar landslides exist in the Lebanese offshore, they would most likely be located along the boundary of the shallow shelf margin and the deep part of the basin (Figure 2-21), however, this is to be further investigated and studied.

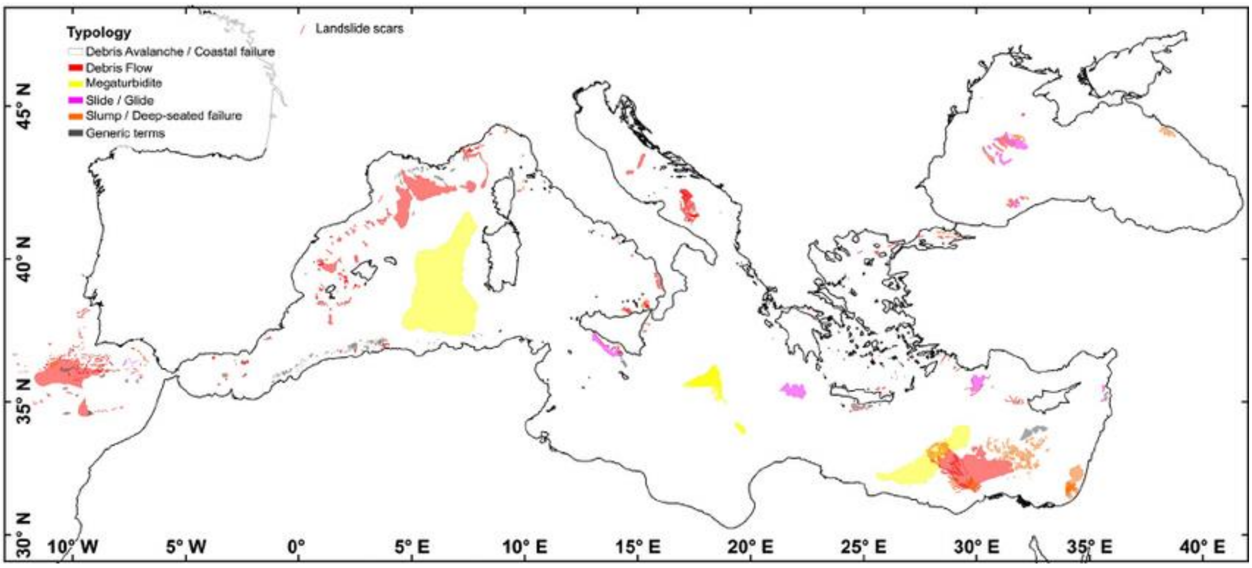


Figure 2-21 Mapped Submarine Landslides within the Mediterranean (modified from Urgeles and Camerlenghi, 2013)

2.7 CLIMATE AND CLIMATE CHANGE

Lebanon is generally characterized by having a typical Mediterranean climate with warm and dry summers (June to September) and cold and wet winters (December to mid-March). The annual mean temperature is about 15°C (MoE/UNDP/GEF, 2017).

Lebanon's climate is shaped by its topography that is mostly mountainous and comprises of: the narrow coastal strip, the Mount Lebanon range that has an average elevation of 2,200 m, the Anti-Lebanon Mountain range and the Bekaa valley plateau with 120 km length and an average elevation of 900 m (MoE/UNDP/GEF, 2016). The Bekaa Valley lies between the Mount Lebanon and the Anti-Lebanon mountain ranges. A typical Mediterranean climate with maritime characteristics exists along the coastal area and West of the country, while East Lebanon exhibits a continental-like climate (MoE, 2017).

During the hot and humid summers, temperatures can cross 35°C in August along the coast (MoE/UNDP/GEF, 2016). In January, temperatures along the coast can drop to 5 to 10°C (MoE/UNDP/GEF, 2017).

In terms of rainfall, coastal areas experience an average annual precipitation that ranges between 700 to 1,000mm (MoE/UNDP/GEF, 2017). The mountainous region of Mount Lebanon has an annual average precipitation level of 1,200mm, whereas the annual average precipitation in the Bekaa valley is 700mm, and can reach as low as 200-600mm in the northern Bekaa region (Farajalla, *et.al*, 2014). Around 70% of the average rainfall in the country falls only in a few days in the rainy season in heavy storms that occur between November and March (MoE/UNDP/GEF, 2017). Overall, rainfall levels inland are higher than along the coast in addition to snowfall in the mountains (MoE/UNDP/GEF, 2017).

Lebanon has a diverse natural coastal, agricultural, forest and mountainous environments with unique biodiversity and ecosystems that are sensitive to climate change (MoE, 2015). As a developing country with scarce water resources and high population density in the coastal areas, Lebanon is facing numerous challenges as a result of climate change that will continue to have a strong effect due to increasing trends in a hotter and drier climate. For that reason, climate change adaptation is a priority for Lebanon (MoE, 2015).

The Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources in the Arab Region (RICCAR), which was led by the United Nations Economic and Social commission for Western Asia (ESCWA), projected climatic changes in the Arab region using an integrated methodology for modelling. The results of the projection showed a general increase in temperatures in the Arab region by the end of the century with more frequent warm days and long summer periods.

In Lebanon in particular, RICCAR showed an increase between 1.2 and 1.7°C by 2046-2065 which intensifies by 2100 along with drier conditions (MoE/UNDP/GEF, 2016). According to the climate change models, namely the Representative Concentration Pathway (RCP) developed by the Intergovernmental Panel on Climate Change (IPCC), temperatures are expected to increase by around 1.2°C, at the same time rainfall is projected to decrease by 4% by 2046-2065 under a moderate projection of 4.5 (RCP4.5) that considers a moderate case scenario (MoE/UNDP/GEF, 2016). Under the worst case scenario (RCP8.5), the average temperature will increase by 1.7°C while precipitation will decrease by 11% (MoE/UNDP/GEF, 2016). Overall, extreme weather events are expected to intensify by the end of the century where seasonal variations and drought periods are projected to continue (MoE/UNDP/GEF, 2016).

The main identified impacts of climate change on Lebanon in the coming years, as identified in the Second and Third National Communication Reports to the United Nations Framework Convention on Climate Change (UNFCC) (MoE/UNDP/GEF, 2016), will be:

- Decreased snow cover and snow residency time;
- Decreased water availability due to reduced precipitation and accelerated snow melt;
- Increased drought periods, especially the Bekaa, Hermel, and South regions;
- Higher energy demands for cooling purposes;
- Weakened winter tourism and loss of natural touristic attractions;
- Sea level rise between 30-60cm in 30 years if the current sea rise rate (20mm/year) continues;
- Increased mortality and morbidity due to outbreaks of infectious diseases, extreme heat events, malnutrition from droughts and floods. In addition to the increase in water-borne, vector-borne, and rodent-borne diseases;
- Damaged infrastructure from changing patterns in precipitation and sea level rise.

The proposed adaptation and resilience measures that can reduce the impacts of climate on Lebanon are identified in 5 main sectors: Water resources, Agriculture, Forest resources and Biodiversity, Public Health, Electricity, Coastal communities and Ecosystems and Tourism (MoE/UNDP/GEF, 2017). Table 2-1 presents a summary of adaptation options for relevant sectors.

Table 2-1 Summary of Adaptation Options in Key Sectors related to Offshore Oil and Gas (MoE/UNDP/GEF, 2017)

Sector	Adaptation Options and Initiatives
Water Resources	Improving water governance by developing a national adaptation plan for the water sector in Lebanon in order to implement and develop water infrastructure projects, improve water quality and access. Measures can include: reducing the likelihood of saltwater intrusion into the coastal freshwater aquifers, improving water-efficiency and water conservation initiatives, developing watershed management plans, and investigating alternative sources of water.
Public Health	Improving knowledge and awareness about the interactions between climate change and public health, strengthening the systems in place for monitoring and responding to climate change impacts, capacity building and developing the parties responsible for responding to climate change impacts on public health.
Electricity	Developing new energy-supply systems that can be minimally affected by the extreme weather events, as well as improving energy-use efficiency in buildings and transportation systems.
Coastal communities and Ecosystems	Improving the resilience and adaptation of coastal communities and ecosystems to climate change can occur by developing or relocating

Sector	Adaptation Options and Initiatives
	human projects away from areas that will be exposed to sea level rise, creating coastal marine reserves, and developing strategies for protecting coastal communities from extreme weather events.
Tourism	For the tourism sector, climate resilience can include developing better insurance plans for touristic establishments, relocating touristic establishments to areas that are less vulnerable, and reducing the stress on climate-sensitive natural resources that can significantly affect the tourism sector.

As identified by the Second National Communication report, in 30 years and if the recent estimated rate of sea level rise at 20 mm/year persists, sea levels will rise up to 30-60 cm (MoE/UNDP/GEF, 2016). Some of the impacts resulting from higher sea levels include: alterations to coastal ecosystems, seawater intrusion into aquifers, increased flooding and coastal erosion.

3. ENVIRONMENTAL QUALITY

3.1 AIR QUALITY AND GREENHOUSE GASES (GHGS) EMISSIONS

Lebanon's coverage in air quality monitoring improved since 2001 (MoE, 2017). Back then, there was no government-driven program for air quality monitoring, monitoring efforts were conducted by academic universities and institutions and had short-term research projects on air pollution in Lebanon, with special focus on the capital city, Beirut. Since then air quality monitoring activities started to become more coordinated and organized (MoE, 2017).

The only reported emissions until 2012 were those prepared under the National Communications for the United Nations Framework Convention for Climate Change (UNFCCC) that focused on Greenhouse Gases (GHG) emissions. In 2013, MoE launched the Lebanese Air Quality Monitoring Network (AQMN). A total of 15 monitoring stations were installed between 2013 and 2017 in addition to 3 monitoring stations installed in the Urban Community of Al-Fayhaa (MoE, 2017). The location of the air quality monitoring stations was based on the technical requirements of the EU directives as well as a pre-assessment of the existing situation.

The implementation of the AQMN was done over two main phases (MoE, 2017):

- Phase 1: implemented in 2013 where five stations were installed and connected to a Data Acquisition System (DAS) at the MoE; and
- Phase 2: implemented in 2017 where 10 additional stations were installed in addition to 8 standalone weather stations, 3 stations to monitor Particulate Matter levels and one calibration station. All the stations are connected to the DAS at the MoE.

  During the same period, the Urban Community of Al-Fayhaa (UCF) in North Lebanon installed three stations in the cities of Tripoli, Mina and Beddawi. These stations will be connected to a DAS within UCF's premises, however, the generated data will be communicated to the MoE's DAS in order to consolidate all air quality parameters (MoE, 2017).

These stations are mainly located in main cities along the coastal line as shown in Figure 3-1.

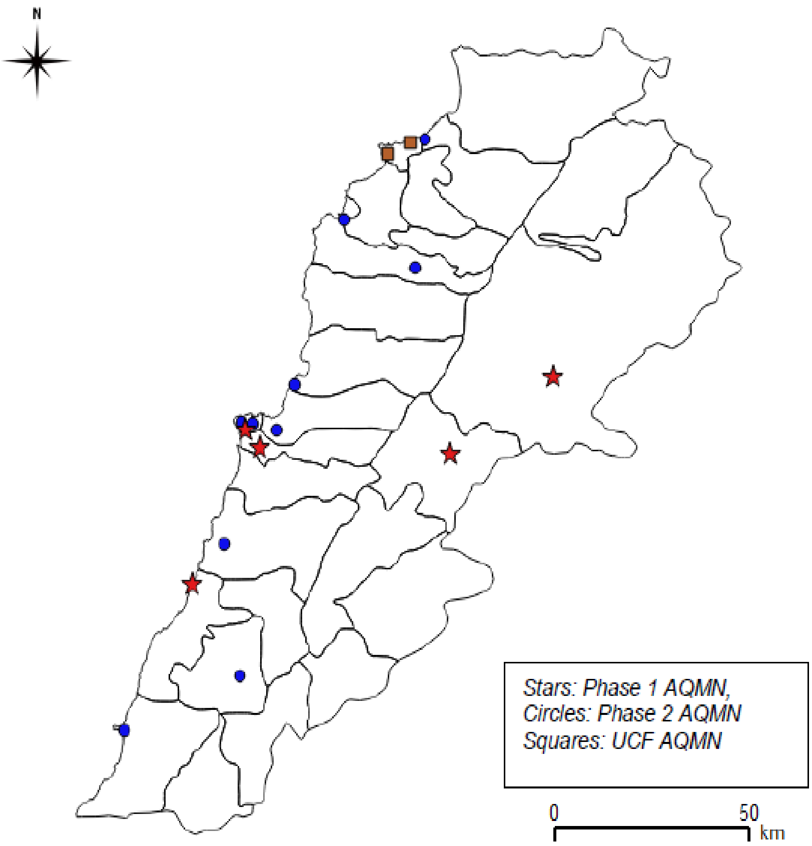


Figure 3-1 Distribution of Air Quality Monitoring Stations (MoE, 2017)

Table 3-1 provides an overview of the status of main air pollutants in Lebanon based on various individual research studies and the most recent AQMN data (MOE, 2017). It is worth to note that prior to the establishment of the AQMN, homogenous local and long-term data were generally missing. Available data were fragmented which limits the ability to understand evolutions and trends.

Table 3-1 Status of Air Quality in Lebanon

Parameter	Overview
Ozone	Ozone levels monitored from May 2004 to February 2006 and since September 2013 (Phase I AQMN) showed a few number exceedances of ozone levels from National Ambient Air Quality Standards (NAAQS) (Decision 52/1), i.e. 135 exceedances for the 150 µg/m³ (1hr) and 18 exceedances for the 100 µg/m³ (8hrs). Results showed higher values in Baalbeck (Bekaa plain) than in Beirut (Coastal). Highest values were observed in the summer as meteorological conditions are more favorable for the formation of ozone.
NO_2	NO_2 levels monitored throughout different field campaigns and studies at various stages since 2004, before it was consistently monitored as of 2013 (Phase I AQMN), were higher than WHO guidelines of 40 µg/m³ but were compliant with NAAQS (Decision 52/1) at 100 µg/m³. It is important to note

Parameter	Overview
	that with the adoption of the new Air Quality Law in Lebanon, national ambient standards should meet at least WHO values, in which case compliance status with standards will change.
PM_{10} and $PM_{2.5}$	PM measurements comprise many years of observation from short to medium term field campaigns in different locations of Greater Beirut Area mostly between 2003 and 2014. PM values always exceeded annual WHO guidelines for PM_{10} and $PM_{2.5}$, set at 20 and 10 µg/m³ respectively, but mostly showed compliance in PM_{10} levels of the Lebanese NAAQS set at 80 µg/m³ with the exception of 2 years were annual values exceeded the 80 µg/m³. PM_{10} and $PM_{2.5}$ levels recorded in Tripoli Urban Center for the period 2000 – 2014 showed values of PM always above WHO guidelines. Annual concentrations of PM_{10} levels exceeded the Lebanese NAAQS (Decision 52/1) over 10 years.
SO_2	SO_2 levels measured from December 2004 till July 2006 within Beirut showed low SO_2 concentrations of 8 µg.m^{-3} compliant with NAAQS (80 µg/m³) (Decision 52/1). Observed values in 2014 were all compliant with the Lebanese standards for the different averaging periods with a yearly average of 12.5 µg/m³, 15 µg/m³, and 4.68 µg/m³ in Zahle, Hadath, and Saida, respectively.
CO	CO levels measured from December 2004 till July 2006 and since 2013 did not indicate any important concentrations in Beirut background even at peak traffic hours hence always being compliant with NAAQS (Decision 52/1).
Benzene	Measurements of benzene conducted in suburban Beirut in summer 2011 and winter 2012 showed average levels of benzene of 2 µg/m³. While this is compliant with NAAQS (16.2 µg/m³), it is associated with an excess lifetime risk of leukaemia according to WHO standards (less than 1/100,000).

Various sources contribute to the emissions of air pollutants in Lebanon. Transportation is one of the main sources of air pollution in Lebanon (Waked et al., 2012, Waked and Afif, 2012). It is estimated that around 93% of the emissions of Carbon Monoxide (CO), 67% of Volatile Organic Compounds (VOCs), and 52% of Nitrogen Oxides (NO_x) originate from the road transport sector. Power plants and industrial sources are also contributors to air pollution: 73% of the emissions of Sulphur Dioxide (SO_2), 62% of Particulate Matter (PM_{10}) emissions and 59% of $PM_{2.5}$ are estimated to originate from power plants and industrial sources. A large fraction of the emissions is concentrated in main coastal cities: Beirut city, Zouk Mikael, Jiyeh, and Chekka (Waked et al., 2012; MoE, 2017).

In terms of Greenhouse Gas (GHG) emissions, it was estimated that in 2013, Lebanon emitted around 26,285 Gg $CO_{2equivalent}$ with the most significant GHG being carbon dioxide, primarily produced from the burning of fossil fuels (MoE/UNDP/GEF, 2017). CO_2 removals from the land use, land use change and forestry category amounted to 3,518.80 Gg CO_2, bringing Lebanon's net emissions down to 22,766 Gg $CO_{2equivalent}$ (MoE/UNDP/GEF, 2017). The main contributor to GHG emissions is the energy sector with 56% of GHG emissions, followed by transport (23%), industrial processes (10%) and waste sector (7%) (MoE/UNDP/GEF, 2017). Figure

3-2 shows the recalculated time series for 1994-2013 that indicates an increase in GHG emissions in Lebanon.

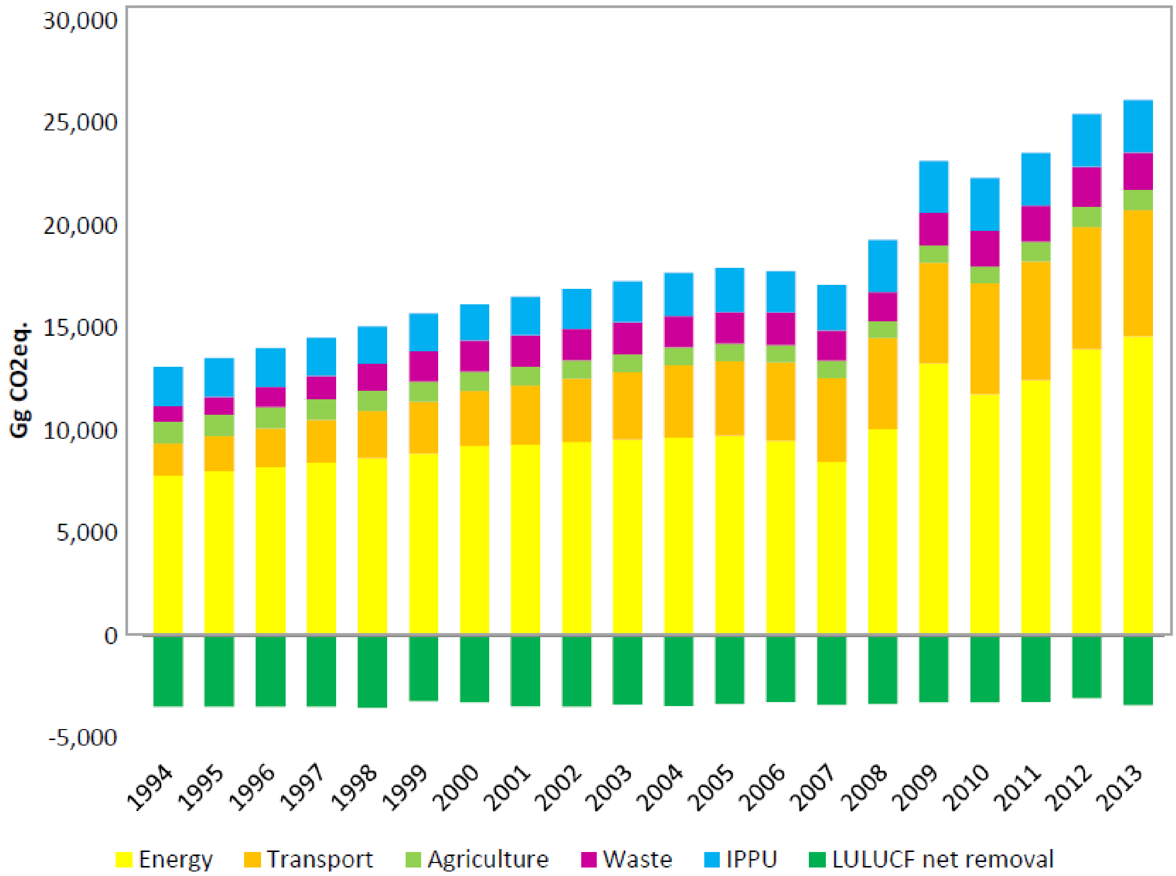


Figure 3-2 Trend in GHG emissions from 1994-2013 (MoE/UNDP/GEF, 2017)

Lebanon aims to reduce GHG emissions by 15% as an unconditional target and 30% as a target conditional to financial and technical support. The GoL is committed to this under the Nationally Determined Contributions (NDC) submitted under Paris Agreement which Lebanon ratified in 2019. Total cumulative reduction in 2030 compared to the BAU scenario (Gg) is presented in Table 3-2. This reduction will originate from the implementation of policies and activities for the energy, transport, waste and forestry sectors (MoE/UNDP/GEF, 2017).

However, considering the calculation of the BAU and emission trajectories of the 15% and 30% in the NDC, even if Lebanon achieves the 30% GHG emission reduction by 2030, GHG emissions will not go below the emission in 2011 base year (see Figure 3-3).

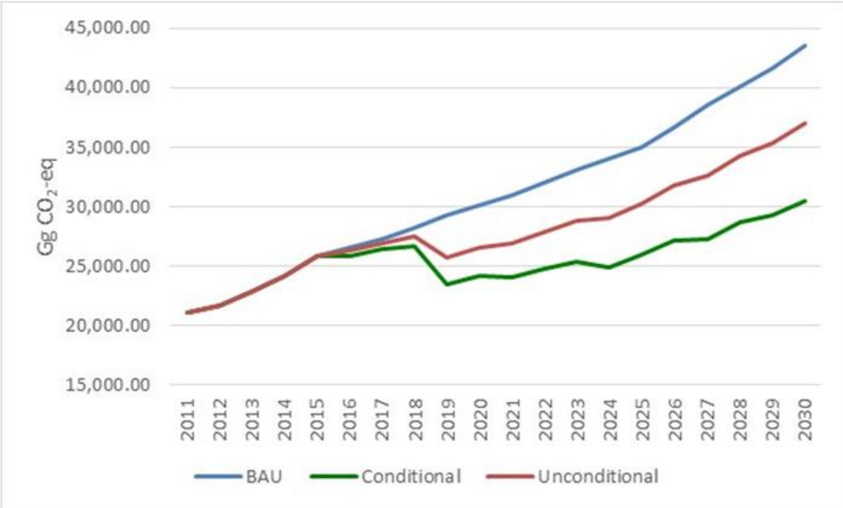


Figure 3-3Greenhouse gas developments at the national level (NDC, 2015)

Table 3-2 Emission Reductions in the NDC in 2015 (MoE/UNDP/GEF, 2017)

Sector		Total cumulative reduction in 2030 compared to the BAU scenario (Gg)				
		CO_2 eq.	NO_x	CO	NMVOC	SO_2
Energy	Unconditional	1,508,797	4,062	304	101	13,317
	Conditional	3,603,603	9,703	727	242	31,808
Transport	Unconditional	1,696	14	101	20	2
	Conditional	6,321	55	379	76	6
Forestry	Unconditional	466	0	3	-	-
	Conditional	606	0	4	-	-
Total	**Unconditional**	**1,511,675**	**4,077**	**410**	**122**	**13,319**
	Conditional	**3,616,075**	**9,758**	**1,111**	**319**	**31,874**

3.2 ACOUSTIC ENVIRONMENT

Data on underwater noise levels are lacking in Lebanon. There is also an absence of systematic monitoring of ambient noise levels in Lebanon.

Exposure to high levels of underwater noise could potentially harm marine fauna as described in Volume 1 of the SEA report. Underwater sound levels associated with different offshore oil and gas activities are summarized in Table 3-3.

Table 3-3 Sound Sources from Various Maritime Activities (adapted from Evans & Nice, 1996; Richardson et al, 1995 as included in Hartley Anderson Limited, 2001)

Activity	Frequency range (kHz)	Average source level (dB re 1µPa-m)	Estimated received level at different ranges (km) by spherical spreading			
			0.1 km	1 km	10 km	100 km
High resolution geophysical survey; pingers, side-scan, fathometer	10 to 200	<230	190	169	144	69
Low resolution geophysical seismic survey; seismic air gun	0.008 to 0.2	248	210*	144*	118*	102**
			208	187	162	87
Production drilling	0.25	163	123	102	77	2
Jack-up drilling rig	0.005 to 1.2	85 to 127	45 to 87	24 to 66	<41	0
Semi-submersible rig	0.016 to 0.2	167 to 171	127 to 131	106 to 110	81 to 85	6 to 10
Drill ship	0.01 to 10	179 to 191	139 to 151	118 to 130	93 to 105	18 to 30
Large merchant vessel	0.005 to 0.9	160 to 190	120 to 150	99 to 129	74 to 104	<29
Military vessel	-	190 to 203	150 to 163	129 to 142	104 to 117	29 to 42
Super tanker	0.02 to 0.1	187 to 232	147 to 192	126 to 171	101 to 146	26 to 71

* *Actual measurements in St George's Channel, Irish Sea.*
** *Extrapolated figure as presented by Evans & Nice, 1996.*

Data measurements from previous environmental studies conducted for projects located along the coast are included in this section in an attempt to document coastal noise levels. These include:

- Environmental, Social and Traffic Assessment for the Coastal Railway between Tripoli and the Syrian border (2016-2017)
- ESIA and the Resettlement Action Plan (RAP) for the Bus Rapid Transit (BRT) system between Beirut and Tabarja and Feeder Buses Services within Beirut (2016)
- Environmental Baseline Monitoring and City Profiles - CHUD Phase III Intervention Area (2016-2017)

A compilation of 33 noise points was extracted from the studies. The points are spread along the coastline from North (Kobet Al Choumra) to South Lebanon (Tyre). The measurements were carried out during day times (7.00 am – 6.00 pm).

The noise monitoring locations in the Northern coast from Qlaiaat to Tripoli are shown in Figure 3-4. 11 points were selected to be representative of the studied area and away from being influenced by interferences such as wind, impulsive sounds and electromagnetic radiation from high voltage transmission lines. As for the noise monitoring locations along the coast in central Lebanon (Figure 3-5), measurements were previously taken in Byblos and along the Northern Beirut Highway starting in Tabarja all the way towards Beirut Outer Ring till Ramlet el Bayda. The remaining noise measurement points were located on the Southern section of the

Lebanese coast starting from the town Damour, to Jiyeh, Saida, and Tyre as shown in Figure 3-6.

The noise metric L90 was used to characterize the baseline noise as it is thought to be more representative of existing conditions than the equivalent sound level or Leq because of the nature of the noise. The L90 is the measured noise level (in A-weighted decibels or dBA) that is exceeded 90 percent of the time during a monitoring event. High noise events, such as a large transport truck passing nearby or a barking dog near the microphone, tend to be excluded in the L_{90} metric. The noise metric L_{90} is generally considered to be representing the background or ambient level of a noise environment.

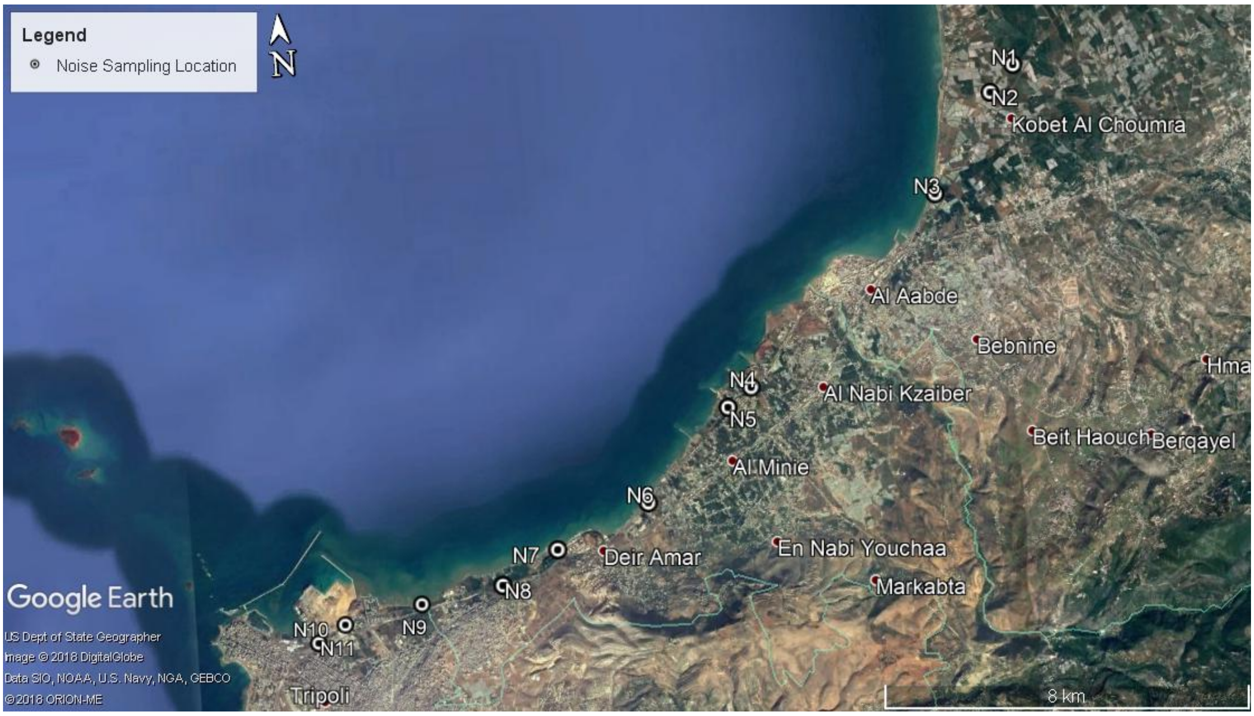


Figure 3-4 Noise Monitoring Location 1

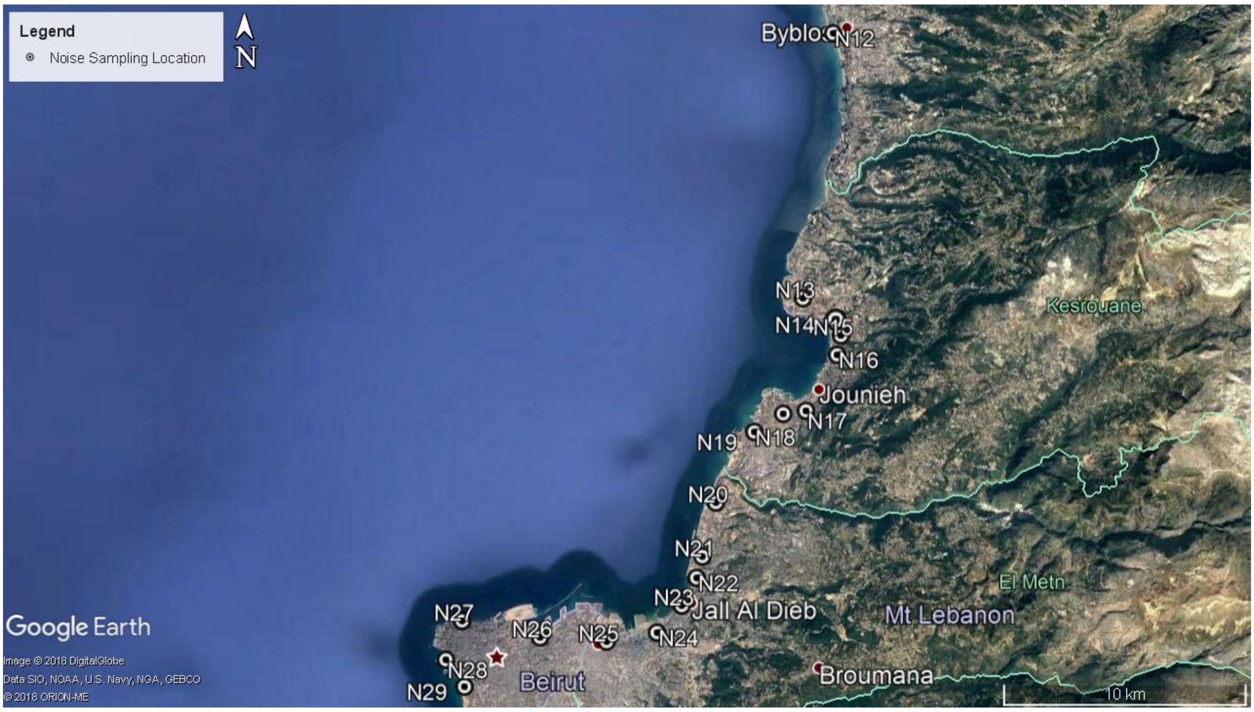


Figure 3-5 Noise Monitoring Location 2

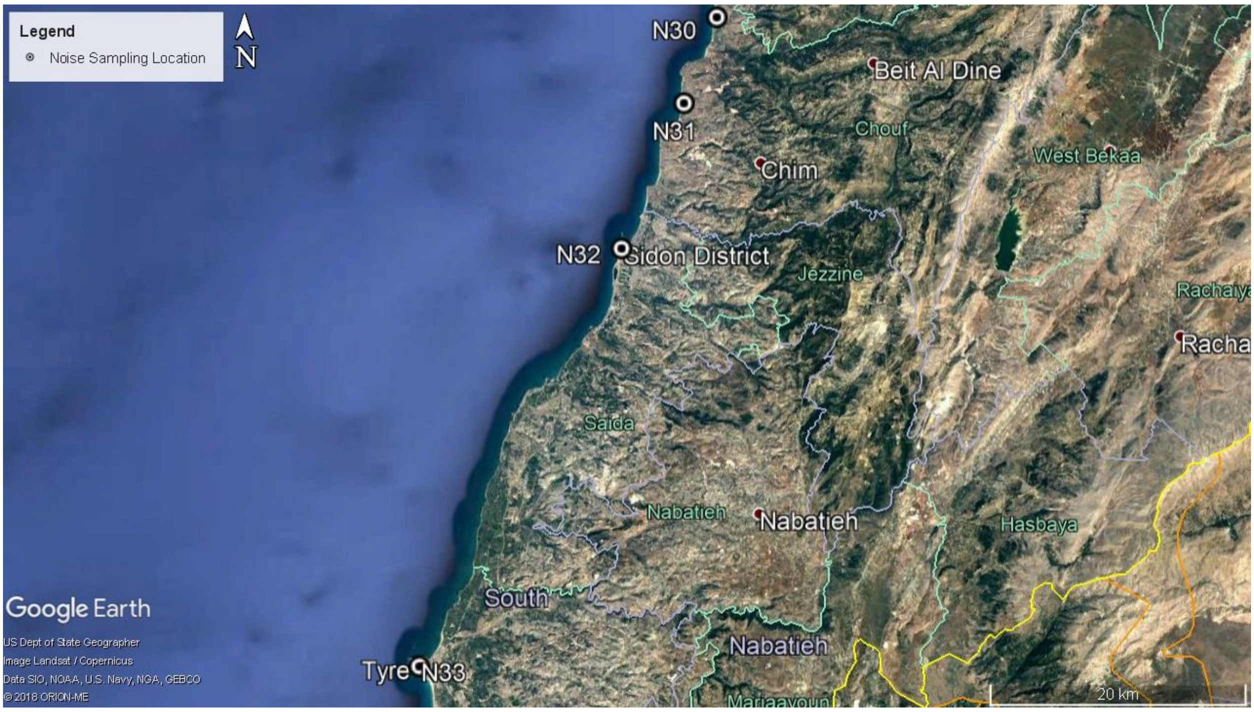


Figure 3-6 Noise Monitoring Location

The measured noise levels were compared to the Lebanese standards for environmental noise as per MoE Decision No. 52/1/1996. The National Maximum allowable noise levels are presented in Table 3-4.

Table 3-4 National Maximum allowable noise level (Decision 52/1996)

Region Type	Limit for Noise Level dB(A)		
	Day Time (7 a.m.- 6 p.m.)	Evening Time (6 p.m.- 10 p.m.)	Night Time (10 p.m.- 7a.m.)
Residential areas with some construction sites or commercial activities or located near a road	50-60	45-55	40-50
Urban residential areas	45-55	40-50	35-45
Industrial areas	60-70	55-65	50-60
Rural residential areas	35 – 45	30 – 40	25 – 35

A summary of the noise monitoring results is provided in Table 3-5. The existing acoustic environment throughout the Lebanese coast varies by location, depending on site characteristics such as proximity to major roadways, and other noise sources, the relative elevation of roadways and receptors, and any intervening structures or barriers.

Exceedances in noise levels with respect to national standards (MoE Decision No. 52/1/1996) were witnessed in 17 points out of 33 monitoring points. Noise levels exceeding the national standards in North Lebanon occur in the city of Tripoli only, whereas the bulk of noise levels exceedances occur along the coastal areas in central Lebanon (from N13 to N26), the L90 fluctuates between 66 and 76.8 db(A) by location depending on site characteristics such as proximity to major roadways like Charles Helou Highway, and other noise sources, the relative elevation of roadways and receptors.

Table 3-5 Summary of Noise Monitoring Baseline

Date	Location	Time/Period	Limit for Ambient Noise Levels dB(A) in Selected Regions (Decision 52/1)	Noise Levels in dB(A)				
				L_{EQ}	L_{MAX}	L_{MIN}	L_{10}	L_{90}
28-11-2016	N1	Day Time (11:41 am)	Residential areas with some construction sites or commercial activities or located near a road 50-60	55.3	71.8	47.4	56.8	50.6
28-11-2016	N2	Day Time (10:51 am)		60.3	96.1	21.3	57.7	42.2
29-11-2016	N3	Day Time (09:57 am)		56	77.3	41.6	59.3	47.1
29-11-2016	N4	Day Time (03:17 pm)		57.1	76.8	42.7	59.8	45.2
29-11-2016	N5	Day Time (02:45 pm)		57.9	80.6	40.5	58.5	47.1
29-11-2016	N6	Day Time (01:46 pm)		57.8	76.3	45	61.1	48.5
23-11-2016	N7	Day Time (02:59 pm)		66.2	100.7	44.8	60.9	48.1

Date	Location	Time/Period	Limit for Ambient Noise Levels dB(A) in Selected Regions (Decision 52/1)	Noise Levels in dB(A)				
				LEQ	LMAX	LMIN	L10	L90
29-11-2016	N8	Day Time (12:42 pm)		53.6	76.6	40.1	54.8	42.7
23-11-2016	N9	Day Time (03:25 pm)		70.5	93.5	49.7	70.7	56.8
23-11-2016	N10	Day Time (03:47 pm)		72.7	94.5	61.9	75.3	**65.3**
23-11-2016	N11	Day Time (05:40 pm)		70.8	87.2	51.3	74.4	**60.4**
06-12-2016	N12	Day Time (02:00 pm)		56.4	101.6	40.0	53.7	43.0
25-04-2017	N13	Day Time (01:24 pm)		80.07	99.55	67.58	82.4	**75.3**
25-04-2017	N14	Day Time (02:00 pm)		76.68	98.28	67.35	78	**71.8**
25-04-2017	N15	Day Time (02:21 pm)		81.75	98.76	72.06	83.9	**76.8**
25-04-2017	N16	Day Time (01:01 pm)		79.67	101.4	68.18	81.4	**73.4**
25-04-2017	N17	Day Time (02:50 pm)		78.57	95.86	67.42	81.3	**72.0**
25-04-2017	N18	Day Time(11:24 am)		75.14	90.36	66.05	77.7	**70.5**
25-04-2017	N19	Day Time (11:01 am)		75.21	95.23	67.34	77.5	**69.6**
25-04-2017	N20	Day Time (10:33 am)		79	90.48	71.35	80.8	**76.1**
25-04-2017	N21	Day Time (10:02 am)		79.32	92.51	72.07	81.4	**76.0**
25-04-2017	N22	Day Time (09:33 am)		78.48	101.55	67.39	80.2	**70.7**
25-04-2017	N23	Day Time (09:07 am)		79.73	99.3	71.22	82.2	**74.9**
25-04-2017	N24	Day Time (08:38 am)		71	91.79	62.16	72.8	**66.0**
27-04-2017	N25	Day Time (04:39 pm)		78.26	92.72	71.74	80.2	**74.7**
27-04-2017	N26	Day Time (04:14 pm)		75.93	95.89	66.5	77.9	**70.0**
27-04-2017	N27	Day Time (01:23 pm)		69.63	93.09	52.08	71	59.0
27-04-2017	N28	Day Time (11:31 am)		71.86	92.12	64.34	73.7	**66.5**
07-07-2017	N29	Day Time (09:50 am)		61.2	76.9	56.0	63.3	57.8
15-04-2015	N30	Day Time (09:41 am)	Urban residential areas 45-55	47.83	64.8	41.95	49.5	43.8
03-01-2014	N31	Day Time (12:06 pm)	Residential areas with some construction sites or commercial activities located near a road 50-60	45.3	70.37	41.72	-	43.1
20-12-2016	N32	Day Time (01:45 pm)		66.7	116.3	52.2	65.8	58.2
08-12-2016	N33	Day Time (02:00 pm)		67.9	114	47.2	54.0	53.2

3.3 SEA WATER QUALITY

The Eastern Mediterranean is characterized by four permanent layers of water:

- Surface water: up to 30-50m depth, temperature between 22-29 ° C, salinity between 38.80 ‰ and 39.30 ‰.
- A low salinity water mass located in the layer between 50 and 75m. It is due to Atlantic waters entering the Mediterranean with a temperature between 18-23 ° C and a moderate salinity between 38.60 ‰ and 38.80 ‰.
- A layer of intermediate water between 150 and 400m. Low temperature between 16-17 ° C and high salinity greater than 39 ‰.
- A layer of deep water below 400m with a temperature of 14-15 ° C and salinity around 39 ‰.

In Lebanon Surface water temperature shows great fluctuations with lowest values (17.3°C) in January and highest values in August (28.9°C). Winter is characterized by a vertical homothermy at ~17°C in the uppermost 100 m, which persists until April, when a gradual warming up of this layer occurs (Abbou-Abi Saab 2008 a; Lakkis 2011; Lakkis et al., 2011).

With the absence of a continuous monitoring system for seawater quality on the Lebanese coast, data and information is compiled from various fragmented studies. Existing studies focused only on coastal waters, but recently the NCMS-CNRS started characterizing deep water quality and results are currently being processed (personall communication with NCMS-CNRS team, 2018). However, the National Centre for Marine Sciences (NCMS) released a report on seawater quality among increased public speculation and concern steaming from its deterioration as a direct result of the waste management issues the country is facing. The report is based on monthly data gathered from 25 points along the Lebanese coast from the period of January 2016 till June 2018, the reported methodology of work follows the recommendations of UNEP/MAP/MEDPOL for coastal water monitoring. The results of the report revealed that biological contamination based on Fecal Streptococci and Fecal Coliforms is revealed in 4 points located in Tripoli, Antelias (between Beirut and Jounieh) and in Beirut (NCMS-CNRS, 2018). Other points had concentrations lower than 500 colonies/100 ml as per the World Health Organization Guidelines for safe recreational water environments (NCMS-CNRS, 2018). The report also reported on metal concentration in some kinds of fish, mollusks and shrimps, all reported results were below the maximum allowed levels set by the European Commission (NCMS-CNRS, 2018). However, NCMS-CNRS highlight that these figures only represent specific points and do not reflect or represent the environmental status of the general area.

Another three year sampling mission was also conducted by the NCMS to monitor seawater quality of five public Lebanese beaches extending from January 2008 till December 2010. 136 samples were taken from fixed locations from the following beaches: Heri in North Lebanon, Byblos in Mount Lebanon, Ramlet el Bayda in Beirut, Saida and Tyre in South Lebanon. Physical, chemical, hydrological and microbiological parameters were analyzed showing very high levels of bacteriological contamination in Beirut and Saida while contamination of the other three beaches was lower with good bacteriological water quality (Ecodit, 2015).

Another study assessed seawater quality of the Northern Lebanese coast (Fallah et. al, 2016). The sampling was conducted in 45 locations along the Mina coastline, one in the month of June and another in November 2012 (Fallah et. al, 2016). Its results revealed a slight decrease in temperature between the June and November sampling where temperature ranged from (24-25 °C) and (24-24.8 °C) respectively. PH ranged between 5.25 and 8.75 (with a mean value of 8.1) during June and between 4.2 and 7.8 (with a mean value of 7.8) during November. The lowest 4.2 pH value was recorded at the site of a sewage discharge along the Mina city coastline. Dissolved oxygen (DO) ranged between 1.38-7.8 mg/L and 2.01-7.8 mg/L during June and November respectively. Low levels of DO concentration are recorded at sites with sewage discharges, and thus are associated with heavy contamination. Electrical conductivity averaged 98.8 mS/cm in June and 107.41 mS/cm in November, while total dissolved solids ranged between 17355-975000 ppm and 280150-1072500 ppm during June and November respectively. Non-contaminated areas had ionic concentrations according to international standards (Fallah et. al, 2016).

However, upon measuring trace metal concentrations, tests revealed that Cr, Cu and Pb exceeded the toxicity reference value (TRV). Results of microbial analysis for heterotrophic bacteria, total and fecal coliform, Salmonella sp. and Shigella sp. revealed significant levels of pollution attributed to untreated sewage dumping in coastal waters (Fallah et al., 2016).

Elevated levels of PAHs and heavy metals are usually found in seabed sediment from coastal areas influenced by human activities. Principal sources of PAHs include fossil-fuel power stations, smelters, incinerators, heavy traffic and oil spills. As for heavy metals, the main sources may originate from anthropogenic activities (municipal and industrial waste waters, coastal dumpsites…) contaminating the marine environment. The concentrations of PAHs and heavy metals in seabed sediment around the PINR do not seem to reflect abnormal contamination in the areas sampled. They were similar to those expected for coastal areas under the influence of urban zones, industry and transport (TRAGSA-AECID-MOE, 2009).

In general,several sources of pollution affect water quality in the Eastern Mediterranean including Lebanon, ranging from river discharge, to industrial effluent, to coastal landfills, to untreated wastewater amongst others. Increasing values of pollution in seawater over the years was reported especially in front of major coastal cities of Lebanon, thus reflecting the negative impact of anthropogenic sources (discharge of untreated sewage, solid waste, port activities, etc.).

Untreated sewage is one of the main forms of urban pollution due to the lack of operational Sewage Treatment Plants (STP), with 162 million m^3/year, equivalent to 276,000 m^3/day, of partially treated and untreated sewage being released into Lebanon's coastline from not less than 53 drain outfalls stretching along Lebanon's 297km shore (Figure 2-5). Sixteen of those drain outfalls are located in the Beirut area (UOB/UNEP/MOE, 2013; Korfali et al., 2014; Mcheik et al., 2015; Jabali et al., 2017).

In addition, large dumpsites or landfills for municipal solid waste which have been created and/or constructed adjacent to the seashore such as in Tripoli, Bourj Hammoud, and Costa Brava pose a threat to seawater quality (Ecodit, 2015). Solid waste dumped daily in these sites is mainly commingled, therefore aggravating the problem of seawater pollution through leachates and other solid and liquid pollutants which could potentially contain heavy metals, high levels of coliforms and organic compounds, etc. and an assortment of hazardous wastes.

3.4 SEDIMENTS

According to Emery and George (1963), the principal sources of coastal sediments found on Lebanese beaches are the adjacent watersheds, calcium carbonates coming from shells, and other minerals coming from the Nile River in Egypt. El Kareh (1981) later confirmed that the sedimentary influence of the Nile ends in Tyre in South Lebanon. Nevertheless, these sediments are transported northward on the Lebanese coast therefore aiding in the replenishment of sand lost during the winter season. Apart from El Kareh (1984) who presented a thesis on sediment movement along the whole Lebanese shoreline, no publications on sedimentary processes were found.

In the current intention to build dams on several Lebanese rivers that release their sediments and organic loaded effluents in coastal waters and therefore blocking their arrival to coastal waters, the main concern to engineers is how to prevent accumulation of sediments behind the dams rather than how to allow the continuation of this natural interaction between rivers and the sea for the benefit of beach replenishment and biological productivity. Actually, this interconnectedness is completely ignored and is not addressed in any of the plans and EIAs for dam construction. This, coupled with extreme coastal artificialization (Figure 2-5) through sea filling activities is surely leading to extensive disturbance in the sediment intake of beaches that is translated into erosion and disequilibrium in coastal dynamics including nutrient transport. In addition, sea filling buries habitats like nursery, spawning, and feeding grounds and renders such habitats non-existent. This is affecting coastal marine productivity and all the socio-economic sectors dependent on coastal marine resources (physical and biological).

On the other hand, and because of construction, quarries, soil erosion, and desertification, sediments are being deposited in rivers and are washing into coastal areas (UOB/UNEP/MOE, 2013). This sediment input seldom leads to beach construction since most of these sediments are not of the proper size and shape to replenish eroded beaches. In addition, this type of sedimentation highly affects coastal and marine fauna and flora by reducing light penetration and therefore photosynthesis, by injuring the gills of fish therefore debilitating them, and by completely burying benthic habitats and their organisms, just to name a few.

Furthermore, due to the lack of infrastructure and proper management of urban/domestic, industrial and agricultural effluents, most of these land-based sources of pollution will find their way to waterways and eventually to coastal waters and habitats (Korfali et al., 2014; Mcheik et al., 2015). In a recent study, Pb, Cd and Cu concentrations indicated the wide dispersion of pollutants in the sediments of the Beirut Army Naval Port and the Tripoli Fishing Port with the highest values detected inside the ports (Abi-Ghanem et al., 2016). In addition, another study assessing the level of pesticides carried by rivers showed 48 different pesticides originating mainly from agricultural runoff (Jabali et al., 2017).

3.5 ECOSYSTEMS AND BIODIVERSITY

Marine ecosystems and associated biodiversity are relatively well studied in Lebanon. However, the majority of research and monitoring activities have been carried out for coastal areas with minimal research on offshore waters. It is imperative that research and monitoring activities be extensively increased for Lebanese deep territorial waters so that enough information will be available when the industry becomes fully established.

Within the framework of the UNEP Mediterranean Action Plan (MAP) under the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution (ratified by the Government of Lebanon in 1977) and specifically within the context of one of the Protocols of the Barcelona Convention, the "Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean" (ratified by the Government of Lebanon in 1994), Lebanon and through the MOE, prepared in 2002 its National Report on coastal & marine biodiversity that presented the basis for drafting five targeted action plans:

- Permanent Monitoring of Coastal and Marine Biodiversity
- Determination of the Physical Parameters of the Lebanese Marine Environment
- Organizing Awareness Campaigns for the Lebanese Coastal Communities and the Public Sector
- Legislation Related to Coastal and Marine Biodiversity
- Establishment of Conservation Strategies for Coastal Habitats.

In 2016, the MOE in Lebanon, updated the first Strategic Action Plan for the Conservation of Biological Diversity in the Mediterranean Region (SAP-Bio) report under the Project Number: GFL-2328-2712-4C02. Updates and achievements in related studies were compiled and list of species were revised therefore summarizing the effort made and results achieved since 2002 to fill gaps in marine research. The National Biodiversity and Action Plan (NBSAP) was also finalized by the government in 2016 and endorsed by the Council of Ministers in 2018.

In October, 2016, Oceana carried out a research cruise in Lebanese waters, across a total of five areas off the coast of the country. In each of the five areas, exploration of the seabed was principally carried out by non-intrusive (visual) methods, using a remotely operated vehicle (ROV) with a high-definition camera. In order to obtain more detailed information about the infaunal communities, sediment samples were collected with a Van Veen grab in soft bottom areas. In addition, oceanographic parameters were recorded with a conductivity, temperature, and depth (CTD) instrument. The Oceana survey areas are presented in Figure 3-7.

Appendix Cpresents: 1) the list of species identified during Oceana 2016 expedition in the Lebanese waters where species are listed according to survey area, depth and sampling method, 2) the identified threatened species and 3) number of identified taxa, according to broad taxonomic group.

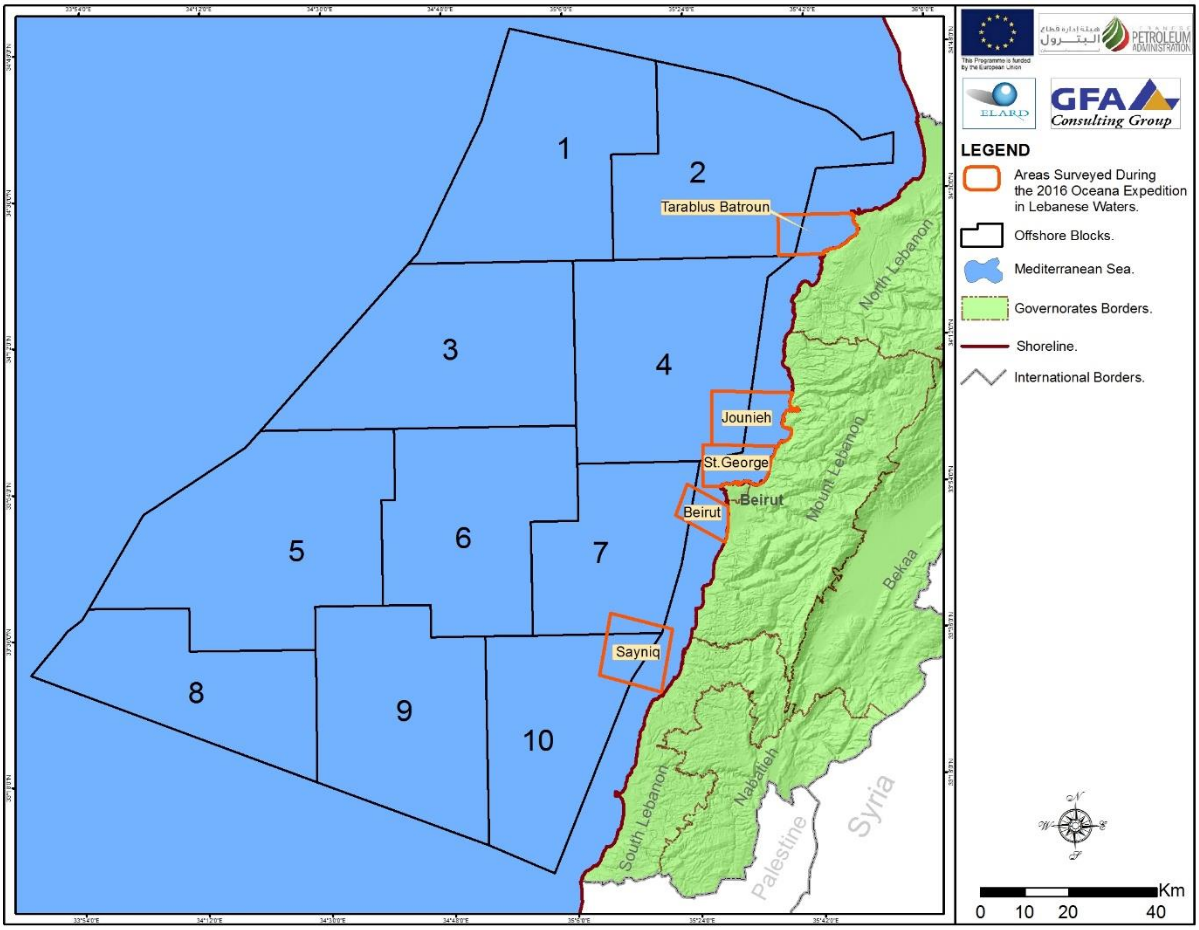


Figure 3-7 Areas Surveyed during the Oceana 2016 Expedition in the Lebanese Waters

3.5.1 Nutrients

Nutrients (such as phosphates, nitrates and silicates, etc.) constitute determinant and limiting factors for microalgae and thus, the whole food web (MOE/GEF, 2016). Hydro-climatic and physical-chemical factors impact the vertical and seasonal variations of plankton populations and their distribution since they play a major role in the transport of nutrients along the water mass (Abboud-Abi Saab et al., 2008 a and b).

During the winter season (December-March), upwelling and seawater mass-mixing create homothermal conditions suitable for spring blooms which cause peaks in productivity in the spring season. During the summer hot season (June-October), the warm seawater surface and heavy evaporation stratify the water layers with a sharp thermocline in the 0-100 m water layer. These hydrological conditions, in addition to the shortage of nutrient concentration and dissolved oxygen, may create impoverishment in the quality and quantity of the plankton community. This is a regular annual cycle showing little fluctuations (Lakkis, 2011a and b; Kouyoumjian and Hamze, 2012).

In addition to the existing natural nutrient cycle, supplementary sources of nutrients are land-based. Wastewater effluents reaching the coastal waters without any treatment cause blooms of certain species. Heavy metals and trace elements from the agriculture and industrial sectors accumulate in some marine organisms, notably filter feeders and sessile species (MOE/GEF 2016). These toxins bio-accumulate through the different levels of the food web and most probably reach humans.

Certain algal blooms have been observed, and with increasing temperatures due to climate change, it is fearful that similar incidents will become more frequent (Abboud Abi-Saab et al., 2006; Abboud Abi-Saab et al., 2008; Lakkis, 2011 a and b; Nader, 2011). Several physical and chemical factors allow the development of algal blooms especially during heat waves coupled with nutrient availability. Algal blooms where observed near Antelias River estuary, and El Kaleb estuary.on the 8th of May 2007 after a heat wave (Chlouk) (Abbou-Abi Saab 2008 a).

3.5.2 Phytoplankton

Marine phytoplankton includes all pelagic microalgae that float in water and represents the primary producers of organic substances and oxygen in the pelagic environment. Like all plankton, they have limited powers of locomotion and are at the mercy of prevailing water movements. Due to the physical characteristics of the Lebanese coast, seawater shows a highly diversified plankton community contrasting with poor plankton biomass (MOE/GEF 2016). During the past 50 years cumulative studies have classified the occurrence and biodiversity of phytoplankton as follows: about 400 species identified belonging to 85 genera including 227 dinoflagellates and 151 diatoms, 5 silicoflagellates and 2 Ebriidae (Lakkis, 2011).

Seasonal variability and physicochemical conditions of the environment of phytoplankton lead to large fluctuations in their seasonal and weekly abundance. The spring bloom in the Levantine Sea is characterized by centric and pinnate diatoms and some neritic dinoflagellates dominating in the summer season. The diversity index of phytoplankton in a 2012 study shows that the annual minimum is in May and the maximum is in September (Abboud-Abi Saab, 2012). Phytoplankton live in the phosphate, nitrates, and organic nutrients rich eutrophic layer where light is extremely abundant to support photosynthesis (Ouba et al. 2016; Khalaf and Fakhri, 2017). However, land based pollution such as agricultural runoff cause a shift in phytoplankton species due to changes in nutrient concentrations and the N:P ratios. On the Lebanese coastal zone, bacteriological pollution is extensive and finds its way to the sea through domestic sewage outfalls, wastewater discharge and mouth river discharges (Khalaf and Fakhri, 2017). An example of such a case is reported in a 2015 WWF report on the impacts of land-based pollution sources in the Mediterranean Sea: Macrophytes such as Cystoseira spp., Dictyota spp., and Halymenia spp. are being replaced by short lived algal species (Piante, 2015).

Lately, special attention has been given to toxic and alien species and their relationships with environmental conditions. Every year, new alien species are recorded in the Mediterranean and the introduction rate is expected to increase in the future due to factors such as the enlargement of the Suez Canal, increased maritime transport (ballast water, fouling organisms), climate change, and aquarium pet trade.

3.5.3 Zooplankton

Zooplankton is a much diversified group of free floating animals. Like all plankton, they have limited powers of locomotion and are at the mercy of prevailing water movements. This group comprises most of marine zoological groups like protozoans and chordates. It is the most studied group of plankton in Lebanese waters where they have been monitored for more than 35 years. Their ecology is affected by the hydrological, hydro-biological and physical/chemical characteristics of the water they inhabit (MOE/GEF 2016).

A recent report by the CNRS on the biodiversity in the Eastern Mediterranean Sea reported the presence of more than 780 recorded species of zooplankton along the Lebanese coast (Khalaf and Fakhri, 2017) of which 220 are microzooplankton and 563 are macrozooplankton. Zooplankton represents the secondary producers of organic substances. The peak development of zooplankton is noted in the summer months, right after the spring phytoplankton bloom. During the winter months, the aquatic environment is zooplankton deficient, however very diversified, due to the mixing turnover of water layers that lead to vertical homothermal conditions (Lakkis, 2011).

The various groups of zooplankton that have been recorded in Lebanese waters are Cnidaria, Ctenophora, Annelida, Polychaeta, Chaetognaths, Crustacea, Cirrhipedia, Thaliacea, Appendicularian, and Ichthyoplankton (Abboud-Abi Saab, 2012).

3.5.4 Bacterioplankton and viroplankton

Bacterioplankton are minute heterotrophic and autotrophic bacteria ranging in size from 0.02 µm to 2 µm while viroplankton, considered a relatively new discovery, range from 0.02 µm to 0.2 µm in size and are thought to be the most photosynthetic organisms in early biomass production. No reports or publications related to these two groups were found for Lebanese marine waters (MOE/GEF, 2016). Given their importance in marine food chains, identification of species and monitoring of these two groups should be launched.

3.5.5 Benthos

Lebanon's varied benthic biodiversity allows it to allocate habitats to many groups of phytobenthos and zoobenthos. The benthic community in Lebanon is either endemic to the East Mediterranean, the Atlantic, Indo-Pacific, or introduced. The Mediterranean Sea accounts for 18% of the world's benthic biodiversity. For a sea that encompasses only 0.32% in volume of the world ocean, there are various reasons why the species biodiversity is high. First, the Mediterranean Sea has been more intensively studied than almost any other sea, its tormented geological history that led to a rate of environmental change and species occurrence, and the current variety of climatic and hydrologic situations that are found in the Mediterranean yielding to temperate and subtropical biota (Bianchi and Morri, 2000). The benthic biodiversity in Lebanon is discussed below with the following subcategories: Macroalgae, Angeosperm Phanerogames, Meiofauna, and Macrofauna (macrobenthos).

Macroalgae

Studies on macroalgae along the Lebanese coast are fairly limited. Many studies reported on the biodiversity of macroalgae from 1976 up to this day. In the earlier years, around 200 species were described followed by more than 230 species in more recent studies (Bianchi and Morri, 2000; Bitar, 2010; Kanaan and Belous, 2016). All studies agreed on the fact that the impact of pollution on their abundance created a negative outcome. At present, certain alien species forming permanent populations are competing with native species and colonizing their habitats. Specifically, one alien brown algae, *Stypopodium zonale* has been identified as an invasive specie that could pose a potential threat to endogenous marine biodiversity (Bitar, 2010).

Angiosperm/Phanerogames

Marine seagrasses form a unique ecological entity; however, they encompass various taxonomic groups. In coastal waters, the occurrence of Monocotyledone is a rare scarcity. Among the marine flora, three species of Phanerogams (Cymodocea nodosa, Halophila stipulacea and Zostera nana) occupy Lebanese coastal waters, especially sandy bottoms, forming meadows. These meadows are considered of great importance as breeding and feeding grounds for an array of marine species (Bitar, 2010; Kouyoumjian and Hamze, 2012; Kanaan and Belous, 2016; MOE/GEF, 2016).

Macrofauna

Throughout a campaign done between 2012 and 2016 using a Remotely Operated Underwater Vehicle (ROV) on the CANA research boat with the CNRS during the OCEANA mission, the biodiversity of macrobenthos was mapped. Six main habitat types have been documented by the OCEANA mission in 2016 over a broad depth range (36m – 1050m): Coralligenous habitats and rodolith/maerl beds; rocky bottom areas; muddy and sandy-muddy bottoms; sandy bottoms; canyon heads; and bathyal muds. Depth of habitat types were not delineated by the authors (Bigagli et al., 2018) The findings indicated different species of which 75 flora counts, 14 fauna of invertebrates, 99 species of molluscs, 82 species of polychaetes, 45 species of crustaceans, 44 species of sponges and 22 species of cnidarians. An extensive list of 650 species and benthic taxa reports the distribution of the latter in 12 zoological groups (Abboud-Abi Saab, 2012; Khalaf and Fakhri, 2017).

3.5.6 Marine Ichtyofauna

Ichtyofauna in Lebanon and the Eastern Mediterranean is constantly changing due to Lessepsian migration. Every year, new species are recorded in the Mediterranean and the migration rate is expected to increase with the new expansion of the Suez Canal. Lebanese Ichtyofauna includes 357 species comprising 44 Chondrichthyes. Nevertheless, a recent study on Chondrichthyians along the Lebanese coast narrowed down the list from 44 to 25 species. It is believed that at present, this is the most comprehensive and realistic list of Chondrichthyes. On the other hand, for Osteichthyes, no revised checklist is currently available (Kouyoumjian and Hamze, 2012; Lteif, 2015).

A National Action Plan on Non-Indigenous Species (NIS) is in its last final draft, and it will be made public before the end of the year and will be launched at the CBD CoP in Sharm El Sheikh. In addition, factsheets for NIS are in progress and not published yet. The aim is to launch them at the CoP part of regional side event organized by IUCN and SPA/RAC on NIS in the Mediterranean **(**www.IUCN.org**)**.

3.5.7 Sea Mammals

Even though Lebanon is a contracting party to ACCOBAMS and that the National Centre for Scientific Research for Marine Sciences - CNRS (NCMS) is carrying out regular monitoring of marine mammals, information on this group in Lebanon is scarce and limited (MOE/GEF 2016).

Among the three orders of marine mammals, studies have shown that dolphins are the most represented with the following species recorded in the country: the Short-beaked common dolphin (*Delphinus delphis* – endangered), Common bottlenose dolphin (*Tursiops truncates* – least concern), fin whale (*Balaenoptera physalus* – endangered), Cuvier's beaked whale (*Ziphius cavirostris* – least concern), Risso's dolphin (*Grampus griseus* – least concern), and Striped dolphin (*Stenella coeruleoalba* – least concern).

The Common bottlenose dolphin was observed during 2010-2011 in high density off the coast of Beirut and is the most abundant species in Lebanese waters (MoE/IUCN, 2012). The results highlight a regular presence of the species in the central area of the Lebanese coast with an average of 3-5 individuals per sighting (Khalaf and Fakhri, 2017). A less recent study conducted in 2009 focused on the *Tursiops truncatus* as well, and reported 56 individuals around Beirut with an abundance of 0.084 in/km (Abboud Abi Saab, 2012).

During a survey conducted in July, 2008 in the international water of the Eastern Mediterranean Sea, as well as the Turkish, Lebanese and Syrian territorial waters, totally 860 nautical miles (nm) of survey effort was made and 16 sightings (108 animals) were recorded (Figure 3-8). During the study, five *Physeter macrocephalus* in one sighting, 72 *Stenella coeruleoalba* in five sightings, two *Grampus griseus* in one sighting (associated with S. coeruleoalba individuals), two *Delphinus delphis* in one sighting and 27 *Tursiops truncatus* in nine sightings were recorded. The overall encounter rate was 0.18 sightings/10 nm.

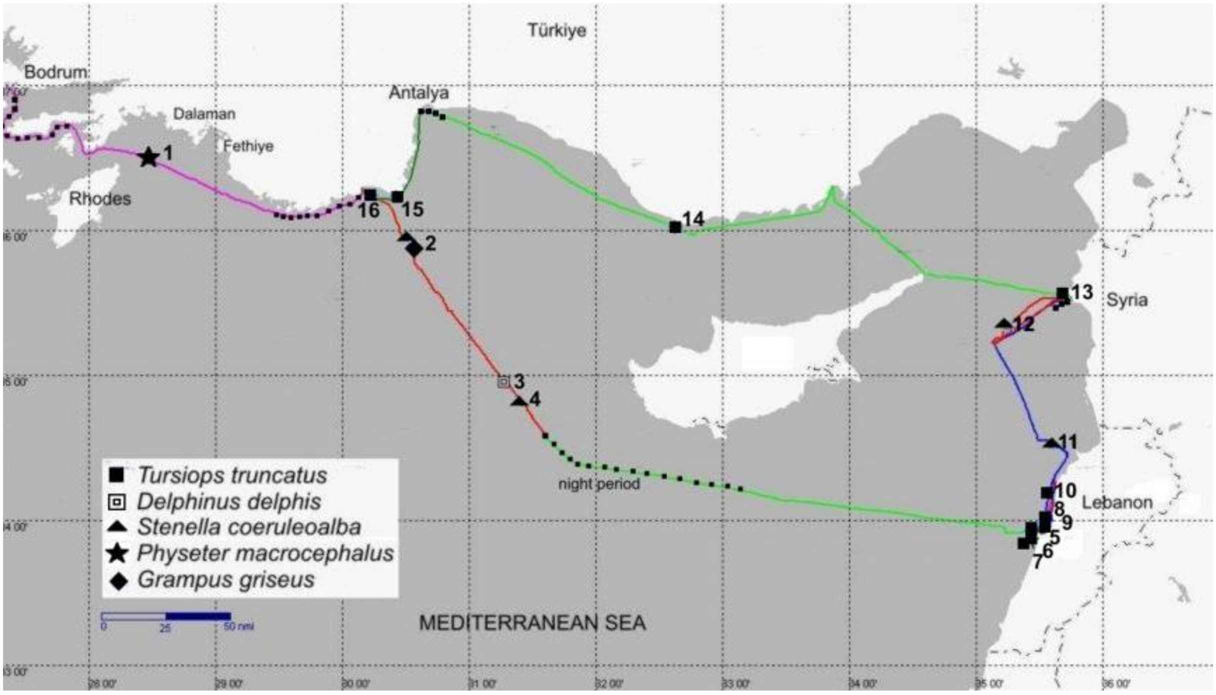


Figure 3-8 Survey track and cetacean sightings in the Eastern Mediterranean Sea (Dede et al. 2012)

The only species of seals present in Lebanon is the Mediterranean Monk Seal (*Monachus monachus*). During the last 20 years, 47 individuals were recorded (1996-2015) along the Lebanese coast corroborated by photos and videos with increased observations during the last 5 years. These observations apparently resulting from increased awareness and availability of technology (mobile telephones with cameras, underwater cameras), with several scientific records and confirmed sightings (n = 25, from 2003 to 2016), corroborated by photos and videos, has led to the re-evaluation of the status of *Monachus monachus* in the country (Mytilineou et al., 2016; Ramadan-Jaradi, 2017 a). Nevertheless, this species was extremely affected by socio-economic development and habitat loss (Khalaf and Fakhri, 2017).

3.5.8 Marine Herpetofauna

There are relatively few reptiles that are apt to life in a marine environment. Three species of marine turtles are found in Lebanese waters: the Loggerhead turtle (*Caretta caretta*- vulnerable), the Green turtle (*Chelonia mydas* - endangered) and the Leatherback turtle (*Dermochelys coriacea* - vulnerable). The Loggerhead and Green turtles nest on Lebanese sandy shores while the Leatherback turtle is just a visitor to the Mediterranean Sea (MOE/GEF 2016). According to the IUCN redlist, the Loggerhead turtle and the Leatherback turtle are classified as vulnerable species while the Green turtle is endangered (IUCN, 2018).

The current and potential nesting beaches in Lebanon have already been identified and surveyed. The most visited sites for nesting are the Palm Island Nature Reserve, Al Mansouri and El Aabassyeh beaches. At Al Mansouri beach in the southernmost part of Lebanon, 51 loggerhead turtle nests and 57 emergences were observed, while at Al Abassyeh beach a total of 20 loggerhead turtles emerged from 10 different nests. The Tyre Coast Nature Reserve is an important nesting site for Loggerhead and Green turtles, the two most abundant species of sea turtles found in Lebanon (MoE/IUCN, 2012).

Two species of marine turtles have also been reported offshore Lebanon: the Hawksbill Sea turtle (*Eretmochelys imbricate*) and the African Softshell Turtle (*Trionyx triunguis*; Hraoui et al, 2002; Cross et al., 2006).

3.5.9 Marine Ornithofauna

Lebanon is considered as a bottle-neck along a major flyway route for birds twice per year and is located on one of the world's key migratory bird corridors (Figure 3-9) (MoE/UNEP/GEF, 2016). According to a study conducted by Ramadan-Jaradi et al. (2008), 395 species in total have been recorded in the Country including 186 coastal and marine species observed near the coast of which 144 have marine affinity. Although major routes have been defined, a detailed analysis of bottle-necks and areas of high vulnerability have not yet been documented. Specifically, the large soaring birds depend on hot air currents for transport and migration in order to decrease the energy needed for flying. Since hot air currents are developed mainly in valleys and coastal areas and do not form over water bodies, soaring birds are thus forced into specific flyway routes over land, twice per year between Europe and Africa.

Figure 3-9 Major flyways between Africa and Eurasia

(Source: Birdlife International, 2018)

According to the IUCN Red List, Lebanon hosts bird species of international significance, with 2 being endangered, 8 vulnerable, and 17 near threatened (Ramadan-Jaradi et al., 2008). Numbers of coastal and marine bird species have not changed between 2002 and 2016, remaining at 186 species observed near the coast of which 144 have marine affinity (MOE/GEF, 2016).

Between 2005 and 2008, A Rocha Lebanon and the Society for the Protection of Nature in Lebanon (SPNL) implemented a 3-year project with funding from the MAVA trust. The project aimed at identifying and conserving new Important Bird Areas (IBA) in Lebanon. In total 15 IBAs were declared including the Palm Island Nature Reserve (PINR) as the only coastal site (MOE/UNDP/GEF, 2014). Some of the main pressures affecting birds in Lebanon, especially marine birds, are habitat loss, pollution, and hunting.

Statistics show that 66% of 171 seabirds studied were found to have plastic pieces in their stomachs (Codina-García, 2013). The Balearic shearwater *(Puffinus mauretanicus)*, a critically endangered species, was found among them. According to the Barcelona Convention Annex II SPA-BD, 60% of the mentioned species are listed as threatened or endangered. Furthermore, there is an augmented loss of suitable habitats leading to additional threats to several bird species residing in the Mediterranean coastal areas.

Scientists at the CNRS have led a study on the status and dispersal of migrating and breeding marine birds in the North of Lebanon. The study area lies along the foreshore running from Batroun up to Cheikh Zennad, 3km short of the northern border between Lebanon and Syria.

2681 individuals dispersed over 86 different species were documented and categorized as follows: 35 foreshore species, 18 coastal, 6 maritime, 9 ducks, 6 herons, 9 various saltwater species, and 3 terrestrial. There are 48 passage migrant/winter visitors, 31 passage migrants, 5 winter visitors and 2 vagrant species (Ramadan-Jaradi, 2017b).

Despite the fact that the Hunting Law 580/2004 established a closed hunting season from February 1st until September 14th, much illegal hunting occurs leading to unsustainable hunting practices and decline in the population of migratory bird species. The most affected species are the White Stork (*Ciconia ciconia*), the White Pelican (*Pelecanus onocrotalus*), the Common Crane (*Grus grus*), the Griffon Vulture (*Gyps fulvus*), the Hobby (*Falco subbuteo*), the Sparrow hawk (*Accipiter nisus*), the Lesser Spotted Eagle (*Clanga promarina*), and the Steppe Eagle (*Aquila nipalensis)* (MoE/UNEP/GEF, 2016).

Many species of seabirds live close to the shore like sea gulls (*Laridae*) and cormorants (*Phalacrocoracidae*), while other species live exclusively offshore in the open sea like shearwaters and petrels (*Procellariidae*). Accordingly, important marine areas for sea birds should be identified and a scientific database should be established to contribute to an effective monitoring and protection of these birds.

3.5.10 Fish Resources (Fish, Cephalopodes, Crustacean)

Lebanon's coastal waters contain more than 80 fish species of commercial importance. Fisheries data obtained from the Ministry of Agriculture (MoA) for the year 2017 reveal that the highest catch was recorded for 2 species: *Etrumeus teres* (640.8 tons per year) and *Engraulis encrasicolus* (548.1 tons per year), followed by 242.7 tons and 219.2 tons per year for *Boops boops* and *Pagellus acarn* species. Significantly lower catch for other species (less than 200 tons per year) were observed as shown in Table 3-6.

Table 3-6 Fisheries Catch Statistics 2017 in Tons per Year (MoA, 2018)

Scientific Name	2017	Scientific Name	2017	Scientific Name	2017
Bothus podas	0.1	*SQUID*	2.9	*Epinephelus aeneus*	21
Epinephelus costae	0.1	*Serranus cabrilla*	3.1	*Dentex macrophtalmus*	21.6
Helicolenus dactylopterus	0.1	*Spicara maena*	3.2	*Epinephelus marginatus*	23.1
Phycis blennoides	0.1	*Nemipterus randalli*	4.1	*Scomber scombrus*	23.1
Dicentrarchus labrax	0.2	*Terapon puta*	4.2	*Mullus barbatus*	25
Spondyliosoma cantharus	0.2	*Octopodidae*	4.5	*Mycteroperca rubra*	25.5
Dentex dentex	0.2	*Sargocentron rubrum*	4.8	*Portunus pelagicus*	27.2
Scarus ghobban	0.2	*Scorpaena porcus*	5	*Sphyraena sphyraena*	29.2
Stephanolepis diaspros	0.2	*Balistes carolinensis*	5.5	*Sardinella aurita*	33.1
Pagrus auriga	0.3	*Sparus aurata*	5.9	*Siganus luridus*	47.8
Solea aegyptiaca	0.3	*Auxis rochei*	7.6	*Scomberomorus commerson*	52.7
Sarpa salpa	0.3	*Kalamar*	8.2	*Caranx crysos*	62

Scientific Name	2017	Scientific Name	2017	Scientific Name	2017
Scorpaena scrofa	0.3	*Micromesistius poutassou*	8.9	*Pagrus caeruleostictus*	71.5
Upeneus moluccensis	0.5	*Liza ramada*	9.1	*Seriola dumerili*	73.7
Sardinella maderensis	0.5	*Sarda sarda*	9.2	*Sphyraena chrysotaenia*	76.9
Scomber japonicus	0.5	*Diplodus cervinus*	9.5	*Liza aurata*	95.1
Dentex maroccanus	0.6	*Alepes djedaba*	10.2	*Oblada melanura*	105.3
Bycatch (landed, used catch)	0.7	*Argyrosomus regius*	10.4	*Pagellus erythrinus*	116.8
Pomadasys incisus	0.8	*Spicara smaris*	11.2	*Euthynnus alletteratus*	153.4
Belone belone	1.2	*Penaeidae*	12.1	*Siganus rivulatus*	166.8
Trachurus trachurus	1.3	*Mullus sumuletus*	12.9	*Diplodus sargus*	175.6
Anguilla anguilla	1.5	*Trachinotus ovatus*	13.8	*Clupeidae*	191
Sparisoma cretense	1.5	*Umbrina cirrosa*	15.1	*Pagellus acarne*	219.2
Pelates quadrilineatus	1.7	*Xyrichtys novacula*	15.7	*Boops boops*	242.7
Coryphaena hippurus	2.1	*Merluccius merluccius*	16.6	*Engraulis encrasicolus*	548.1
Fistularia commersonii	2.5	*Pagellus bogaraveo*	17.3	*Etrumeus teres*	640.8
Hemiramphus far	2.6	*Lithognathus mormyrus*	18.3		
				TOTAL	**3,536**

The MoPWT holds the jurisdiction of the licensing for fishing vessels, and as of 2005, a computerized fishing vessels register has been created that conforms with FAO and GFCM requirements (Cubadda et al., 2005). According to the official census held in 2004, the Lebanese fishing fleet is made up of 2,662 operational fishing vessels working from 44 fishing ports along the coast (Majdalani, 2004). These fishing vessels are typical artisanal Mediterranean boats of less than 12 m in length, with 33% of the fleet less than 6 m (Majdalani, 2005). The average gross tonnage of the boats and the average power are 2.52 t (Majdalani, 2005) and 22.68 hp respectively (Sacchi and Dimech, 2011), with 71% of the vessels having an engine power less than 30 hp (Majdalani, 2005). No other official census was held till date while the provided total number of licensed fishing boats by the DFW-MOA is 2193.

Due to the importance of the fisheries sector and in order to improve the fishermen's wellbeing, several initiatives were launched addressing the problems plaguing the sector. These include:

- **Catch/Effort initiatives**

In 2006, the MCR-IOE-UOB initiated a catch/effort data collection program of commercial fisheries for the Mohafaza (Governorate) of North Lebanon and Akkar, covering approximately 45% of the Lebanese coastline. Since then and to date, information about fishing gear, species, quantity, price and size is collected on a weekly basis for commercial species from the four major ports in North Lebanon: Batroun, Qalamoun, Tripoli and Abdeh (Figure 3-10).

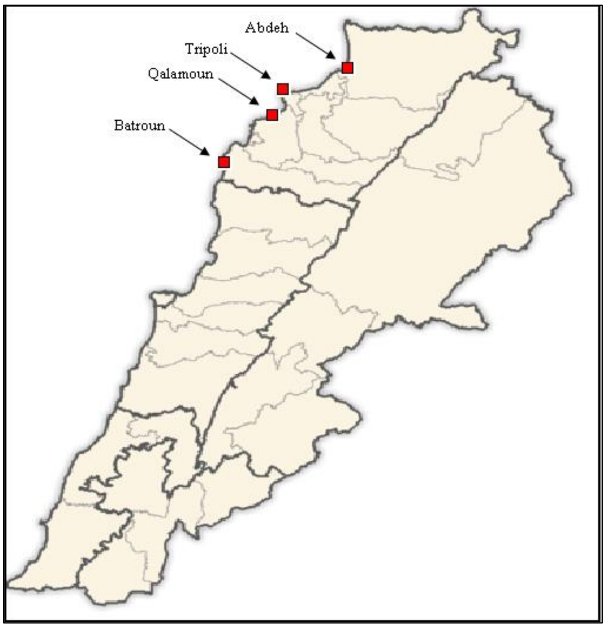


Figure 3-10 Major fishing ports in North Lebanon (Source: Nader et al., 2014)

Gathered information is entered in the utility "Fish Landings Operational Utility for Catch Assessment" (FLOUCA-Web) created and implemented by the MCR-IOE-UOB team for monitoring marine commercial fisheries. The FLOUCA utility allows the generation of monthly and yearly trends of catch, catch per unit effort (CPUE), average size and average price for the monitored species. The main goal of the initiative is to establish long-term monitoring of commercial fish landings and effort. It contributes to developing appropriate management plans based on scientific data to protect the diversity of valuable marine biological resources and to sustainably benefit from the resource (Nader et al., 2012; Nader el al., 2014). Data collection has been on-going since and time series for a period of 10 years for all parameters is currently available (Table 3-7, Table 3-8, Figure 3-11 and Figure 3-12).

Table 3-7 Annual average Catch and average Effort for the fisheries sector in North Lebanon (2006-2017; Source: MCR-IOE-UOB)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Catch North Lebanon (Tons)	3,46	2,66	1,89	1,70	2,54	3,23	4,54	3,26	2,48	3,33	4,96	7,17
Effort IOE-UOB North Lebanon (Day)	142,22	179,46	184,39	172,99	181,67	168,70	158,09	158,78	195,36	356,06	359,13	373,20

Table 3-8 Annual average Catch Per Unit Effort (CPUE) and average Price/Kg for the fisheries sector in North Lebanon (2006-2017; Source: MCR-IOE-UOB)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
CPUE (Kg/day) North Lebanon	24.311	14.841	10.255	9.856	14.008	19.138	28.716	20.527	12.71	9.341	13.809	19.212
Price IOE-UOB North Lebanon (1000 L.L./ Kg)	4.65	7.304	8.815	9.105	7.58	5.733	4.37	8.152	8.742	12.863	8.747	6.021

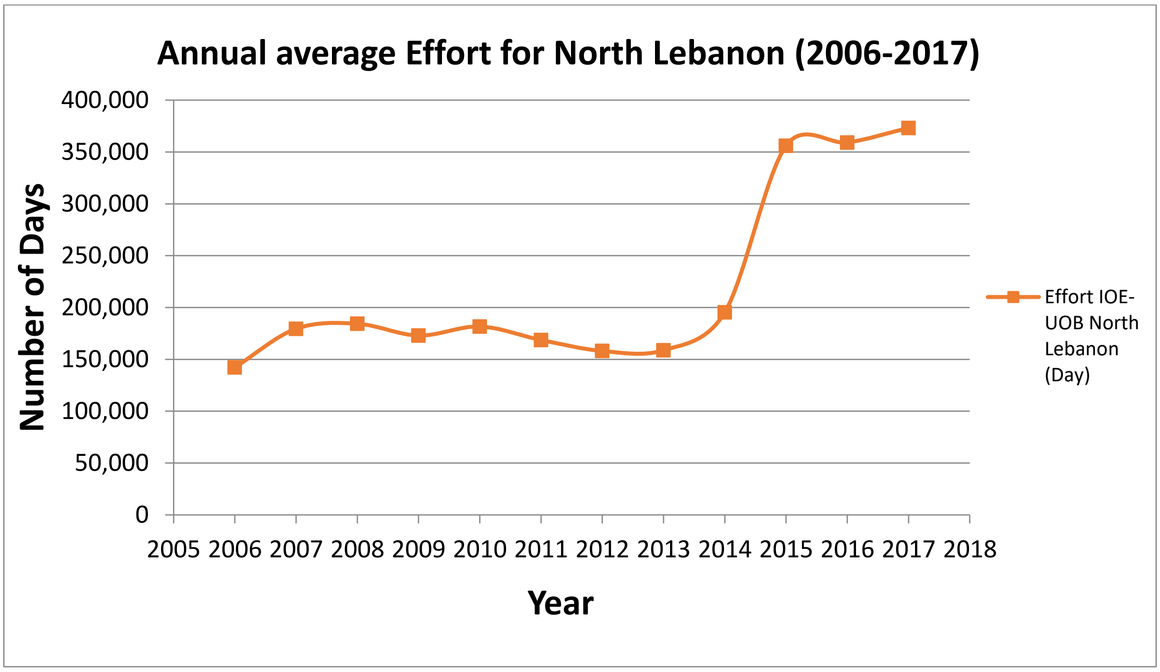


Figure 3-11 Annual average Effort for the fisheries sector in North Lebanon (2006-2017; Source: MCR-IOE-UOB)

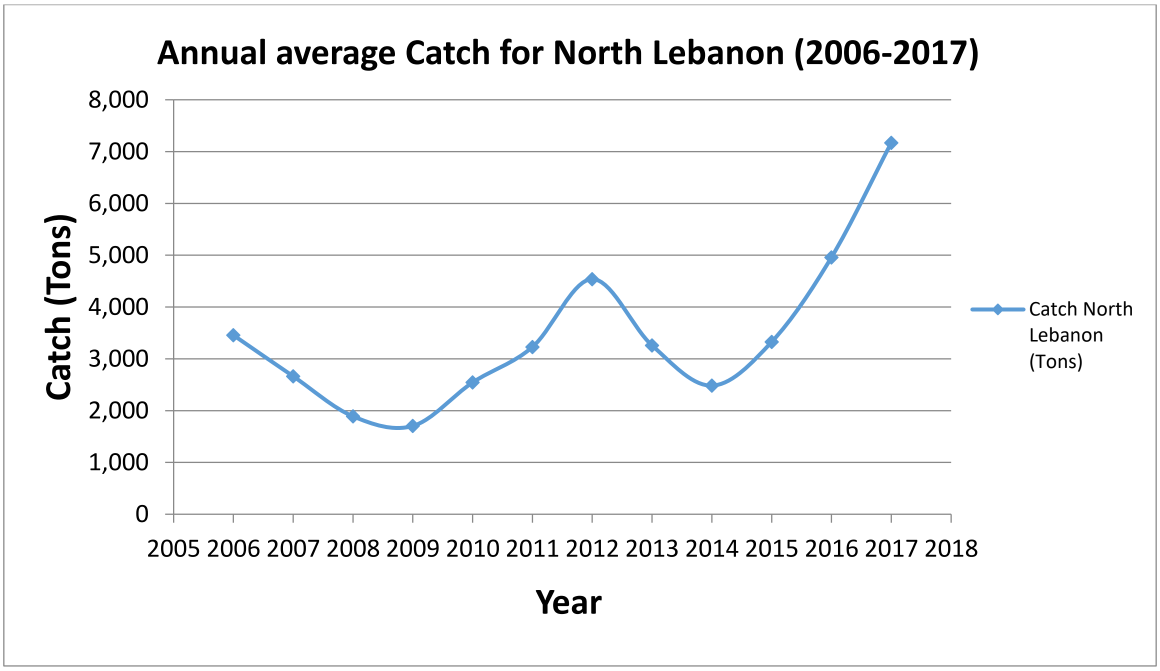


Figure 3-12 Annual average Catch for the fisheries sector in North Lebanon (2006-2017; Source: MCR-IOE-UOB)

Furthermore, the NCMS-CNRS (www.cnrs.edu.lb) implemented the CANA project (www.cana-cnrs.gov.lb) funded by the "Italian Cooperation for Development in Lebanon and Syria" and the Lebanese Government. The overall objective was to increase the knowledge of coastal and marine environments towards drawing responsible and sustainable development outlines while preparing guidelines for an integrated coastal policy. In addition, the Italian Ministry of Foreign Affairs, in collaboration with the NCMS-CNRS and the CANA team, implemented in 2012-2013 the project PescaLibano. Its main objective was to provide "technical assistance to the MOA in the field of fishery development" (Kouyoumjian and Hamze, 2012). Within this context, the PescaLibano project has created a Fish Atlas listing English and Arabic nomenclature for 389 species recorded in Lebanese waters. In addition, the project listed related documentation in an extensive biobliography. One main output is the creation of a GIS database with layers for boundaries of administrative divisions, environmental details, ports, stock assessments and restaurants for the coastal zone.

On another front, the University of Balamand with the collaboration of the University of British Columbia reconstructed the historical fish catch between the 1950s up until 2010. The study used available information on artisanal, subsistence, and recreational fisheries, as well as discards in Lebanon based on available historical fisheries data in the country.

On the other hand, the FAO-EastMed Project (www.faoeastmed.org) funded by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the MoA in Lebanon supported an agreement with the MCR-IOE-UOB to initiate a "Pilot Survey on Fisheries Dependent Data Collection in Lebanon Including Training" that was implemented in 2013-2014. The MCR-IOE-UOB contributed to improve and implement the national fisheries dependent data collection program through the expansion of the original FLOUCA into FLOUCA Web. Related staff of the MoA was trained on the different aspects of data collection and data entry, and field guides for commercial fish species and for fishing gear were developed, produced and delivered to simplify the data collection process. The FLOUCA Web application was expanded to function as an internet-driven system and is quite transparent in its operations. It also offers a wide variety of statistical diagnostics that are in line with the latest requirements demanded by regional and international fisheries bodies, specifically FAO and the GFCM. FLOUCA Web is currently being used by the MoA as the system for reporting catch/effort data to the FAO and GFCM.

Moreover, and under the FAO-EastMed Project another agreement was signed in January 2016 between the FAO and the MCR-IOE-UOB through the FAO-EastMed project to implement a pilot case study on the Ecosystem Approach to Fisheries in Lebanon targeting the purse seine fishery. A management plan for the purse seine fishery in collaboration with, and for the benefit of the MoA was produced using the participatory approach.

Additionally, the GFCM (www.gfcm.org) at the FAO hosted the Concerted Actions for Lebanon meeting in December 2012. The goal of the meeting was to identify objectives and priority issues for Lebanon, to review results achieved/to be achieved by organizations, agencies and projects supporting Lebanese fisheries and aquaculture, and to elaborate a multiannual roadmap (2013-2018) to help Lebanon in strengthening its fisheries and aquaculture sectors. The plan was put on hold.

A study aimed to reconstruct the historical fish catch between the 1950s up until 2010 by using available information on artisanal, subsistence, and recreational fisheries, as well as discards in Lebanon based on available historical fisheries data in the country (Nader et al., 2014). According to the study, the estimated value of total catches for Lebanese coastal regions from 1950-2010 was over 345,000 t, which is 2.4 times the 141,000 t reported by the FAO on behalf of Lebanon. The study reveals that 7,100 tons of fish were caught in 2010, and is currently being updated using recently collected data and will be published in related journals (Nader et al., 2014).

Other sources of data on fisheries in Lebanon are taken from stock assessment studies. Stock assessment has a long history around the world due to its importance in fisheries management. It is an essential tool that determines the dimension and current status of stocks, the effect that exploitation is having on fish mortality, and can predict future trends for fisheries managers to make proper decisions and therefore protect the biodiversity of seas and oceans. Several initiatives to assess the stock of valuable species of commercial importance in Lebanon were launched by different institutions (Nader et al, 2014; Boustany et al, 2015). Some of the findings from the studies include:

- Fishing pressure on the *Boops boops* (Bogue) and the lessepsian crab *Portunnus pelagicus* (Blue crab) species while fishing pressure is on the limits for the *Diplodus sargus sargus* (White Sea Bream) species (MCR-IOE-UOB study: Boustany et al., 2015).

- The lessepsian *Lagocephalus sceleratus* (Silver Cheeked Toadfish) species spawns from May to August and the length at first maturity is reached at 40cm (MCR-IOE-UOB study: Boustany et al., 2015). Similar results were achieved by another study done on the population structure and sexual maturity of the pufferfish *Lagocephalus sceleratus* in 2014 (NCMS-CNRS study: Khalaf et al., 2014).

- Many of the fish caught were juveniles based on several studies carried out on the biological parameters and behavior of the Lessepsian *Siganus luridus* and *Siganus rivulatus*, and on the structure and biological characteristics of several fish species landed by purse seines off the Lebanese coast (American University of Beirut (AUB) studies: Bariche et al., 2007; Bariche et al., 2009).

- The diet of the Lessepsian *Fistularia commersonii* (blue spotted cornetfish) is mostly on *Spicara smaris* and *Boops boops* (amongst 41 different taxa) especially in the spring and summer (Bariche et al., 2009).

Stock assessment studies targeting *Sardinella aurita*, *Engraulis encrasicolus, Lithognatus mormyrus* and *Pagellus erythrinus* were carried out and results are expected to be published in related scientific journals (NCMS-CNRS studies in collaboration with the FAO-EastMed project).

3.5.11 *Important Biodiversity Areas*

According to the framework of the Stable Institutional Structure for Protected Areas Management (SISPAM) Project (MoE, 2006), protected areas in Lebanon are generally classified into:

- 8 Nature Reserves
- 24 Natural sites
- 5 Himas
- 12 Protected Forests
- 14 touristic sites, and
- A multitude of sites that is worth protection, that include: Wetlands, Grottos, Holes, Natural Bridges and Rocks, summits, mountains, etc.

However, in terms of the coastal and marine environments, there are only two protected areas: 1) the Palm Islands Nature Reserve (PINR), and 2) the Tyr Coast Nature Reserve (TCNR). The PINR was established under Law no. 121 of 9/3/1992 while the TCNR was established by Law no. 708 of 5/11/1998 (MoE/IUCN, 2012).

On the other hand, the Ramsar Convention on Wetlands defines wetlands as "Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". The Convention listed three Lebanese coastal sites: Promontory cape and cliffs of Ras Shaqaa, PINR and TCNR including Ras El Ain springs.

Due to highly dense and populated coastal areas in Lebanon and the excessive coastal development and exploitation (Figure 2-5), marine protected areas are crucial to the conservation and maintenance of healthy ecosystems and coastal biodiversity. The Ministry of the Environment (MoE) in Lebanon along with the IUCN, the support of partners such as RAC/SPA and UNDP suggested 14 Marine Protected Areas (MPA) (Figure 4-10) and an associated program to evaluate their management effectiveness. The goal of this program is to: 1) establish a more systematic approach to marine protected areas planning and establishment, 2) enhance collaboration for management and monitoring of MPAs, 3) increase awareness and understanding of the local community in the MPA network, 4) and finally to link Lebanon's network of MPA's to Mediterranean networks. The proposed sites are listed in Table 3-9 as reported in the MPA strategy.

Table 3-9 Proposed sites as per MPA Strategy (MoE/IUCN, 2012)

#	Site	Quality and Importance
1	Nakoura	The Nakoura site is unique for vermetid platforms of relatively small size; rocks and coralligeneous concretions at shallow depths; crevices and overhangs common; soft bottom areas of small sizes occasionally present in patches. The site provides nurseries, spawning and feeding grounds.
2	Sidon Rocks	Islets of rocks and vermetid reefs in the vicinity of Saida. A beach composed of gravel found nearby as well as the estuary of the Awally River. Hard bottom in shallow areas and surrounded by a sandy soft bottom. Saida (Sidon) includes an archaeological and historic features site that was nominated (1984) as a UNESCO World Heritage Site. Very low biodiversity, dominated by introduced species.
3	Raoucheh Cliffs and Caves	Beautiful limestone cliffs area with two large standing rock formations (Pigeons' Rocks). Shallow hard underwater bottoms extending over most of the area. Soft bottoms found at greater depths. Archaeological and historic site and a popular tourist destination (scale bar 250m).
4	Beirut Port Outer Platform	Artificial site composed of a long jetty (>2km) that protects the port of Beirut. Concrete structures as well as rocks and boulders of various sizes create artificial caves and crevices which act as an artificial reef.
5	Byblos	Large vermetid reefs with significant ponds. A beach composed of gravel is found north of the area and the Byblos historic port lies to the south. Hard bottom found in shallow areas and soft bottom with a seagrass meadow dominates deeper waters. Archaeological and historic features.
6	Medfoun Rocky Area	Rocky area with moderate cliffs.Hard underwater bottoms with occasional soft bottom patches. This area could be considered as partly protected since it lies within a military area
7	Batroun Phoenician Wall	Rocky area with important vermetid reefs and hard underwater bottoms. Shallow hard underwater bottoms extend over most of the area. Soft bottoms found at greater depths. Archaeological and historic site and a popular tourist destination. A historic wall is believed to have been erected by the Phoenicians for protection from waves.
8	Ras El Chekaa Cliffs	Limestone cliffs area with hard underwater bottoms and caves.Landscape and seascape with cultural and religious importance.
9	Enfeh Peninsula	Limestone rocks and vermetid reefs forming a peninsula.Shallow hard underwater bottoms; soft bottom in deeper waters.Archaeological and historical site.
10	Litani Estuary	The Litani River is an important water resource in southern Lebanon. Exceeding 140 km in length, it is the longest river in Lebanon and provides an average annual flow estimated at 920 million cubic meters. The waters of the Litani both originate and flow entirely within the borders of Lebanon. The site is important for fisheries, and in relation to the presence of marine turtles and seagrass meadows. The habitat, a combination of physical features and living organisms that provide food, nesting, resting and shelter for fish and wildlife, has recently experienced significant changes in benthic community structure, possibly as a result of anthropogenic activity. The potential of the site for restoration is therefore apparent. Being a distinct topographic entity,

#	Site	Quality and Importance
		identification of the Litani estuary as a protected area with defined boundaries is relatively straightforward.
11	Awali Estuary	The Awali is a perennial river flowing in Southern Lebanon. It is 48 kilometres (30 mi) long, originating from the Barouk Mountain at a height of 1,492 metres (4,895 ft) and the Niha Mountain. The Awali is supplemented by two tributaries, the Barouk and Aaray Rivers. The Awali is also known as the Bisri River in its upper section; it flows through the western face of Mount Lebanon and into the Mediterranean. The Awali River has a discharge of 10.1625 m^3/s (358.89 cu ft/s), it forms a watershed with an area of about 294 km^2 (114 sq mi). The Awally river estuary is important in terms of fisheries and seagrass meadows. Habitat is a combination of physical features and living organisms that provide food, nesting and resting areas, and shelter for fish and wildlife.
12	Damour Estuary	The site is characterized by a sandy bottom area with seagrass meadow in patches. The estuary is a nursery, spawning and feeding ground for numerous species. The green turtle (Chelonian mydas) has been recorded in this site.
13	Nahr Ibrahim Estuary	The site is characterized by a sandy bottom area with seagrass meadow in patches. The estuary is a nursery, spawning and feeding ground for numerous species. The green turtle *(Chelonia mydas)* has been recorded here.
14	Areeda Estuary	The site is characterized by a sandy bottom area with seagrass meadow in patches. The estuary is a nursery, spawning and feeding ground for numerous species. The green turtle (Chelonia mydas) has been recorded here.

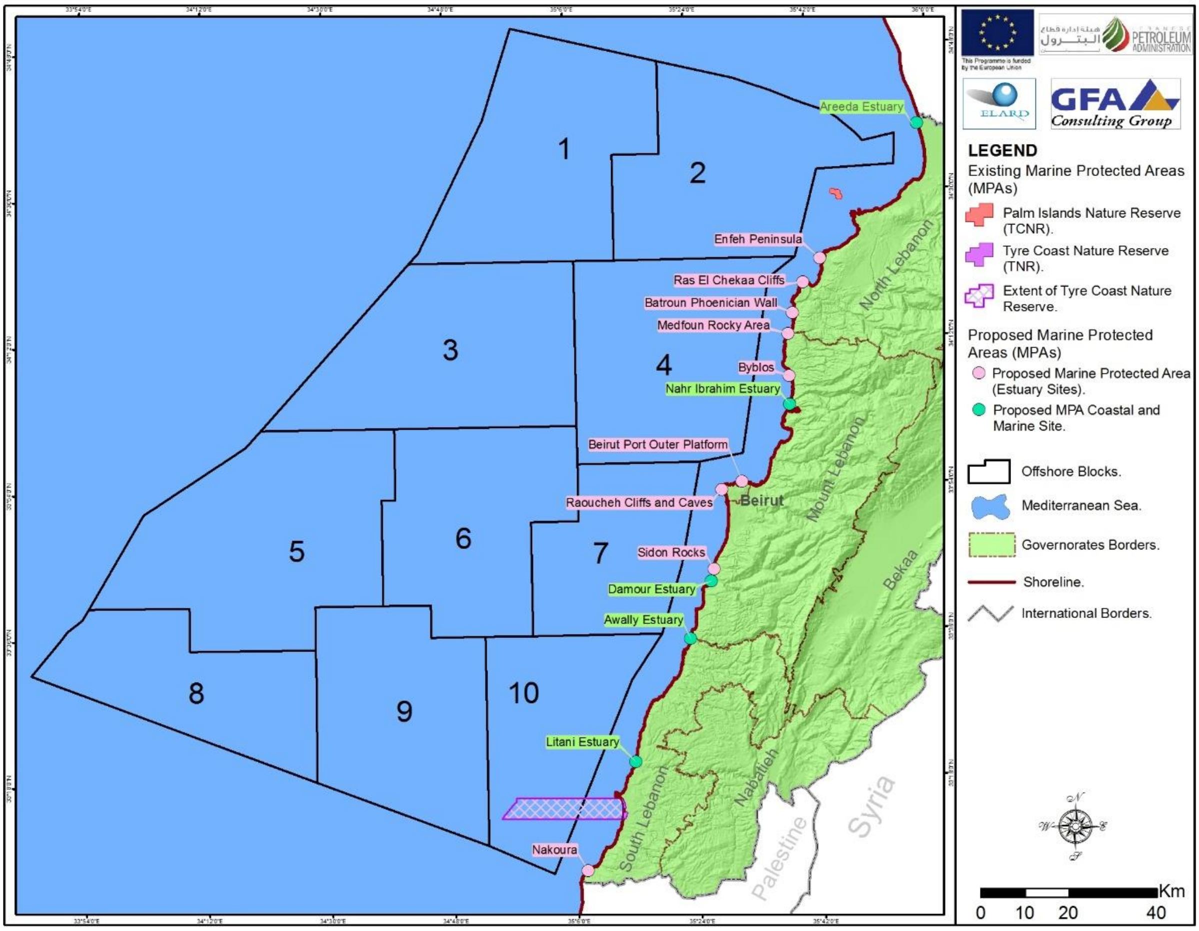


Figure 3-13 Proposed Marine Protected Areas (MPA)

Based on a project conducted in 2014 by MedMPA Network," Ecological Characterization of Sites of Interest for Conservation in Lebanon: Enfeh, Ras Chekaa, Raoucheh, Saida, Tyre and Nakoura" sites were assessed for conservation in terms of taxa biodiversity, habitats, interesting species, fish populations and naturalness. Accordingly, the study team established four categories with different management measures:

a) Tyre Springs and Ras Chekaa present the highest values (> 4). Ras Chekaa has some pristine areas (central sector) which merit an integral protection. Furthermore, the underwater rocky outcrops from northern Tyre, between 30-50m depth, due to the rarity and the presence of interesting habitats (cold and hot freshwater springs, coralligenous, maerl beds) must be protected.
b) Nakoura and Raoucheh have presented high values (~3.5). Also, in the Nakoura zone, Ras El Bayada represents a pristine area which merits an integral protection (littoral cave, cold freshwater springs, and relatively high fish biomass). Raoucheh shows an impressive landscape with important marine caves and tunnels. This area is small and rounded by the city of Beirut; the adequate protection figure would be Natural Monument.

c) Enfeh and Tyre: Due to the high human presence, they have medium values (~3.0) and an integral protection area would be inoperative. In these cases, the buffer zone could be operative, permitting some regulated uses (fishing, tourism) and applying mitigation measures to the human impacts (sewage treatment, selective fishing methods, no marinas). In the case of the Tyre Coast Nature Reserve, a buffer zone could reinforce the protection of this important area for turtle nesting.
d) Saida: Despite the important cultural value, Saida presents a very impacted and crowded environment, with the lowest EV (1.66), where a MPA would be impossible. Nevertheless, the multi-use zone could be applied with an integrated coastal zone management.

Also, based on a similar project conducted in 2016 by MedMPA Network project that was financially supported by the European Union (EU), sites in Batroun, Medfoun and Byblos were assessed for conservation and the establishment of two management areas was proposed (Figure 3-14):

a) Batroun-Medfoun (together with Kfar Abida): Between Ras Selaata (at the north) and Ras Barbara.
b) Byblos: Between Ras Amchit (at the north) and Fidar (south).

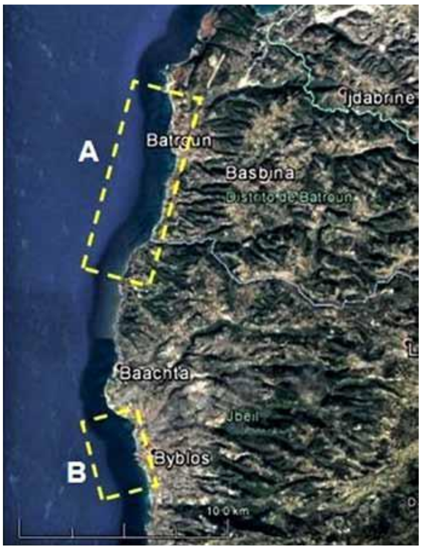


Figure 3-14 Proposed zones for protection (A) Batroun-Medfoun; (B) Byblos.

Proposed deep sea sites

The ELCA is of particular biological importance as described in Section 0. For example, the Turgut Reis Seamount that lies between Turkey, Syria, Lebanon and Cyprus, is still a host for virgin stocks of deep sea shrimps such as *P. longirostris*, *Plesionika martia*, *Aristaeomorpha foliacea* and *A. antennatus* (Würtz M. (ed.), 2012). Furthermore, this area is on the migration routes of bluefin tuna and tunalike species. These pristine habitats should be protected from submarine mining activities, international fishing fleets, Illegal, Unreported and Unregulated (IUU) fisheries and ship origin pollution amongst others.

Furthermore, several key species have been identified residing on the ELCA (Nader, 2012; Bariche M., 2007). Also, the eastern Mediterranean coasts host one the largest areas in the Mediterranean of Opisthobranch formations (F. Crocetta, 2013) dominated by the threatened Dendropoma platforms (IUCN Red List of endangered species, Annex II, SPA/BD Protocol). Furthermore, the region experiences the highest winter temperatures (~ 20℃; Figure 2-4) in the Mediterranean allowing it to act as a refuge and spawning grounds to an array of biologically important species like the giant devil ray, *Mobula mobular*, that was recorded in front of the Gaza Strip, Palestine (Couturier C.I.E, 2013). Many other marine species, some on the IUCNthreatened/endangered Red List, have also been reported in the ELCA adding credence to its definition as an EBSA: monk seal (*Monachus monachus*), several species of sharks like the smalltooth sandtiger shark, *Odontaspis ferox* (Walker P., 2005), the Cape Shark/Piked Dogfish/Spurdog Squalus acanthias (Fordham, S., 2006), the Common Guitarfish/Violinfish *Rhinobatos rhinobatos* (Notarbartolo di S., 2007), and marine mammals (*Physeter macrocephalus*, *Stenella coeruleoalba*, *Grampus griseus*, *Delphinus delphis*, *Tursiops truncates*) (Dedel et. al, 2012) amongst others. The region is also recognized as one of the most important nesting grounds in the Mediterranean for two marine turtles, *Chelonia mydas* and *Carretta carretta* as well as visiting grounds for *Dermochelys coriacea*.

Furthermore, the warm temperatures in the south-east of the Mediterranean (Figure 3-15) also allow lessepsian species to survive the cold winter temperatures experienced in other areas of the basin. Below the warm surface water, the temperature begins to fall and undergoes a rapid decline over a narrow depth range. The depth zone of most rapid temperature decline is the thermocline. In Lebanon, it begins to form in the 35-75m layer with warming surface water temperatures in the month of May and peaks in August (between 60 and 75 m). In winter, the thermocline is destroyed by diminished insolation and increased surface turbulence due to storms (Abboud-Abi Saab, 2002; Abboud-Abi Saab et al., 2008 c; Lakkis, 2011; Lakkis et al., 2011).

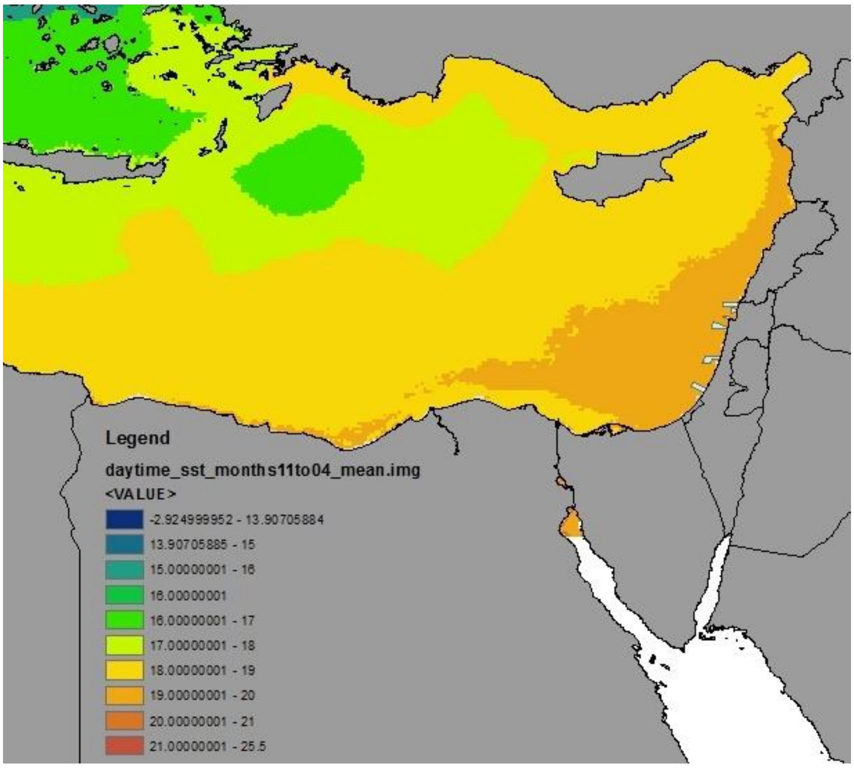


Figure 3-15 Winter Month – Sea Water Surface Temperature
(Source: CBD/UNEP – EBSA Workshop, Malaga Spain, April 2014)

Within this context, a workshop was organized by the Convention of Biological Diversity (CBD) in April 2104 in Spain to define Ecologically and Biologically Significant Areas (EBSAs) for the Mediterranean. In the workshop, it was suggested by Lebanon's team that an EBSA for the East Mediterranean under the title of East Levantine Canyons Area – ELCA as shown in Figure 3-16.

The criteria for sites selection included:

- C1: Uniqueness or rarity
- C2: Special importance for life-history stages of species
- C3: Importance for threatened, endangered or declining species and/or habitats
- C4: Vulnerability, fragility, sensitivity, or slow recovery
- C5: Biological productivity
- C6: Biological diversity
- C7: Naturalness

And the ELCA met the criteria as presented below.

Location and brief description of areas	C1	C2	C3	C4	C5	C6	C7
12. East Levantine Canyons (ELCA) • Location: The East Levantine Canyons is located all along the Lebanese and Syrian coastline. The East Levantine Canyons is a system composed of deep canyons, as well as hydrothermal vents and submarine freshwater springs, and is of particular biological importance. The coastal areas of the eastern Mediterranean host one of the largest areas of Opisthobranch formations, and its waters experience the highest winter temperatures, allowing it to act as a refuge and spawning ground for many biologically important species of chondrichthyes, marine mammals, reptiles and teleosts (many of which are listed as vulnerable/endangered on the IUCN Red List).	H	H	H	H	-	H	M

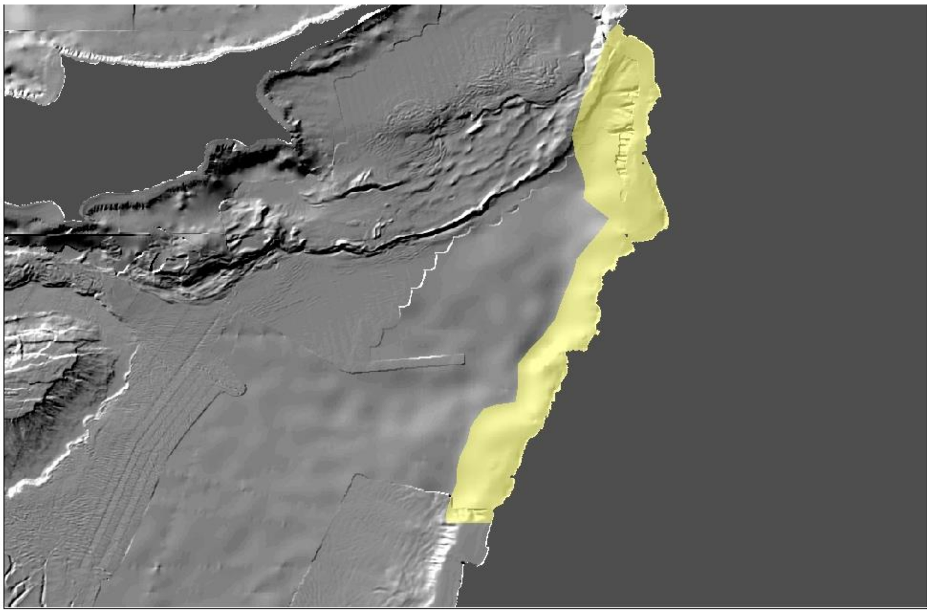


Figure 3-16 Proposed East Levantine Canyons Area in yellow
(Source: CBD/UNEP – EBSA Workshop, Malaga Spain, April 2014 link: https://www.cbd.int/meetings/EBSAWS-2014-03)

Today, a large number of Indo-Pacific species, including fish, macrophytes, and invertebrates, have entered the Eastern Mediterranean through the Suez Canal. The relatively shallow water of the Canal with an average depth of around 10 m is considered as a major physical barrier for the migration of deepwater species. Accordingly, most of the invasive species can be found at depths of less than 70 m in the Eastern Mediterranean (Nader, 2012).

Lebanon's territorial water contains deep sea areas more than 1,000 m depth (please refer to Section 0). These areas include a number of habitats that may represent potential "hot spots" of biodiversity. Knowledge of the biodiversity associated with these habitats and ecosystems is expected to enhance significantly the understanding of biodiversity and the functioning of the deep seas. A tentative, possibly not exhaustive list of these systems includes: open slope systems, submarine canyons, deep basins, seamounts, deep-water coral systems, cold seeps and carbonate mounds, hydrothermal vents and permanent anoxic systems.

Following a request for partnership sent from the Lebanese MOE, OCEANA "an international organization focused solely on oceans, dedicated to achieving measurable change by conducting specific, science-based campaigns with fixed deadlines and articulated goals"; took another deep-sea expedition, "The Deep-Sea Lebanon" Project in 2016. After an in-depth analysis of several sites around the Mediterranean, proposed 100 areas that will constitute its proposal for a network of Mediterranean MPAs, MedNet (www.moe.gov.lb). Amongst these sites, four were proposed in deep waters within Lebanon's territorial waters further validating the importance of the East Levantine Canyon Area (ELCA):

- Beirut Escarpment
- Saint Georges Canyon

- Jounieh Canyon
- Tyre Canyon

Another deep-sea expedition was undertaken as part of "The Deep-Sea Lebanon" Project in 2016 following a request for partnership sent from the Lebanese MoE (refer to Figure 3-7 for the areas surveyed during the expedition). This project, which is funded by the MAVA Foundation, is a partnership between Oceana, IUCN and UNEP/MAP-RAC/SPA, on behalf of the MoE with the support of CNRS-L, GFCM and ACCOBAMS. The expedition declared that more than 200 species, including new records for the Mediterranean Sea (recorded previously only in the Atlantic Ocean and in polar regions) have been documented. The expedition showed that there is "a superb belt of coralligenous gardens discovered at 80 meters depth, beautiful corals, and a huge variety of sponges". Some fish species came as a surprise as well. The longnosed skate (*Dipturus oxyrinchus*) was seen for the first time in the Levantine Sea, and observations of lantern shark (*Etmopterus pusillus*) marked the first record of this species in the Mediterranean". Such findings should help in the declaration of the four identified deep-sea sites as MPAs.

The areas of conservation interest based on Oceana 2016 expedition overlaid with the offshore blocks is presented in Figure 3-17.

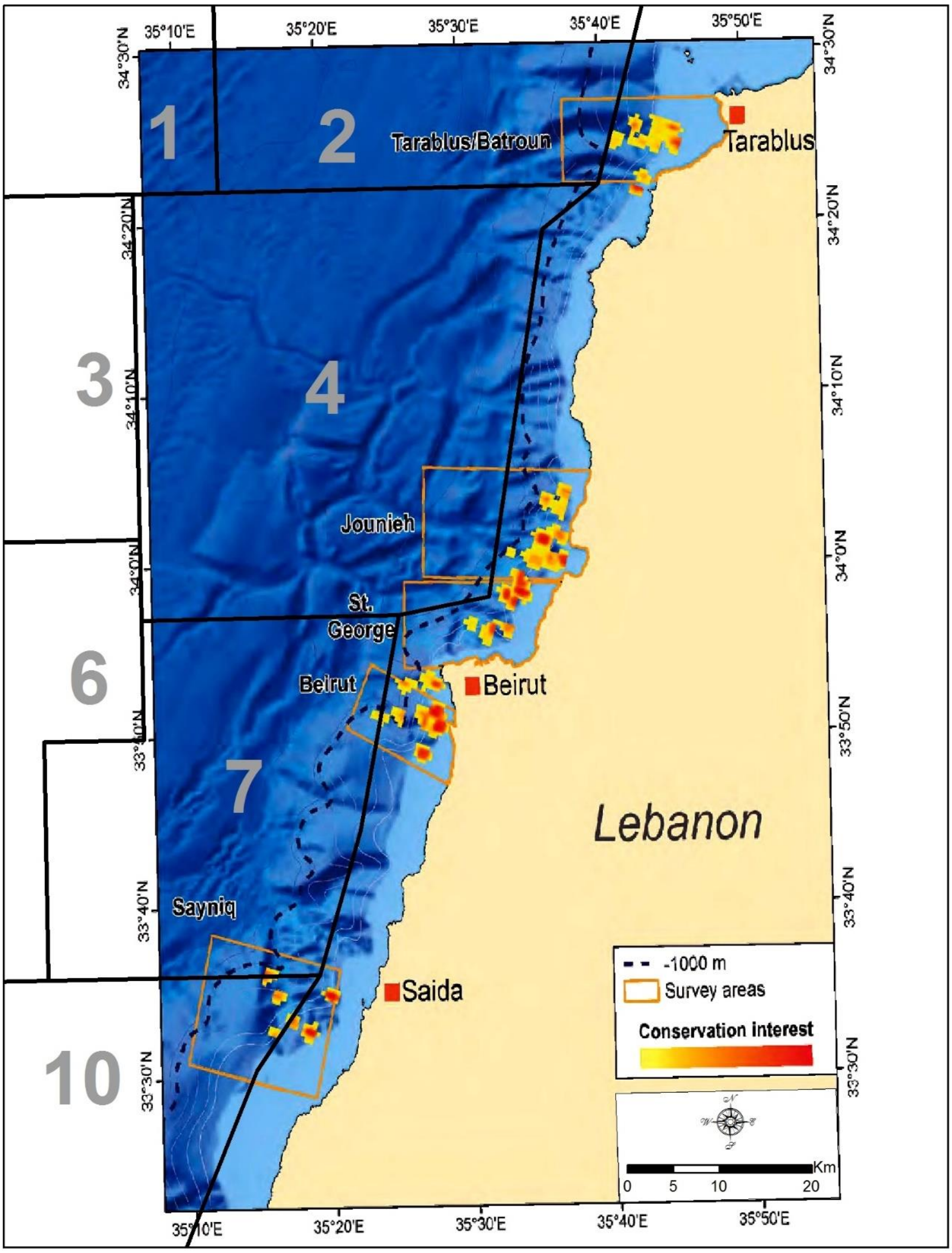


Figure 3-17 Areas of Conservation Interest based on Oceana 2016 Expedition in the Lebanese Waters

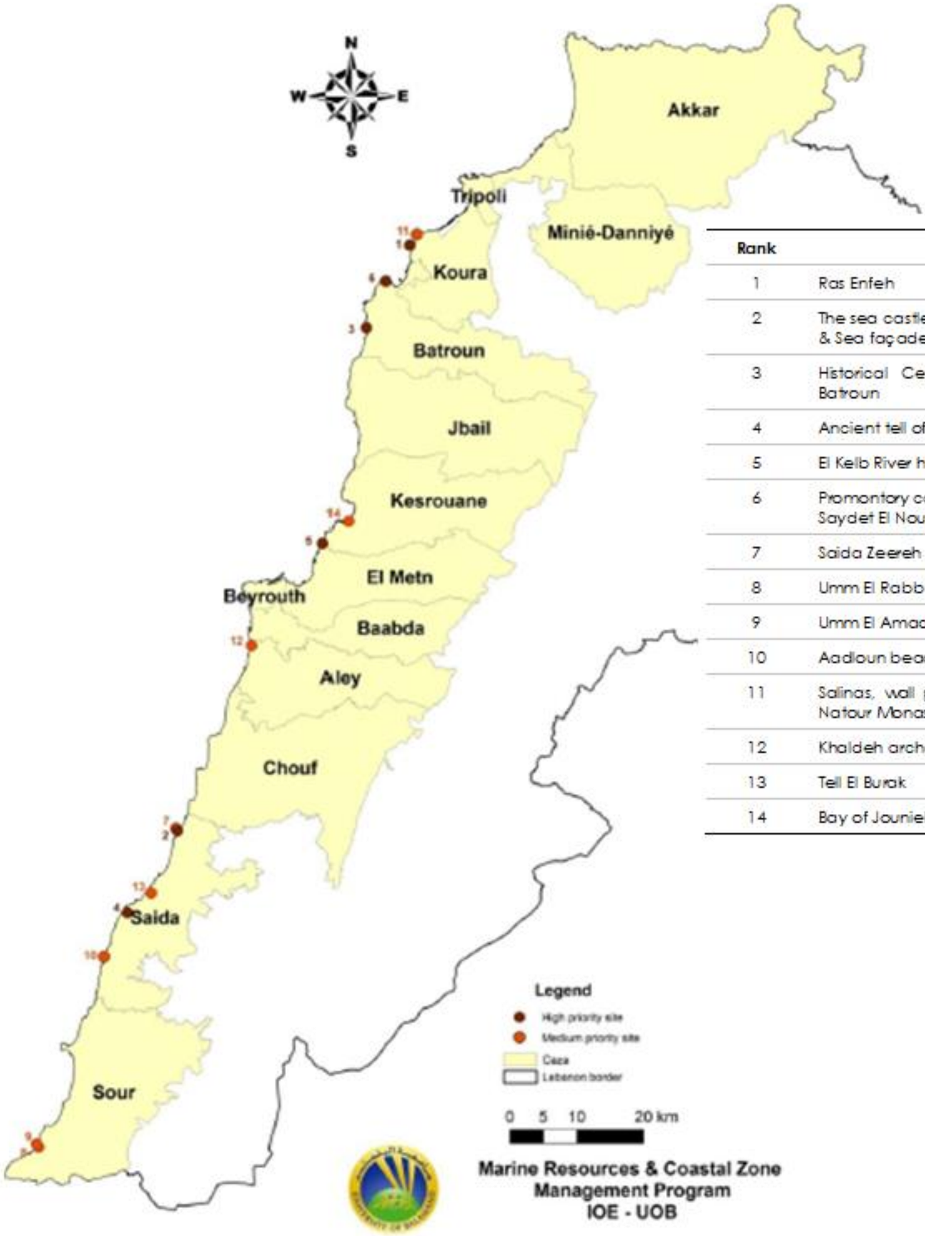
4. ARCHEOLOGICAL AND CULTURAL HERITAGE

Conservation and protection of coastal and marine biodiversity requires the protection of their habitats. Within this context, the "Improved Understanding, Management and Monitoring in the Coastal Zone" Report, Component A (i) of the Environmental Resources Monitoring in Lebanon (ERML) project (UOB/UNEP/MOE, 2013) had, amongst others, the objective to assess the status of Coastal Sensitive Areas in Lebanon.

The assessment aimed at preparing a database of natural and cultural heritage sites. Geographical, biological and cultural features, the existing and potential stresses, and current conservation status were all considered as parameters for the identification of the main coastal and marine sensitive sites. The most sensitive were then evaluated based on the criteria developed by the CBD and UNESCO-World Heritage Center (WHC). Consequently, priority ranking from the most to the least sensitive was given. 14 touristic cultural sites were identified of cultural importance and need protection. Five sites were ranked high priority while nine had medium priority as shown in Figure 4-1and Figure 4-2.

Recommendations concerning the high priority sites emphasized the need for their immediate protection and management through a precautionary approach. In addition, high and medium priority sites were identified as hotspots for preservation then restoration whenever possible and feasible.

However, The Directorate General for Antiquities is developing a more extensive list based on a survey of the coastline offshore and onshore that is being carried out to identify and locate the possible identification of potential archaeological features including freshwater submarines, diving sites, ship wrecks, underwater cities, etc. The purpose is to protect all the coastal archaeological sites and not just sensitive sites.



Rank	Name
1	Ras Enfeh
2	The sea castle of Saida and underwater city & Sea façade & old harbor
3	Historical Center and Fishing Harbor of Batroun
4	Ancient tell of Sarafand
5	El Kelb River historical site and estuary
6	Promontory cape and cliffs of Ras Shaqaa & Saydet El Nouriyeh Monastery
7	Saida Zeereh
8	Umm El Rabb site
9	Umm El Amad site
10	Aadloun beach and caves
11	Salinas, wall promenade and our Lady of Natour Monastery
12	Khaldeh archaeological site
13	Tell El Burak
14	Bay of Jounieh

Figure 4-1 ERML High Priority Sites Map-1

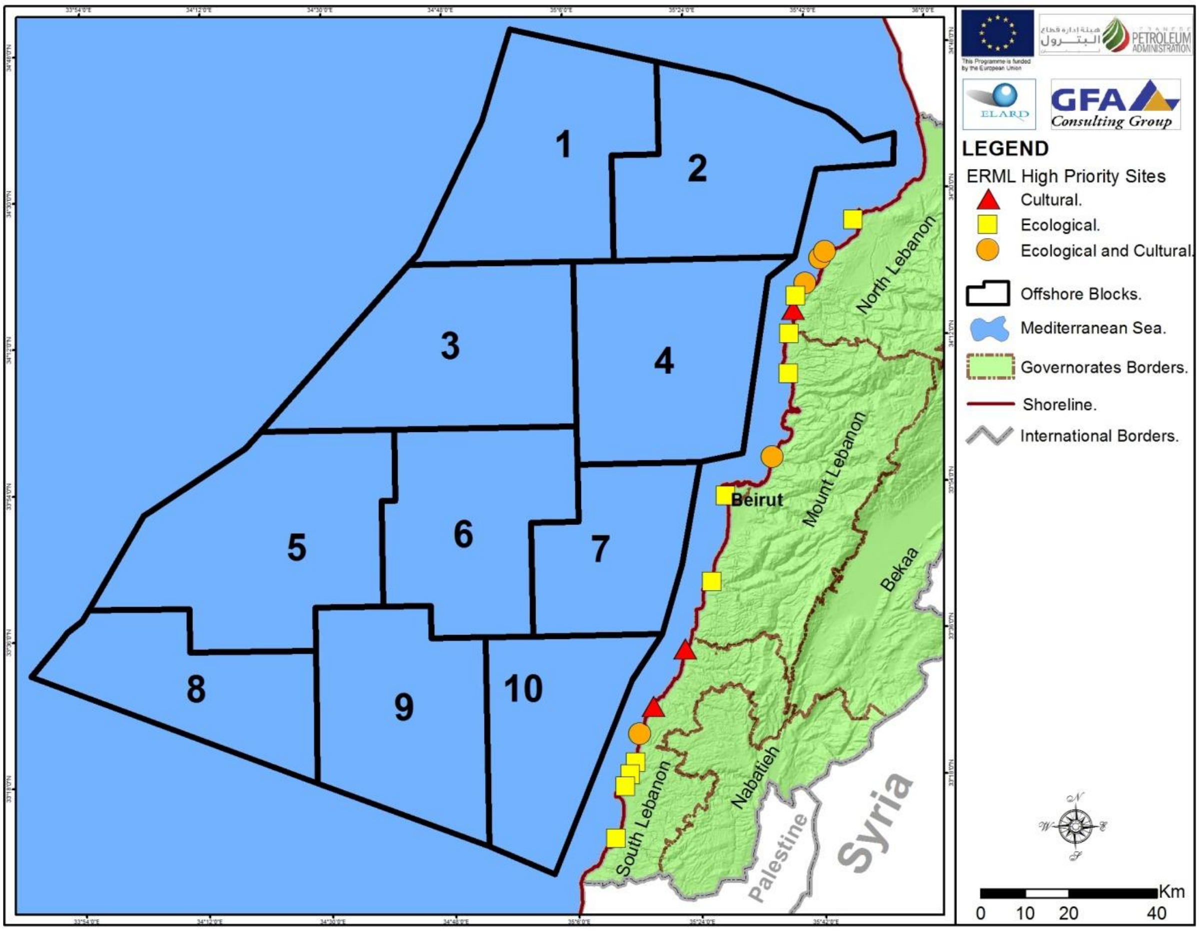


Figure 4-2 ERML High Priority Sites Map-2

The Mediterranean Sea: commerce, connections and regulations

The Mediterranean Sea lies in the center of a region that forms a cultural environment in space and time. Its waters both divide and bond the various peoples residing on the three continents boarding its perimeter and the diverse civilizations that developed on its shores and hinterlands throughout centuries.

Trade connections between the different settlements and their populations were identified through the diverse artefacts found during excavations and confirmed by written records.

Evidence of harbors, port amenities, shipwrecks, anchors and other remains related to navigation and sea trade are numerous and attest the interactions between east and west starting the Bronze Age Period at least (c. 3000 B.C.).

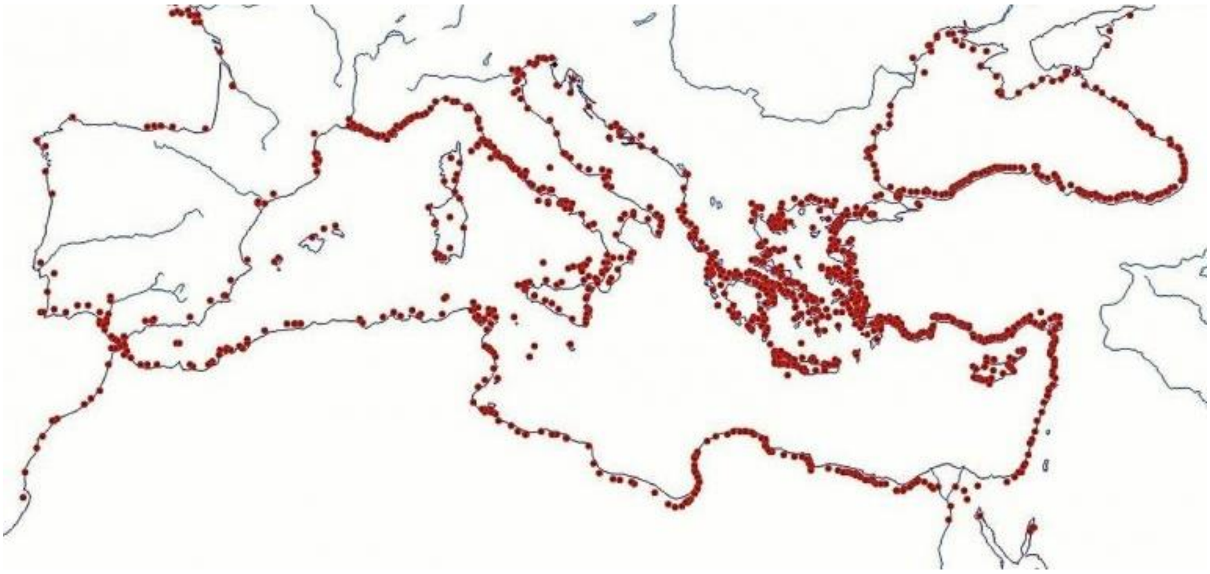


Figure 4-3 Ancient harbors as defined through ancient texts (retrieved from Cities Database).

Archaeological researches has shown that ships did not remain on the coastline, but sailed the open sea. The evolution of ship construction can be explained through the need of having stronger ships to transport heavier loads in difficult sea and wind conditions.

Written sources have also revealed various aspects of international maritime travel and trade regulations as of the Bronze Age Period. One testimony comes from the Amarna letters dated to the middle of the 14th century BCE (EA 114, 6-26), addressed by the prince of Byblos to the pharaoh, in which he reports a ship coalition in Tripoli that harassed his city:

"May the king, my lord know that Aziru is at war with me. He has seized 12 men of mine, and the ransom price between us he has set at 50 (shekels of) silver. It was the men whom I sent to Sumur that he has seized. In Wahliya are the ships of the ruler of Tyre, Beirut, and Sidon. Everyone in the land of Amurru is at peace with them; I am the enemy. Because Yapah-Hadda is now on the side of Aziru against me, he has, I assure you, seized a ship of mine and he has, I assure you, for this very reason been going to sea to seize my ships. May the king give thought to his city and his servant; my peasantry long only to desert. If you are unable to rescue me from my enemies, then send back word so I can know what action I am to take"

The coast of Lebanon: harbors and trade routes.

It is with Father Antoine Poidebard during the 19th c. that the interest to harbors and marine archaeology at famous sites such as Byblos, Sidon and Tyre began. He applied the technique of aerial photography for his study and initiated the underwater archaeology discipline in the Lebanon.

Studies on the harbors, connections between coastal cities and the trade trends are active and constantly advancing, but until today, the organization of Phoenician maritime trade is moderately known, and although trends can be noted, routes were going all around the

Mediterranean, secondary routes were often used, which demonstrate the multiplicity of small and large exchange networks.

Some 15 harbors or maritime installations can be asserted on the Lebanese coast that operated starting the Bronze Age Period, till recently.

- The oldest structure of the port of Byblos is roughly dated ca. 2570 B.C.
- Anchorages of the Middle Bronze Age (2100-1550 B.C.) sheltered by offshore ridges were used in Beirut, Sidon, Sarepta (Sarafand) and Tyre.
- The Sidonian North breakwater (230 m long) is dated ca. 1700-1500 B.C.

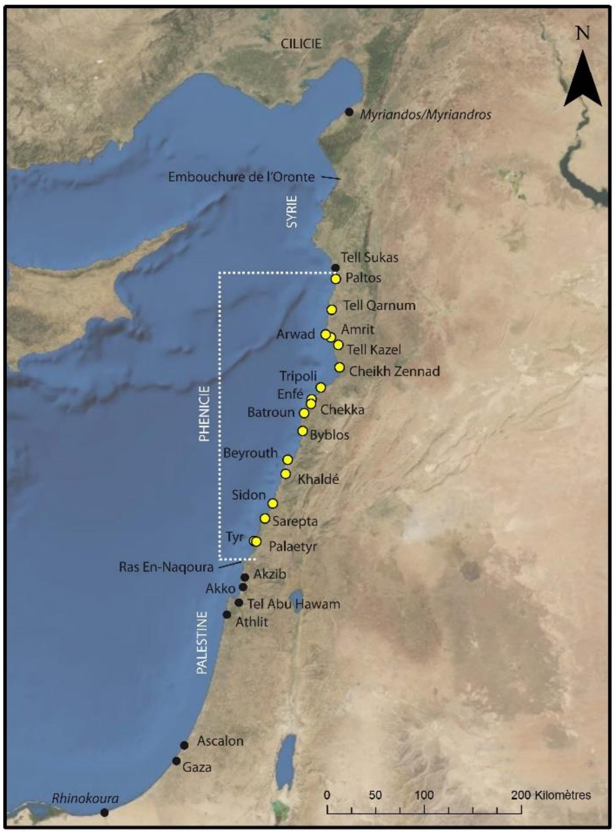


Figure 4-4 Map showing Phoenician harbors on the Lebanese coast (courtesy N. Carayon).

The harbors were used for both trade and war ground. The trade of timber, glass, olive oil, wine and purple dye exported from the Levantine coast is well attested both through text and archaeological findings – during different periods starting from the Bronze Age till the Medieval Periods.

The connections between the different cities in the Mediterranean Sea based on the written texts of geographers during antiquity (first - third c. Anno Domini) reported by P. Arnaud, 2005 are shown in Figure 4-5. it shall be noted that these connections do not present the exact navigation routes.

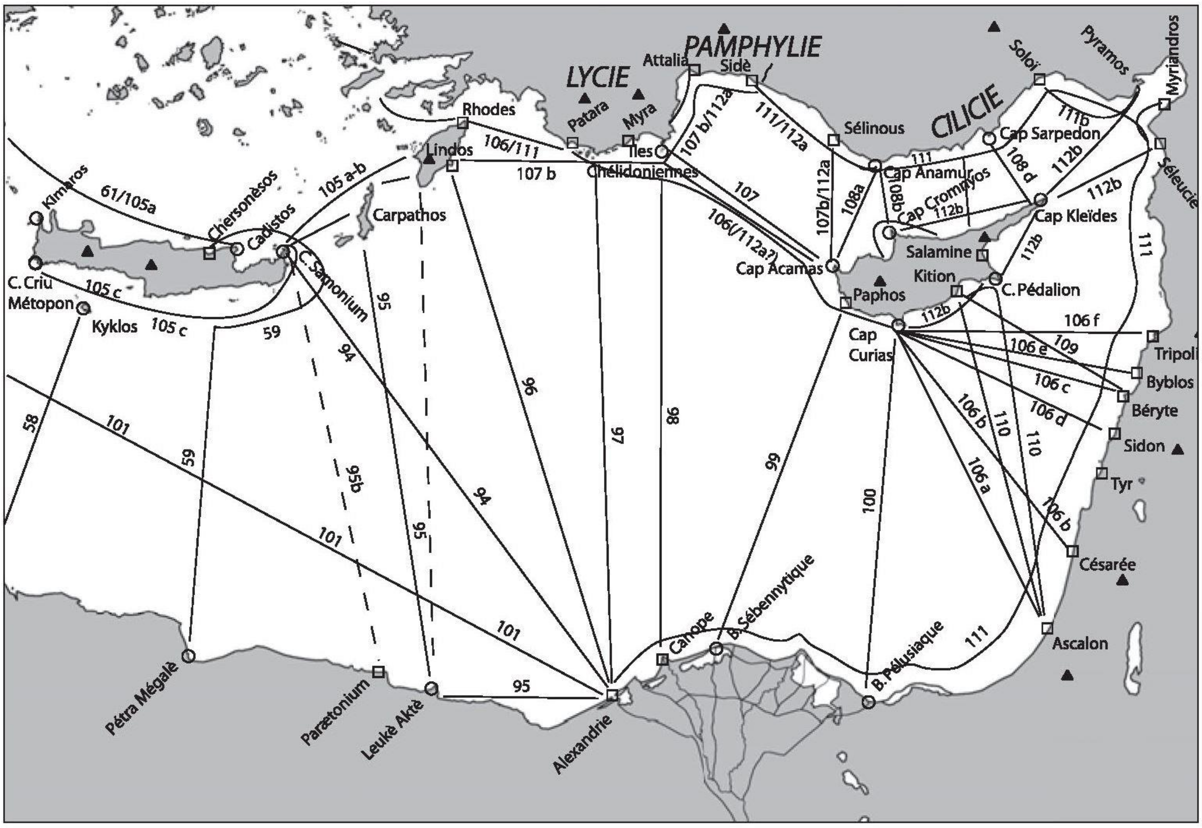


Figure 4-5 Connections between Different Cities in the Mediterranean during Antiquity (P. Arnaud, 2005)

Shipwrecks:

Shipwrecks are of great value in cultural and trading studies. Their cargo is usually well preserved and sealed, thus allowing to date it and further understanding the merchandizing and trade routes, the naval engineering and boat building.

The studied shipwrecks discovered on many maritime sites on the Levantine coast raises the possibility of unearthing Bronze Age to Islamic wrecks off the shore of Lebanon.

One shipwreck off the coast of Tyre was investigated between 2006 and 2010, at a depth of 34 meters, 4.5 Km North-West from Tyre, allowing the recovery and study of the artefact that constituted the cargo: a large amount of clay statues, both of female and male figures, dated between the 6th and 4th c. B.C.

The main shipwreck discoveries of interest in the vicinity of the Lebanese coast are:

- In 1997: The shipwrecks of Tanit and Elissa were discovered at a depth of 400 m, 33 miles off the shore of the Ashkelon coast. The cargo of Tanit consisted of some 385 amphorae, while Elissa carried some 396 amphorae. Both ships yielded amphorae produced on the Levantine coastal cities, around 750 – 700 B.C.

- In 1999: two ships dated to 750 B.C. that had set sail from Tyre were found at a depth of 1,500 feet about 30 miles off the coast to the south of Tyre. The ships were "almost perfectly preserved – a result of the bitterly cold deep-sea waters, where sunlight cannot reach, pressure is intense and sediment scarcely accumulates".
- In 2014: Phoenician shipwreck dated to 700 B.C. was discovered 1 mile off the coast of Malta, at a depth of 400 feet.

As of the 1990s, studies on the Lebanese coast have gained in significance, consolidating both the ancient texts and land archaeological evidence.

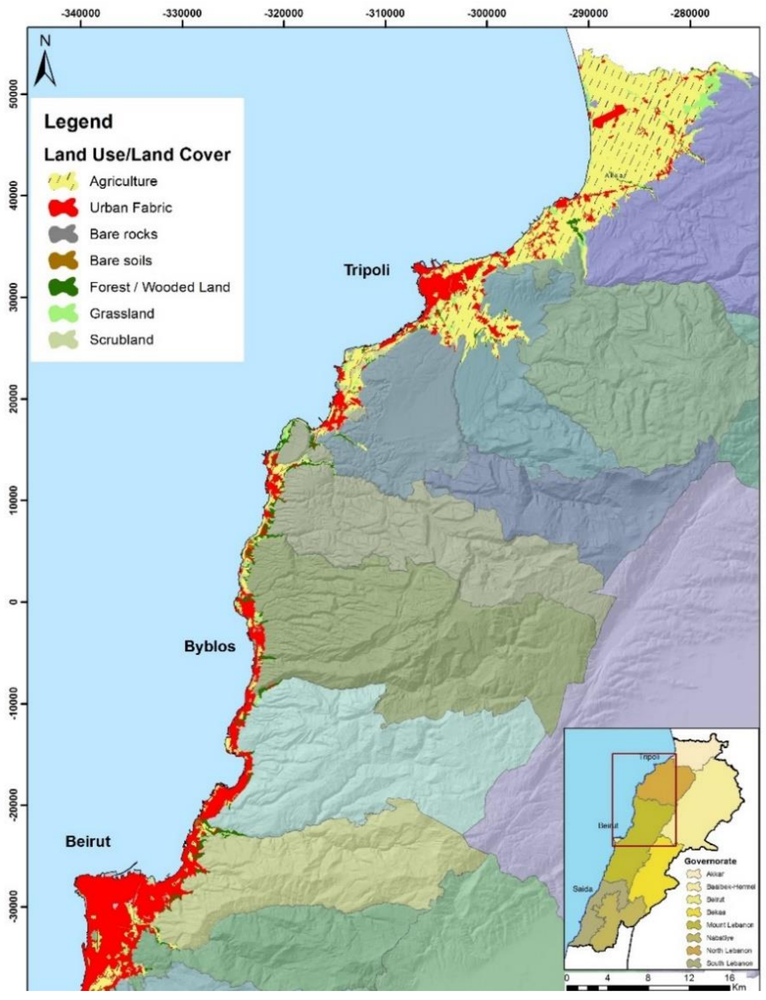
The prominence of the Phoenician's skills in terms of navigation and trade, the results of coastal investigations and the historical records lead to the expectation of significant discoveries off the shore of the Lebanon.

5. LANDSCAPE

The National Physical Master Plan of the Lebanese Territory (NPMPLT) which was endorsed by Decree 2366/2009, is the reference document for strategic regional and local urban development and planning in Lebanon. It guides and locates major public investments. The existing and proposed land use/landscape of the Lebanese territory, including the coastal line is determined by the NPMPLT as shown in Figure 5-1.

Some coastal areas have special significance and are protected by Law. These should be restricted areas for E&P activities and they include:

- Aarqa river estuary (MOE, Decision no. 188/1998)
- Terraces and Beach of southern Tripoli towards Qalamoun (Decree No. 3362/1972)
- El Jawz River estuary (MOE, Decision no. 22/1998)
- Batroun National Marine Hima at the National Centre for Marine Sciences (MOA, Decision no. 129 of 1991)
- Ibrahim River estuary and archaeological sites (MOE, Decision no. 34/1997)
- Coastal Front Rocks and terraces of Wata Slim (Tabarja)(MOE, Decision no. 200/1997)
- El Kelb River estuary and historical site (MOE, Decision no. 97/1998)
- Beirut River estuary (MOE, Decision no. 130/1998)
- Awali river estuary (MOE, Decision no. 131/1998; CDR/DAR/IAURIF, 2005).


Legend
Land Use/Land Cover
Agriculture
Urban Fabric
Bare rocks
Bare soils
Forest / Wooded Land
Grassland
Scrubland
Tripoli
Byblos
Beirut
Governorate
0 4 8 12 16 Km

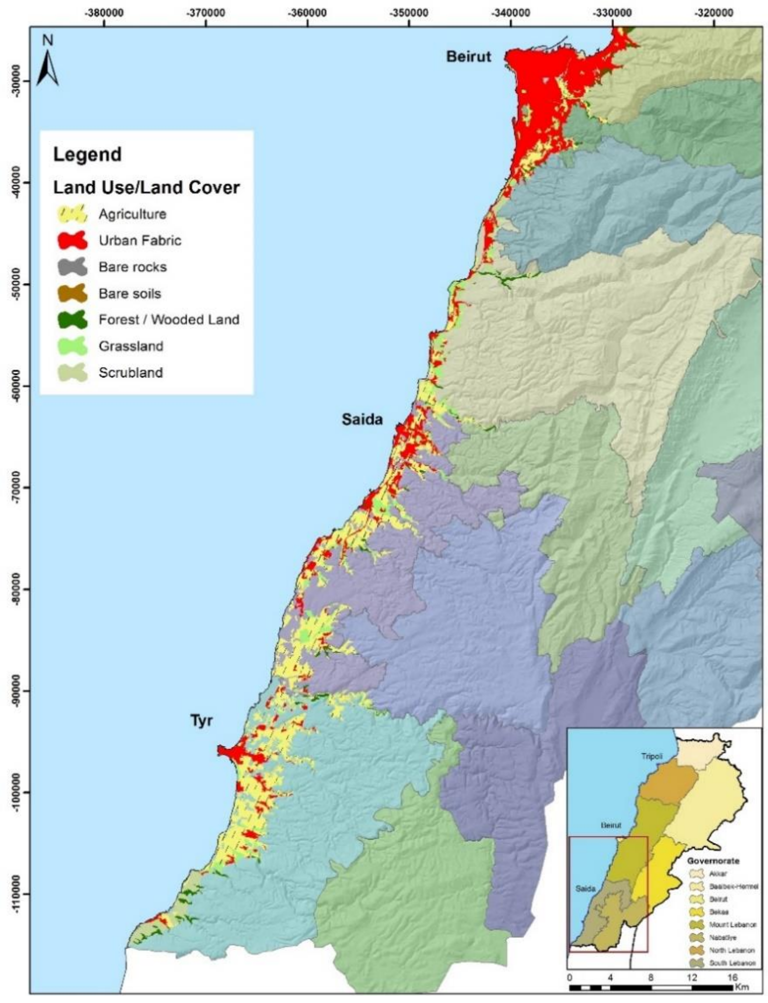

Legend
Land Use/Land Cover
Agriculture
Urban Fabric
Bare rocks
Bare soils
Forest / Wooded Land
Grassland
Scrubland
Beirut
Saida
Tyr
Governorate
0 4 8 12 16 Km

Figure 5-1 Existing and Proposed Land use/landscape of the Lebanese coastal line (Based on the NPMPLT)

6. DEMOGRAPHY AND SOCIAL PROFILE

The following section presents an overview of the existing socio-economic conditions in Lebanon. Social, economic and demographic data in Lebanon are often incomplete and outdated. The last official population census was conducted in 1932, population reports since then are often based on surveys and estimations.

Existing socio-economic data were collected from various sources that included ministries, other governmental organizations, academic institutions, research institutes, NGOs and non-official entities. A rigorous research was carried out to compile available data pertaining to socio-economic situation in Lebanon that could serve as a baseline indication to current status in order to analyze the possible consequences (positive and negative) that could eventually result from the offshore oil and gas activities.

6.1 POPULATION

The population number in Lebanon is estimated at 4,356,000 (MoPH, 2016), excluding foreign workers, Palestinian and Syrian displaced people. The Lebanese population has been on the rise in recent years, as shown in Figure 6-1, with an estimated population growth rate of 1.5 (MoPH, 2016). Lebanon has a high population density, around 496 persons/km². Around 90% of the population resides in an urban environment, most of them concentrated in the biggest cities along the coastline (MoE/UNDP/GEF, 2016).

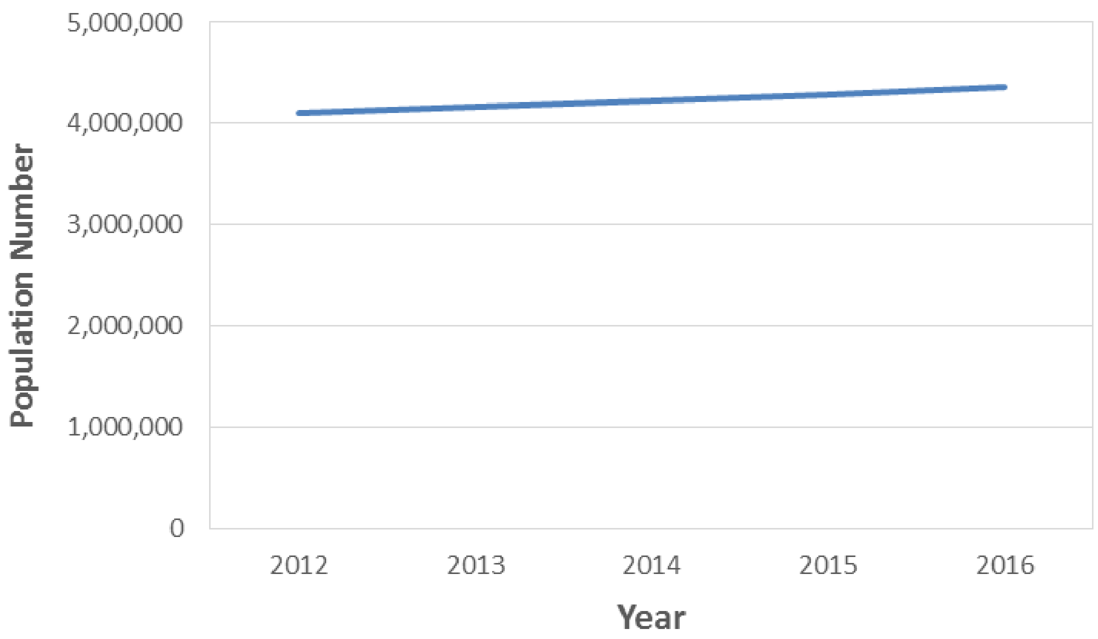


Figure 6-1 Population Trend Since 2012 (MoPH, 2016)

For the year 2016 the total number of registered births was around 89,000 while the total number of registered deaths was around 24,600 (MoPH, 2016). There is no fixed trend, i.e. increase or decrease, over the past five years with respect to births and deaths as is reflected in Figure 6-2.

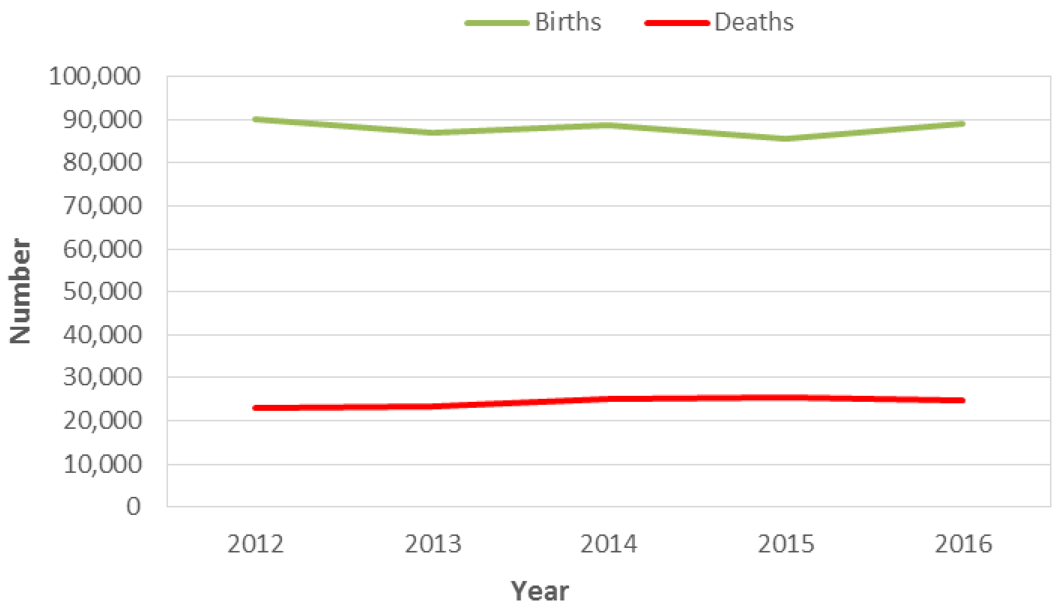


Figure 6-2 Number of Registered Births and Deaths Since 2012 (MoPH, 2016)

Lebanon's population has changed substantially in the past few years. The armed conflict in Syria that started in the beginning of 2011 imparted a heavy pressure on Lebanon's already fragile infrastructure and resources resulting from incoming displaced persons. As of October 2017, it was estimated that Lebanon hosts around 1.5 million Syrians who have fled the conflict in Syria and sought refuge in Lebanon, including 991,917 million registered with UNHCR, 34,000 Palestine displaced persons from Syria, and around 35,000 Lebanese returnees (GoL/UNDP, 2018). Moreover, around 495,985 Palestine displaced persons are registered with UNRWA and reside in Lebanon (UNRWA, 2015).

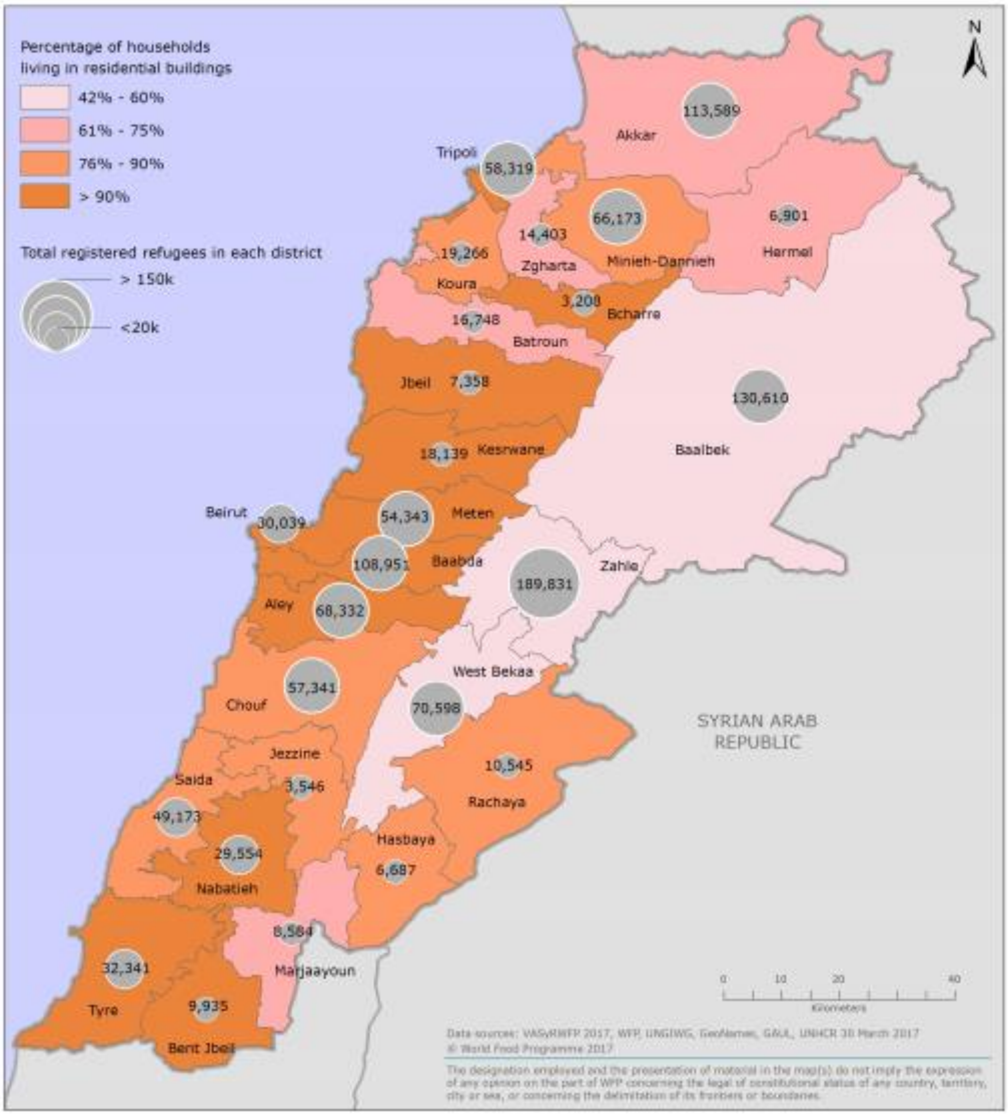


Figure 6-3 Total Registered Syrian Refugees in each District and Percentage of Households Living in Residential Buildings (UNHCR/UNICEF/WFP, 2017)

6.2 EMPLOYMENT

The Lebanese labor is distributed among several sectors as shown in Figure 6-4. The services sector leads with 39% followed by the trade sector with 27% then manufacturing with 12%, construction with 9%, transportation and telecom with 7% and agriculture with 6% (CAS, 2011).

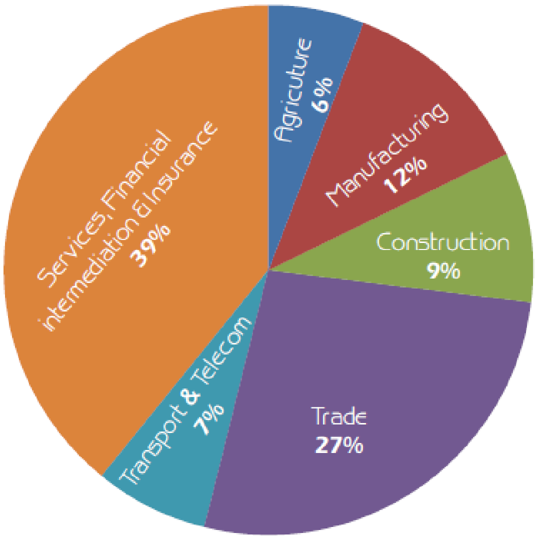


Figure 6-4 Employment by Sector (CAS, 2011)

The labor market in Lebanon is characterized by high, often long-duration, unemployment rates. Around 11% of the labor force is unemployed, unemployment rates are particularly high for women (18 %) and youth (21.6%) (UNDP, 2015).

For youth, specifically between the age18-29, the transition from education to employment in the Lebanese market is challenging for two main reasons (UNDP, 2015):

- Graduates from less privileged schools and universities are perceived differently; and
- Saturated market since Lebanon produces more graduates and job seekers than the domestic market demands.

Skilled graduates in business, social science, agriculture and law take the most time to find a job while education, engineering, humanities, health and welfare majors find jobs more quickly. Additionally, graduates from top universities find employment easier as well (UNDP, 2015).

6.3 POVERTY

Available data on the poverty levels show that 27 to 28.5% of the Lebanese population were considered poor and were living below 3.884 USD per person per day between 2008 and 2011, while, 10% of the population were extremely poor (GoL/UNDP, 2018). Poverty levels have further increased by 6% between 2011 and 2015, after the Syrian crisis in 2011 (GoL/UNDP, 2018).

Poverty is the lowest in Beirut, followed by Mount Lebanon and Nabatieh. The poorest regions are Bekaa and North Lebanon (CAS/WB, 2015).

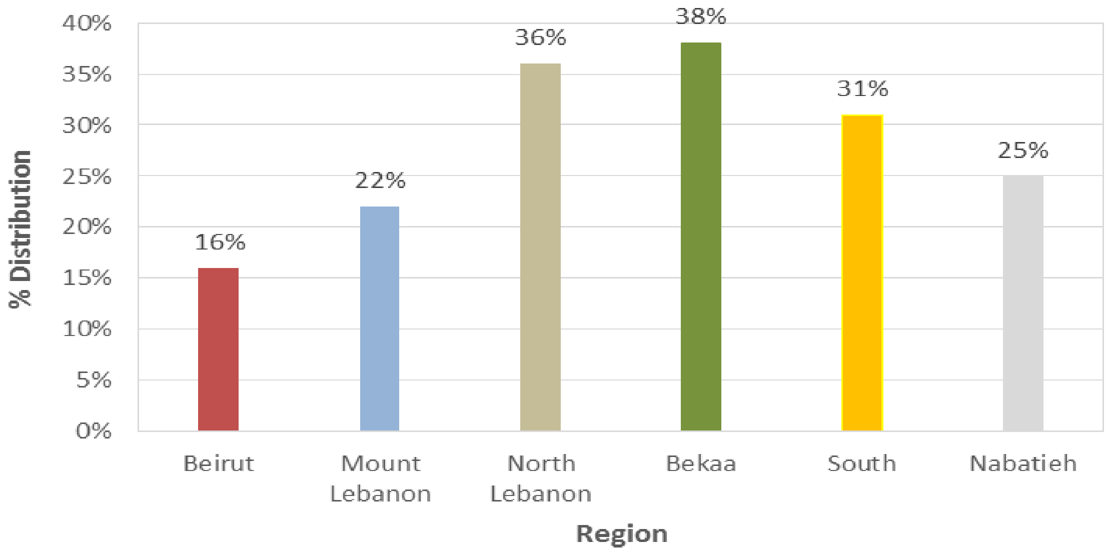


Figure 6-5 Poverty Rates by Region (CAS/WB, 2015)

MoSA's National Poverty Targeting Program (NPTP) was launched in October 2011. The aim of the program is to support poor households fight poverty and enhance their general welfare. An application and evaluation process determines whether a household enter the NPTP or not. According to the Program, every household living below 3.84$/capita/day is classified as an extreme poor Lebanese households (CMU, 2014). Extreme poor householders also benefit from free access to health and education services.

Until December 2013, a total of 42,703 households were classified which is 56.2% from the total number of households who applied to the Program. Table 6-1 summarizes the distribution of these beneficiaries among Lebanon with North Lebanon scoring the highest number of beneficiaries in Lebanon with 42.3% which is due to the fact that it has the highest number of extremely poor households, followed by Bekaa (23.7%) and Mount Lebanon (16.5%) (CMU, 2014).

Table 6-1 Distribution of NPTP Beneficiaries until December 2013 (Based Data provided by CMU)

Governorate	Number of Applications	Number of Household Beneficiaries	Beneficiary Rate (%)	National Distribution (%)
Beirut	2,690	325	12%	0.7
Mount Lebanon	18,364	7,049	38.4%	16.5
North Lebanon	20,873	18,044	86.4%	42.3
Bekaa	16,345	10,138	62%	23.7
South Lebanon	8,795	4,962	55.3	11.6
Nabatieh	8,749	2,185	25	5.2
Total	**75,996**	**42,703**	**56.2%**	**100%**

Around 50% of the beneficiaries have a household size of 5 or less members (CMU, 2014). 50% are youth (below the age of 22), while around 10% are above the age of 57 and 5% above the age of 68. The male labor force participation rate is 62.6% while that of female is 16.6% (CMU, 2014). The labor Force Participation Rate is the proportion of the working–age population that is actively engaged in the labor market either by working or looking for work. As can be seen in Table 6-2, Beirut has the highest labor force participation rates for both males and females.

Table 6-2 Labor Force Participation by Gender and Governorate (CMU, 2014)

Governorate	Labor Force Participation (%)	
	Male	Female
Beirut	66.6	30
Mount Lebanon	62.5	27.8
North Lebanon	65	12
Bekaa	57.7	15.4
South Lebanon	62.9	19
Nabatieh	61.6	23.7
Total	**62.6**	**16.6**

50% and 40% of males and females beneficiaries have an occasional work that is they do not have a continuous and fixed source of income (CMU, 2014). The education of the household head was a major indicator of poverty, 45% of poor households were headed by an individual with less than elementary education (UNDP, 2015).

6.4 CRIMINALITY

An increase in the number of annual detainees held for charges of misdemeanors or felonies has been witnessed since 2011 as is presented in Figure 6-6.

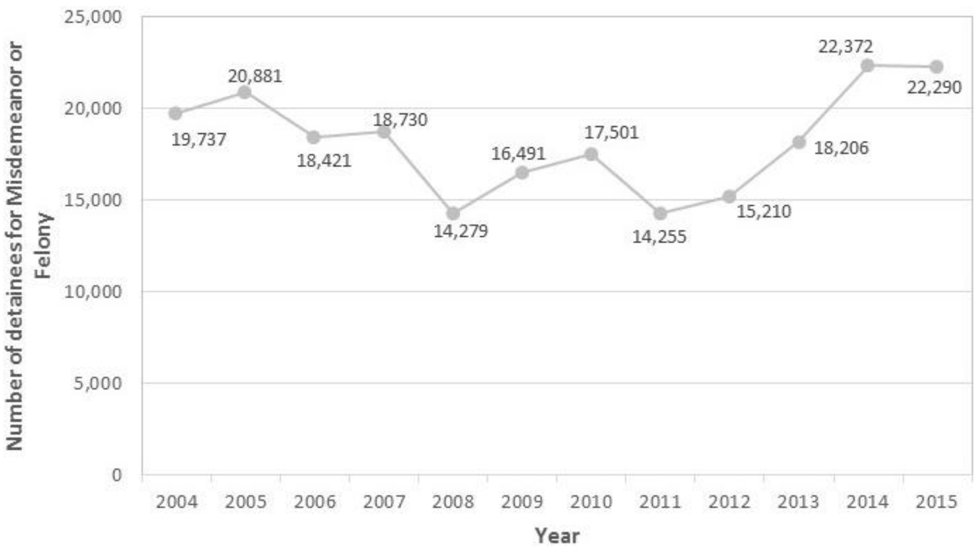


Figure 6-6 Annual Number of Detainees for Misdemeanors and Felonies
(based on data from Directorate General of the Internal Security Forces)

Figure 6-7 presents the type and frequency of crimes occurring on annual basis since 2004. An increase in drug-related crimes has been witnessed since 2011. Although an increase in robbery and theft has been witnessed in 2011 and 2012, such crimes have been on a decrease since 2013.

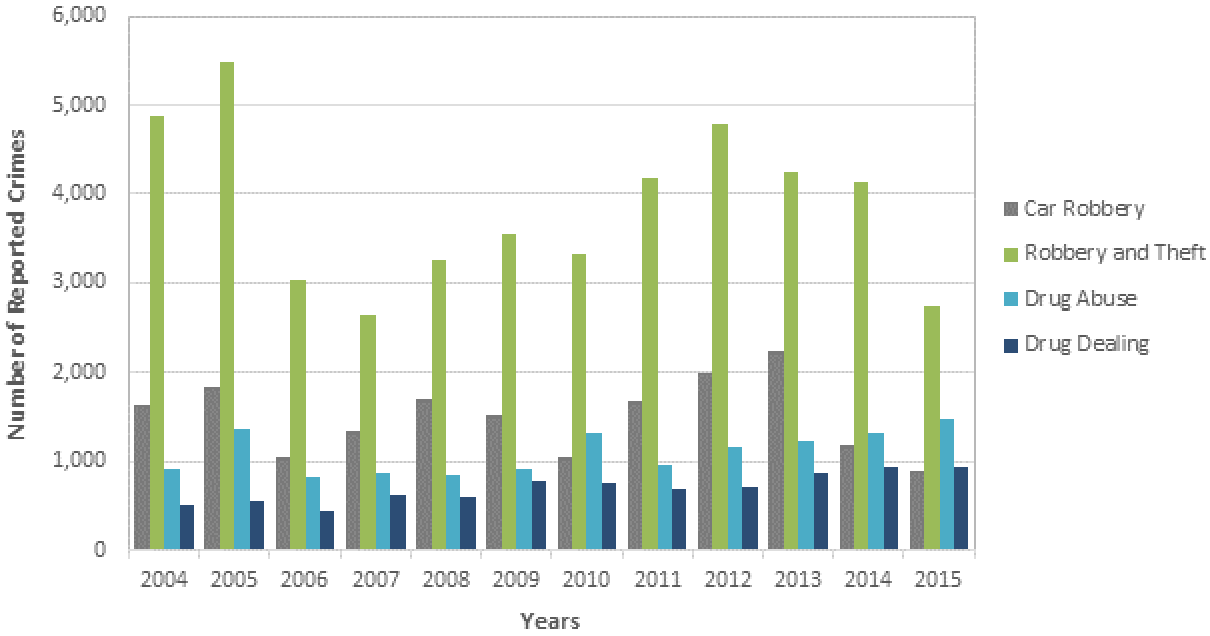


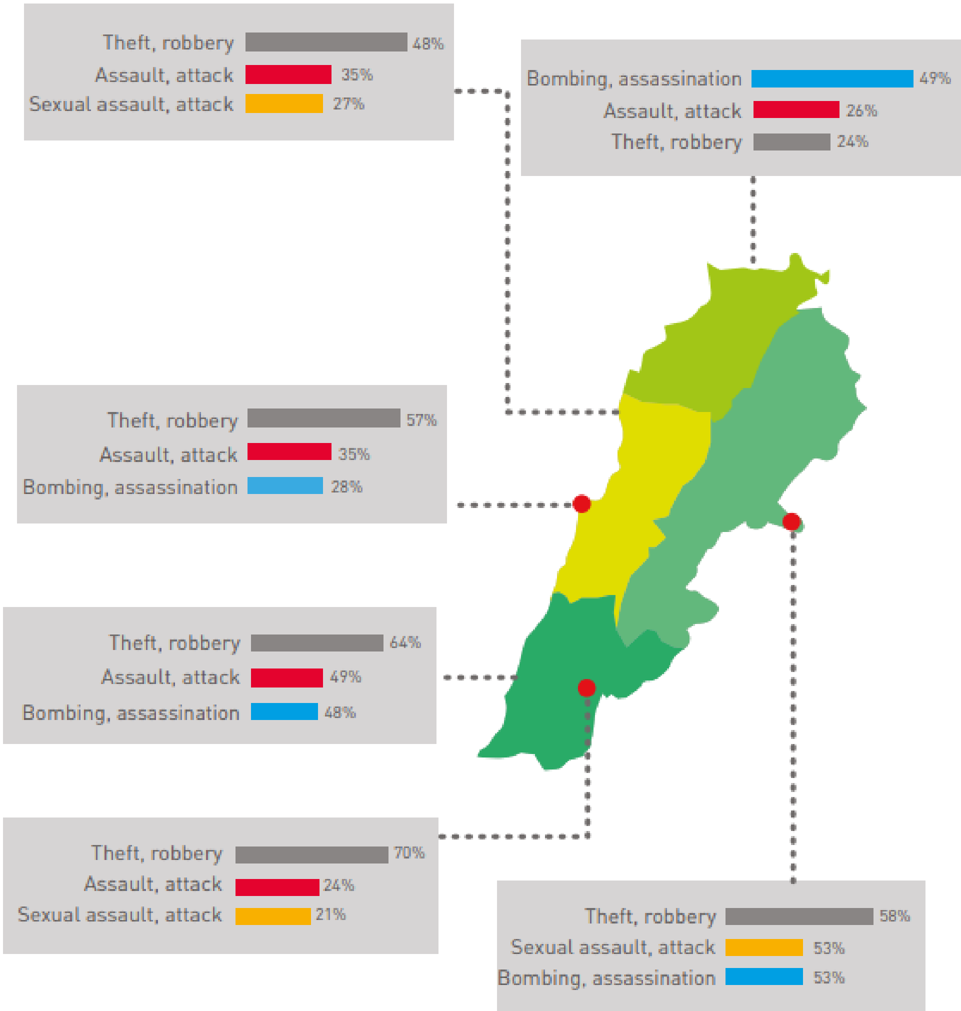
Figure 6-7 Annual Frequency and Types of Crimes
(based on data from Directorate General of the Internal Security Forces)

The number of murders has increased since 2011 as shown in Table 6-3. The average monthly occurrences increase from 67 in 2011 to reach 171 in 2014. In around 85% of the cases, the criminal was identified and detained.

Table 6-3 Average Monthly Occurrences of Criminal Murders
(based on data from Directorate General of the Internal Security Forces)

Year	Monthly Average of Criminal Murders
2011	67
2012	89
2013	140
2014	171

International Alert and The Lebanese Center for Policy studies (LCPS) assessed the security threats that intimidate the Lebanese citizens by conducting a survey. Findings revealed that most respondents expressed similar fears, however, the seriousness of the threats varied depending on the area where the respondents live. In the North, respondents do not identify theft and burglary as the most serious threat, whereas other mouhafazas do. However, North residents believe assassinations and bombings to pose the highest threat (International Alert/LCPS, 2014).



Crime in Lebanon is attributed to the following reasons: poverty, unemployment, inefficient state security institutions, sectarian discrimination, easy availability of drugs and small arms, and political disputes (International Alert/LCPS, 2014).

6.5 ACCESS TO BASIC SERVICES AND LIVELIHOODS

6.5.1 *Education*

6.5.1.1 Schools

The number of students attending schools in Lebanon has been on the rise in recent years as is shown in Figure 6-8.

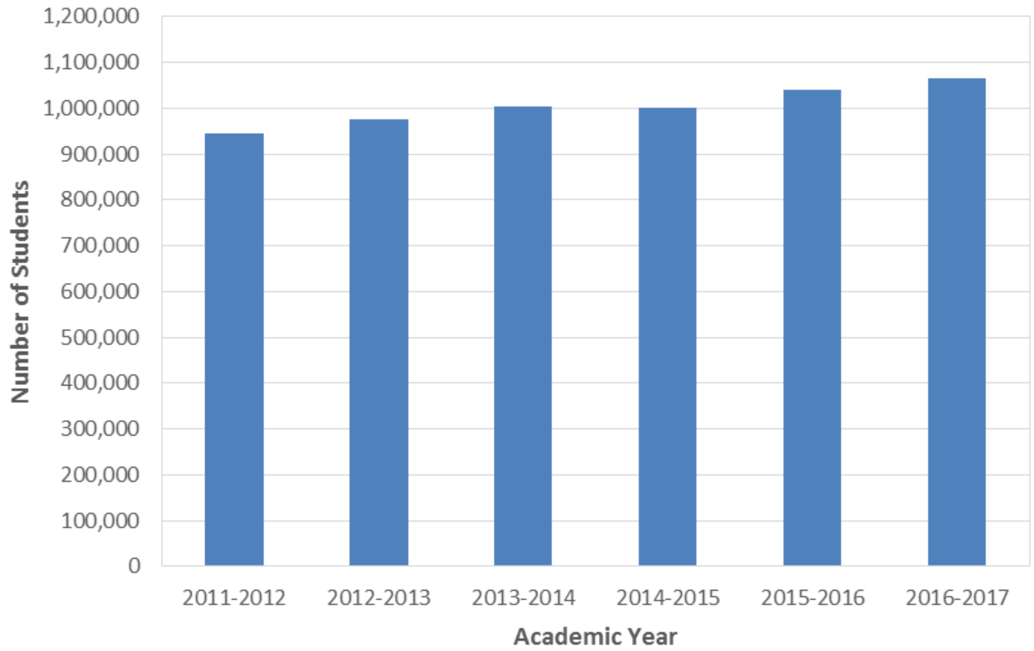


Figure 6-8 Number of Schools Students (CERD, 2017)

The total number of students in Lebanon for the academic year 2016-2017 was 1,065,490, among which 35,349 are UNRWA students. The majority of students in Lebanon (52.5%) attend private schools, followed by 30.8% who attend public schools, while 13.4% attend free private schools and only 3.3% attend UNRWA schools (CERD, 2017). 50.18 % are male students whereas, 49.8% are female students (CERD, 2017).

The total number of schools serving throughout the academic year 216-2017 were 2,871as shown in the below table (CERD, 2017).

Table 6-4 Distribution of school sectors in Lebanon (CERD, 2017)

School	Count	Percentage
Public schools	1,257	43.8 %
Free Private schools	370	12.9%

School	Count	Percentage
Private schools	1,177	41%
UNRWA school	67	2.3 %
Total	**2,871**	**100%**

6.5.1.2 Higher Education

A total of 85,244 students were enrolled for vocational and technical education for the academic year 2016-2017 (CERD, 2017).

A total of 75,956 students were attending the Lebanese Public University, with 3,699 being non-Lebanese. A total number of 124,851 students were registered in private universities, among which 108,880 are Lebanese (Table 6-5). A total of 47 private universities exist in Lebanon.

Table 6-5 Number of University Students in Lebanon
(based on CRDP Statistics https://www.crdp.org/statistics?la=en)

	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Public University Students	71,440	NA	69,994	72,518	75,956
Private University Students	120,348	NA	120,163	127,161	124,851
Total	**191,788**	**NA**	**190,157**	**199,679**	**200,807**

The number of university students attending high education in universities has been increasing since 2014 as noted in Table 6-5. The distribution of students between public and private universities and faculties since 2015 is presented in Table 6-6and

Table 6-7.

Table 6-6 University Students in Public Universities
(based on CRDP Statistics https://www.crdp.org/statistics?la=en)

Faculty/Majors	2015-2016		2016-2017	
	Number	%	Number	%
Faculty of Sciences	14289	19.70	15720	20.70
Faculty of Law and Political and Administrative Sciences	9808	13.52	9938	13.08
Faculty of Pedagogy	2328	3.21	2472	3.25
Faculty of Social Sciences	4128	5.69	4290	5.65
Faculty of Letters and Human Sciences	17643	24.33	18537	24.40
Faculty of Fine Arts and Architecture	2931	4.04	2968	3.91
Faculty of Information	1774	2.45	1815	2.39
Faculty of Economics and Business Administration	7651	10.55	7486	9.86
Faculty of Agronomy	837	1.15	849	1.12
Faculty of Engineering	2452	3.38	2609	3.43
Faculty of Public Health	3468	4.78	3779	4.98
Faculty of Medical Science	1380	1.90	1453	1.91
Faculty of Pharmacy	411	0.57	422	0.56
Faculty of Technology	945	1.30	992	1.31
Faculty of Tourism and Hospitality Management	383	0.53	390	0.51

Faculty/Majors	2015-2016		2016-2017	
	Number	%	Number	%
Faculty of Dental Medicine	496	0.68	448	0.59
Doctoral School of Humanities, Literature & Social Sciences	247	0.34	287	0.38
Doctoral School of Science and Technology	296	0.41	277	0.36
Doctoral School of Law, Political, Administrative & Economic Sciences	1051	1.45	1224	1.61
Total	**72518**	**100**	**75956**	**100**

Table 6-7 University Students in Private Universities
(based on CRDP Statistics https://www.crdp.org/statistics?la=en)

Faculty	2015-2016		2016-2017	
	Number	%	Number	%
Services	773	0.61	690	0.55
Health and Social Precaution	12159	9.56	11912	9.54
Agriculture, Forestry, Fishery, Veterinary Sciences	3154	2.48	2935	2.35
Engineering and Manufacturing	27584	21.69	27260	21.83
Information Technology and Communication	5488	4.32	5007	4.01
Natural Sciences, Mathematics and Statistics	4734	3.72	4892	3.92
Business and Law	43397	34.13	42588	34.11
Social Sciences, Journalism and Media	4896	3.85	4409	3.53
Literature and Arts	18097	14.23	17644	14.13
Pedagogy	3660	2.88	3981	3.19
General Programs, Preparatory and Certificates	3219	2.53	3533	2.83
Total	**127161**	**100**	**124851**	**100**

Additionally, since the adoption of the Offshore Petroleum Resources Law in 2010, various universities have initiated programs related to petroleum engineering and related studies and have attracted a significant number of students (Table 6-8).

Table 6-8 Programmes related to petroleum studies in Lebanese Universities

University	Program	Degree
American University of Beirut	Chemical Engineering	BS, BE, MS, ME
	Petroleum Engineering	Minor
Lebanese American University	Petroleum Engineering	BE
Notre Dame University – Louaize	Chemical Engineering	BE
	Petroleum Engineering	BE
Saint Joseph Unviersity	Chemical and Petrochemical Engineering	Diploma of Engineering

University	Program	Degree
Holy Spirit University of Kaslik	Chemical Engineering	BE, MS
	Petroleum Engineering	MS
University of Balamand	Chemical Engineering	BS,BE, MS
Lebanese University	Petroleum Geology	BS
	Chemical and Petrochemical Engineering	Diploma of Engineering
Beirut Arab University	Chemical Engineering	BE
	Petroleum Engineering	BE
Phoenicia University	Petroleum Engineering	BE

6.5.2 Health

6.5.2.1 Overview

Despite ongoing political, social and economic challenges, the Lebanese healthcare system was able to sustain its services and achievements. It was able to prevent and control outbreaks, to ensure access to quality care and crease out of pocket expenditure while at the same time lowering maternal and child mortality (MoPH, 2016). The World Health Organization (WHO) listed Lebanon by 2013 among the only 45 countries to have reached the Fourth Millennium Development Goal: Reducing Child Mortality by a Two Thirds, and among the only 16 countries to have reached Fifth Millennium Development Goal: Reducing Maternal Mortality by 75% (MoPH, 2016).

Furthermore, studies showed that:

- According to an article published in 2014 by the Economist Intelligence Unit Healthcare in 2014, "Health outcomes and cost: a 166-country comparison", Lebanon is ranked 32 in the second out of 6 tiers in health outcomes. The study proved that the Lebanese healthcare system ranks well in terms of outcomes internationally that healthcare is not expensive when compared to countries with similar health outcomes (MoPH, 2016);
- The World Economic Forum published the Global Competitiveness Report 2016-2017, which confirmed the good performance of the health system in Lebanon, ranked 34 with a score of 6.8 out of a maximum of 7, despite the adverse conditions of other sectors including the social and economic determinants for health, as shown in the same report (WEF, 2016).

6.5.2.2 Noncommunicable Diseases

Noncommunicable diseases (NCDs), or chronic diseases, are diseases of long duration and are a result of a combination of genetic, physiological, environmental and behaviour factors. NCDs include cardiovascular diseases (like heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma) and diabetes. In Lebanon, the main bulk of morbidity and health care costs are burdened now by NCDs, namely cardiovascular diseases (CVDs), cancers, respiratory conditions and diabetes. For that reason, the Ministry of Public Health (MoPH) set out a National Non Communicable Disease Prevention and Control Plan (NCD-PCP) for 2016- 2020.

The study highlights some of the NCDs history in Lebanon in recent years:

- In 2002, 77% of death certificates were linked to chronic conditions as follows: cardiovascular disease (45%), cancer (10%), chronic respiratory diseases (5%) and diabetes (2%) (MoPH/WHO, 2016);
- The proportion of premature deaths (below 70) from NCDs is about 45% in men and 38.7% in women (MoPH/WHO, 2016);
- In a 2004 national survey, almost 75% of those above 70 years reported having at least one chronic disease (MoPH/WHO, 2016);
- The predominance of NCDs in the epidemiology of Lebanon has also been recorded in the WHO global report "NCD Country Profiles 2011" (MoPH/WHO, 2016).

The following figure displays the precent distribution of chronic conditions in Lebanon.

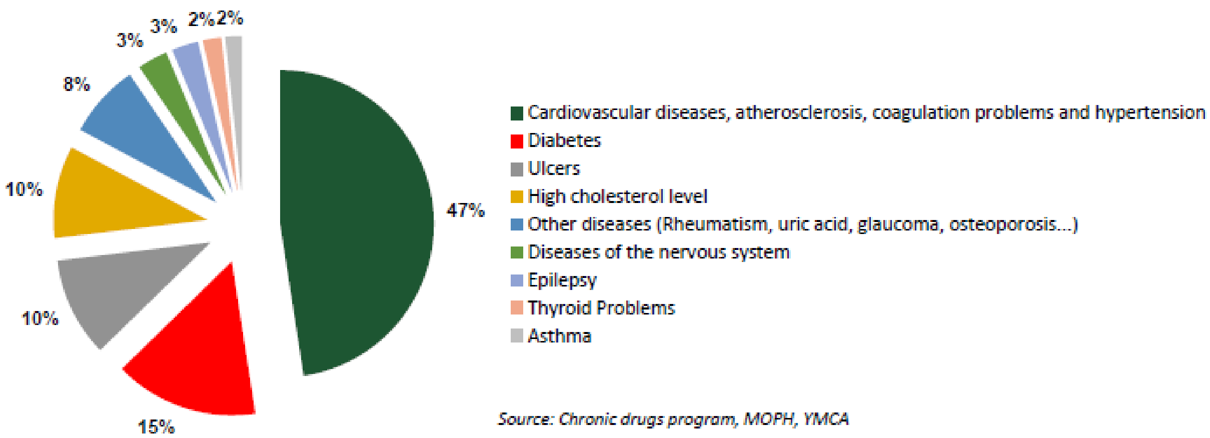


Figure 6-9 Distribution of chronic conditions among users of chronic drugs (MoPH, 2016)

A brief overview at the historical evolution of mortality rates in Lebanon is shown in the below figures. The probability of dying from one of the four main NCDs is 12% (WHO, 2014).

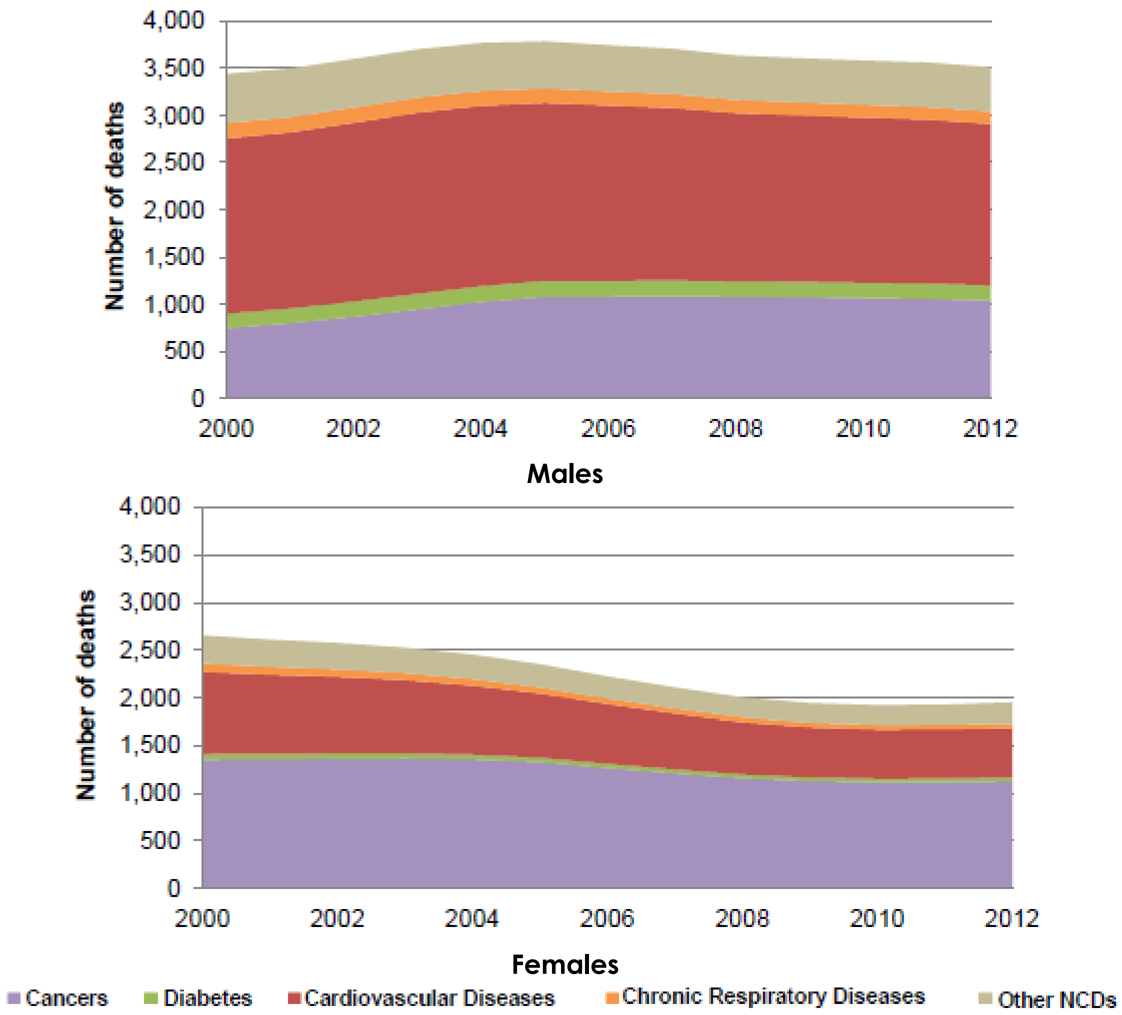


Figure 6-10 Number of deaths, under 70 years

Moreover, studies have indicated the prevalence of asthma to be at least 50% higher in Lebanon than that in Europe or the United States. Studies also examined the relationships between emergency hospital admissions for respiratory and cardiovascular diseases and air pollution in the city of Beirut and found significant effects of PM on emergency hospital admissions for diseases of the respiratory and cardiovascular systems (MoE, 2017).

6.5.2.3 *Other Health Indicators*

The crude birth rate is 20.4 while crude death rate is 5.7 (per 1,000 population for 2016 figures) (MoPH, 2016). In general, there is low occurrence of AIDS in Lebanon. The following table summarizes the status of selected health indicators as reported by the MoPH between 2012 and 2016.

Table 6-9 Selected Health Indicators (MoPH, 2016)

Selected Indicator	2012	2013	2014	2015	2016
Crude Birth Rate (per 1000 pop)	22.2	21.2	21	19.9	20.4
Crude Death Rate (per 1000 pop)	5.6	5.7	5.9	5.9	5.7
Total GDP on Health (Billion LBP)	64,800	-	-	76,518	-
Measles	9	1,760	235	39	44
Tetanus	2	4	0	3	2
Acute Flaccid Paralysis	10	34	53	76	123
Hepatitis A	757	1,551	2,582	985	519
Hepatitis B	152	141	218	390	367
Hepatitis C	45	103	736	1496	486
Mumps	-	-	100	136	116
Brucellosis	-	-	252	389	402
Typhoid Fever	-	-	546	576	598
AIDS	33	15	38	22	21
Measles	9	1,760	235	39	44
Tubercolosis	630	689	682	666	657

6.5.2.4 *Mental Health*

Mental health has been an increasing public health concern in Lebanon (MoPH, 2015). A study conducted in 2008 showed that around 4.6% of the population had suffered from a severe mental disorder, including anxiety and depression, in the year before. Additionally, 25.8% of the population experiences at least one mental disorder at some point in their lives while 10.5% experienced more than one. Depression and anxiety were the most prevalent disorders. To a lesser extent, suicide was considered (4.3%) or even attempted (2%) (MoPH, 2015).

Given that mental health is perceived as a taboo in Lebanon, people with such problems do not seek professional treatment and chose the care of religious or spiritual advisors. Very few individuals received professional treatment but with a substantial delay ranging from 6 years to 28 years between the onset of the disorder and the beginning of professional treatment, leading to increased burden on healthcare. The absence of proper mental health treatment have exacerbated the burden of mental disorders (MoPH, 2015).

6.5.1 *Water*

According to the State and Trends of the Lebanese Environment Report of 2010, the available water exceeds projected water demand for 2035; however, these resources are under stress due to pollution, overexploitation of groundwater, and poor water infrastructure which limits the ability to meet future water demands. The average rate of the Lebanese population connected to the public water network does not exceed 80%, varying from 96% in Beirut to only 55% in North Lebanon. Most of the existing networks are aging, poorly maintained, and losing large quantities of non-revenue water (FRANSABANK, 2018).

6.6 Civil Society

Civic engagement is an essential prerequisite for effective economic and political development of a country. Civil Society Organizations (CSOs) include charitable foundations, civic associations, non-governmental organizations, and social movements. A strong civil society in Lebanon has emerged recently, thus not only challenging the government's underperformance, but also challenging the Lebanese sectarian political system.

Exact information about the CSOs' size and scope of work is limited, however as reported by the Ministry of Interior and Municipalities, there are 8,311 registered CSOs. According to a report on the state of civil society in Lebanon funded by EU, there are around 1,094 CSOs that are active in Lebanon. The report took a random representative sample of those CSOs. Findings shows that 93% of the surveyed CSOs are registered as non-governmental nonprofit organizations. 62% of CSOs are working at the national level, while the remaining 38% are community based. CSOs are mostly active in topics related social development, health, education, human rights and environment, however they are least active in municipal services, urban planning, judicial development, technology and entrepreneurship (Beyond/EU/Trasntec, 2015).

6.7 Infrastructure

6.7.1 Transport Infrastructure

6.7.1.1 Land

With the absence of appropriate infrastructure transport systems, the transport system in Lebanon mainly relies on the roads network. Most parts of Lebanon are connected by good but narrow roads. Several types of roads exist as described in Table 6-10.

Table 6-10 Classified road networks (based on the Lebanon State of the Environment Report - MoE, 2002)

Classified road network category	Road width (meters)	Length (km)	% of the total network
International roads	10-14	548	8.3
Primary roads	8-10	1,799	27.3
Secondary roads	5-8	1,474	22.3
Tertiary/Local roads	4-6	2,770	42.0
Total		**6,591**	

32% of the network is located on Mount Lebanon, followed by the North and Bekaa with 24% each. The shortest road networks (20%) lie in South and Nabatieh. It is worth to note that international and primary roads network lie along the Lebanese coastline. Three key road routes exist in the country, each radiating from Beirut (ILF/UNDP, 2018):

- North: a 2-way, 83 km long coastal route that passes through such major cities as Jouniyeh and Byblos leading to Tripoli.
- East: a 2-way, 53 km long mountainous route crossing the Lebanon Mountains which connects Beirut directly to the Bekaa valley. The road passes through the key city of Chtaura and continues all the way to the Lebanese-Syrian border at Al-Masnaa.
- South: a 2-way, 104 km long coastal route to leading to Saida and Tyr and further to Naqoura.

A second north-south road axis, running along the length of the Bekaa Valley exist. Roads in the northern valley meet on the Beirut-Damascus highway at Chtaura and link Baalbek and Zahle with the primary road network. The southern valley's local road network also centers on Chtaura at its northern end. Cross-mountain secondary routes link the northern Bekaa Valley with Jouniyeh and Tripoli, and the southern valley with Saida.

Four official border crossings exist between Lebanon and Syria that allow land access to and from Lebanon, these are (ILF/UNDP, 2018):

- Al Masnaa – Al Jdeideh border: eastern part of Lebanon, located 53 Km from Beirut
- Al-Abboudiyeh border: North-east Lebanon
- Al-Aarida-Tartous border: Northwest end of Lebanon, located 170 km from Beirut
- Al-Qaa border: Northern end of Bekaa valley.

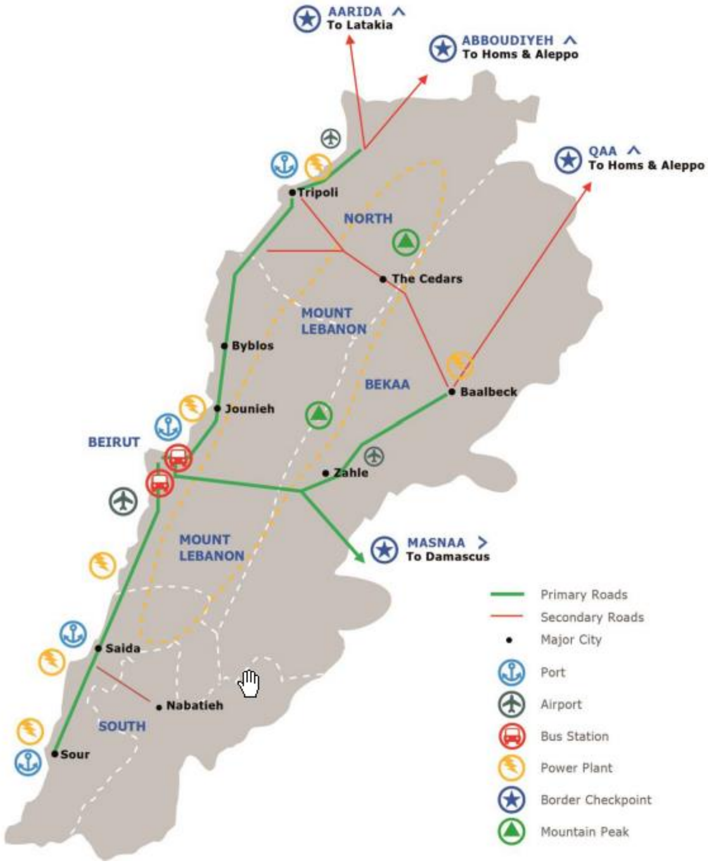


Figure 6-11 Border crossings between Lebanon and Syria
(*Source: www.investinlebanon.gov.lb)*

With the absence of appropriate infrastructure transport systems for non-motorized vehicles and rail networks, the land transport system in Lebanon mainly relies on motorized vehicles. The vehicles mainly consist of privately owned passenger vehicles for personal use, whereas mass transport includes public and private buses, mini-vans as well as taxis (exclusive and shared). Mass transport operation is unorganized and uncoordinated which results in poor occupancy rates and increased reliance on private passenger cars (MoE/URC/GEF, 2012).

The 2015 National Greenhouse Gas Inventory Report and Mitigation Analysis for the Transport Sector in Lebanon, reported that a total of 1.58 million passenger vehicles were registered in Lebanon in 2012 with 71% older than 10 years, i.e. 2002 (MoE/UNEP/GEF, 2017).

In 2014, the Ministry of Public Works and Transport (MoPWT) presented to the Council of Ministers (CoM) with the Master Plan (MP) to renew the public transport for passengers. It includes a set of actions to be implemented to integrate public mass transit systems.

6.7.1.2 Aviation

Lebanon has 3 airports: Beirut Rafic Hariri International Airport, Riyak Airport and Kleyaat Airport. However, Riyak and Kleyaat airports are primarily used for military purposes. Rafic Harriri International Airport is the only operational commercial airport in Lebanon, with Middle East airlines (MEA) as the main national air carrier of Lebanon (MoE/UNDP/GEF, 2017), in addition to Wings of Lebanon that recently started operation in Lebanon as a low cost airline. Due to its small area, Lebanon does not have internal domestic flights or other internal small-scale airports. The Higher Council for Privatization (HCP) has recently entered into an agreement with the International Finance Corporation (IFC) as a transaction advisor to engage an investor under the Public Private Partnership Law to expand the Beirut airport.

6.7.1.3 Marine

There are five commercial ports in Lebanon, however the two main are:

- Port of Beirut: Located in the capital city Beirut, the Port of Beirut is the main port in Lebanon. Today, the port consists of a total area of 1.2 million m² and has four basins, 16 quays, as well as a new container terminal. By the year 2014, the Port of Beirut has accounted for about 73% of total imports of Lebanon and about 43% of Lebanon's total exports (Bankmed, 2015).

- Port of Tripoli: it is the second most important port in Lebanon with an approximate area of 3 million m². It receives around 450 ships every year. The Port of Tripoli also contains a Free Zone with an area of 150,000 m² (Bankmed, 2015).

Overall, the port of Beirut receives around 65.5% of the incoming ships to Lebanon and the port of Tripoli around 27% (CAS, 2016). More specifically, the number of yearly incoming ships and oil tankers to Beirut port reach 2,000 ships with a total capacity reaching around 855,631 containers Total Equivalent Unit in 2016 (CAS, 2016). As for Tripoli, its port hosts more than 800 cargo ships, and 70 oil tankers (CAS, 2016).

There are 3 remaining commercial ports that include Saida, Tyre and Jounieh that have specific roles and are secondary to Beirut and Tripoli ports. They have a more active role as fishing ports and for small freights.

There are 7 ports dedicated for fuel, oil and others, these include: Ez Zahrani, Ej Jiye, Aamshite, Selaata, Chekka, Ed Daoura and Zouq.

Moreover, several private marinas or bays for recreational purposed exist in Lebanon such as Zaytouna Bay or Saint Georges Bay in Beirut, Jiyeh marina in Jiyeh, etc.

6.7.2 Waste Management and Wastewater Infrastructure

6.7.2.1 Waste Management

6.7.2.1.1 Municipal Solid Waste Overview

Municipal Solid Waste is mostly commingled across the country (no source separation). Material recovery, where it exists, is carried out at the end of the waste collection scheme at centralized facilities and/or composting plants. This reduces the quality of recyclables (due to cross contamination from other wastes as well as leachate), and leads to low recovery rates (MOE/UNDP/ECODIT, 2011). After the closure of the Naameh Sanitary landfill and as a solution for the solid waste crisis of summer 2015, the Lebanese authorities created two dumpsites in the sea at the Costa Brava and Bourj Hammoud suburbs of Beirut. The new landfills were promoted as temporary solutions for the problem of the accumulation of solid wastes in the streets of cities but not as a permanent solution.

A total of 6,500 tons of municipal solid waste (MSW) are produced daily in Lebanon. The composition of MSW is mainly organic (52.5%), 36.5% of the waste constitutes of waste that can recycled such as paper, glass, metal and plastic, while the remaining 11% is inert waste that cannot be treated. Overall, waste management at the national level can be summarized as such:

- Around 35% of the waste is disposed in sanitary landfills. There are three sanitary landfills in Lebanon: Costa Brava or Ghadir, Bourj Hammoud and Zahle Landfill;
- Around 50% of the waste is directly disposed of in open and uncontrolled dumpsites throughout Lebanon. There are around 940 dumpsites in Lebanon;
- Only 15% of the waste is treated in sorting facilities where material recovery and composting occurs. Around 50 facilities currently exist throughout Lebanon, however not all of them are operational and not all those that are operational are operated efficiently.

The following section gives a brief overview on key WM practices in each region in Lebanon. However, it should be noted that some of these facilities are not operating at full capacity, or operated for a limited period, or were never even operational.

Table 6-11 Summary of Solid Waste Management Facilities in Lebanon (MoE/EU/GFA ,2017)

Area	Existing Facilities	Potential/Planned Facilities
Beirut and Mount Lebanon	- Amroussieh Sorting Facility - Karantina Sorting Facility - Coral Composting Facility - Costa Brava (Choueifat) Sanitary Landfill - Bourj Hammoud Sanitary Landfill	- Costa Brava (Ghadir) Sanitary Landfill Extension - Costa Brava Composting Plant - Incineration Plant by Beirut Municipality and CDR - Hbaline – Extension of sorting and composting with a capacity of 150 t/d

Area	Existing Facilities	Potential/Planned Facilities
	- Hbaline Sorting Facility - Chouf Swayjani sorting and composting	- Hbaline – Landfill and rehabilitation of the old dump
North	- Tripoli sorting and composting facility - Tripoli controlled dumpsite - Minieh-Dannieh Sorting and Composting facility - Mechmech sorting and composting	- Closure of Tripoli controlled dumpsite and construction of an alternative Sanitary Landfill - Srar (Akkar) Sorting and Composting facility and Sanitary Landfill - Zgharta Sorting and Composting Facility with a capacity of 120t/d - Al Dannieh sorting and composting facility - Koura sorting and composting with a capacity of 80 t/d - Batroun sorting and composting - Bcharreh sorting and composting
South	- IBC treatment facility - Ain Baal sorting and composting facility - Khiam sorting and composting facility - Qabrikha sorting and costing facility - Bint Byblos sorting and composting - Aytaroun sorting and composting - Kherbet Selem sorting and composting - Ain Ebel sorting and composting - Kfour Nabatiyeh sorting and composting with a capacity of 200 t/d	- Al Zahrani sorting and composting with a capacity of 100 t/d. - Ain Baal upgraded facility by EU/OMSAR - Burj Shemali planned treatment facility - Bint Byblos Planned facility with a capacity of 150 t/d. Funded by OMSAR / EU. - Jezzine sorting and composting with a capacity of 150 t/d
Beqaa	- Baalback sorting and composting facility - Zahle sorting facility and sanitary landfill - Barr Elias sorting and composting facility	- Baalback facility under upgrading funded by EU/OMSAR - Baalback sanitary Landfill funded by EU/OMSAR - Hermel sorting and composting facility - Joub Jannine sorting and composting facility and sanitary landfill - Al Mhaydtheh sorting and compostingwith a capacity of 60 t/d. - Hasbaya sorting and composting with a capacity of 60 t/d

6.7.2.1.2 Hazardous Waste and Other Wastes

Around 50,000 tons of hazardous solid wastes are generated in Lebanon each year. These include:

- Hazardous industrial chemical waste, used oil and used tires;
- Electronic waste and used batteries;
- Expired solid drugs and materials;
- Healthcare waste;
- Persistent organic pollutants from the energy sector or other sectors and various types of sludge.

In addition, other waste such as solid waste from the olive oil industry, slaughterhouse waste, construction and demolition waste, and bulky waste are also generated.

Treatment of hazardous solid waste and other waste is also non-existent in Lebanon. The majority of these types of wastes are either stored by waste generators or exported via the Basel Convention.

A portion of healthcare hazardous infectious waste is treated, in accordance with the provisions of Decree 13389/2004, in privately-owned and operated treatment facilities that exist in some private hospitals and/or services providers such as Arcenciel. Similarly, some types of hazardous waste are exported in accordance with the provisions of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Law 389/1994).

With the absence of waste management strategies for hazardous waste at the national level, the Policy on ISWM (CoM Decision 45 dated January 11, 2018) indicates that three interim storage plants for different types of waste including expired drugs, healthcare waste (hazardous and non-infectious and those requiring special management) should be established.

The Ministry of Environment has submitted a concept note to the Higher Council for Privatization to implement these storage facilities (which could include some sort of pre-treatment to allow for storage) through PPP arrangements. HCP is currently evaluating the commercial viability of the proposed projects to attract private sector finance.

6.7.2.2 Wastewater

Despite the importance of wastewater management, not all Lebanese cities have full coverage to the sewer network. Large cities like Beirut, Tripoli and Saida have the highest sewage network coverage. Nevertheless, those networks need rehabilitation with the exception of Beirut's network. Lebanon has approximately 8% wastewater treatment rate before discharging into the sea, which is well below acceptable levels (MoE/UNEP/GEF, 2017). Several projects to establish coastal wastewater treatment plants are planned or have been completed but are still non-operational. These projects face significant implementation and operational challenges.

6.7.3 *Existing Hydrocarbons Infrastructure in Lebanon*

A summary of the existing infrastructure (operational and non-operational) related to the logistics of petroleum products in Lebanon is presented in this section. This Section is based on the Infrastructure Analysis Report for the Cost Benefit Analysis for the Use of Natural Gas and Low Carbon Fuels prepared by ILF on the behalf of the UNDP (ILF/UNDP, 2017).

6.7.3.1 *Transport*

Four main methods to transport petroleum products in Lebanon exist, these are:

- Water transport
- Pipelines
- Road transport
- Rail
- Or a combination of two or more of the above methods.

Currently, importation of petroleum products takes place through marine transport. Sea tankers carrying petroleum products arrive at marine terminals (public and private) where the products are transferred and stored, after which they are distributed to the end users within the country through road transport.

6.7.3.1.1 Water Transport

Besides receiving its needs of petroleum products via marine tankers, Lebanon does not have any navigable river channels that can be utilized for the transport of bulky commodities from the marine import terminals to end user locations within the country through boats. Therefore, inland water transportation system does not exist in Lebanon.

6.7.3.1.2 Pipelines

Two oil pipelines and one gas pipeline exist in Lebanon:

- **The Iraq Petroleum Company (IPC) Pipeline:** An 833 km long crude oil pipeline that was constructed in the1930s. The IPC pipeline transported oil produced in Kirkuk-Iraq through three pipelines across Syria and to a terminal and a refinery in Tripoli, north of Lebanon.
  The IPC pipeline is composed of three major sections: (i) 376 km across Iraq with 4 major pump stations, (ii) 424 km across Syria with 3 pump stations and (iii) only 33 km across Lebanon with no pump stations.
  In 1960, the average receipts and exports of the installations at the Tripoli terminal are said to have been at the rate of 445,000 bpd.
  The IPC pipeline has not been operational since 1976 and no recent published information on its condition exist.

- **Trans-Arabian Pipeline (TAPLINE):** A 1,213 km long crude oil pipeline which was used to transport light crude oil from the Abqaiq fields in Saudi Arabia across Jordan and southern Syria to an export terminal and a refinery in Zahrani near Sidon. Oil was then shipped from the export terminal to markets in Europe and Eastern United States.
  The TAPLINE was constructed by Bechtel Co. in the late 1940s and at the time it was considered ground-breaking and innovative as it was the world's largest oil pipeline system which had a nameplate capacity of 500,000 bpd.
  Due to disagreements on transit fees and increasing competition from sea transport the pipeline stopped in 1976. Today, the TAPLINE is in an unfit condition for oil transport.
- **The Lebanese Gas Pipeline (GASYLE):** a 1,200 km long trans-regional gas export pipeline which runs 30 km from the Syrian border to Tripoli. It was built between 2003 and 2007 to deliver gas from Egypt to the Deir Ammar CCGT power plant near Tripoli, it is a spur of the Arab Gas Pipeline (AGP) and has a design capacity of 6MMCM/day. It was first activated in 2009 in cooperation with the Egyptian Company for Natural Gas-GASCO. Eventually, gas was being supplied by Egypt through Syria and quantities received were 26.3 MMCM/month which were enough to fire one of the two gas turbines of the Deir Ammar power plant. This stopped in 2010 due to geo-political problems in the region. There are no current plans about recommissioning the GASYLE in the near future, particularly given the unstable situation in Syria.

6.7.3.1.3 Roads

As described in Section 6.7.1.1 land transport via the existing roads network is the most utilized mode of transportation in Lebanon.

6.7.3.1.4 Rail

Today Lebanon has around 400 km rail lines that are abandoned and neglected due to the considerable damage inflicted by the Lebanese civil war. These constitute parts of four rail lines that used to connect Lebanon with Syria reaching Iraq and Turkey. The routes are:

- Beirut-Damascus (Syria),
- Naqoura-Tripoli (coastal railway),
- Tripoli-Homs (Syria) and
- Rayak-Aleppo (Syria)

The Ministry of Public Works and Transport (MoPWT) undertook feasibility studies and Environmental Impact Assessment for the Beirut-Tripoli section of the old coastal railway with the financial support from the European Investment Bank. The study considers having the section Beirut-Tabarja operational by 2023 and the section Tabarja-Tripoli operational by 2030. Both sections would include freight and passenger transport. A feasibility study and an Environmental Impact Assessment for the railway section between Tripoli and the Syrian border were also carried out by the Council for Development and Reconstruction (CDR).

International interest in investment in these projects exists but at the current time the status of the projects is not clear. Such rail lines would be beneficial to the oil and gas sector as they could offer an opportunity for hydrocarbons transport. At the same time, these projects conflict with the possibility of laying down a coastal gas pipelines on the railway's Right of Way (RoW).

6.7.3.2 Terminal and Storage Facilities

Existing oil and gas terminals and storage facilities in Lebanon are either publicly owned and managed by the Lebanese Oil Installations (LoI) or privately owned and managed by the private Lebanese companies.

- Public Infrastructure: consists of the facilities at the Tripoli Oil Installations (TOI) and the Zahrani Oil Installations (ZOI). The TOI consists of a terminal and a closed refinery and is connected to the IPC pipeline. The ZOI consists of a terminal and a closed refinery and used to receive light crude oil from Saudi Arabia through the TAPLINE. As for gas, it has no public infrastructure in Lebanon.

- Private Infrastructure: There are 13 private fuel import terminals on Lebanon's coastline with a total holding capacity of around 440,500 Liters. 10 are located on Mount Lebanon's seaside with 77% of the total storage capacity and 2 on the seaside of the North Governorate, while 1 on the seaside of the South Governorate. As for gas, there are 6 private gas import terminals in Lebanon located along the Lebanese coastline with a total holding capacity of 44,668 m^3. 5 are concentrated on Mount Lebanon's seaside with 92.6 % of the total storage capacity and one in Tripoli.

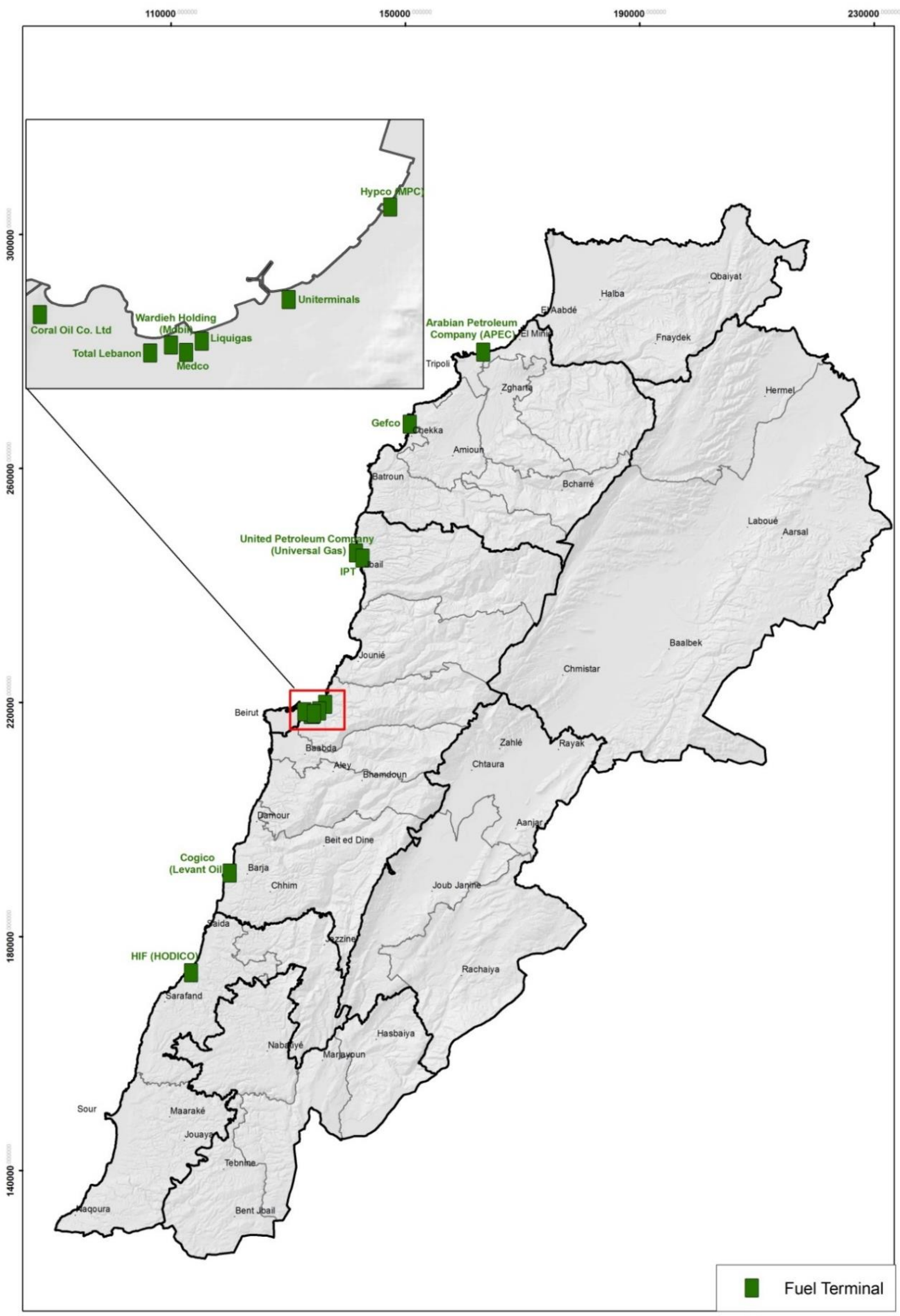


Figure 6-12 Location of Private Terminals in Lebanon (based on APIC's data)

6.7.3.3 Local Refineries

Lebanon is entirely dependent on imported fuel sources, since it currently has no refining capacity, although it has two old refineries: the Tripoli refinery and the Zahrani refinery:

- Tripoli Refinery: located within the TOI with a total surface area reaching 114,875 m². It was established in 1940 to refine crude oil reaching Tripoli from Karkuk-Iraq via the IPC pipelines. It has a storage capacity of 34,500 bpd, and its refining capacity was 21,000 bpd. Its main products were:
    - 50 % fuel oil
    - 21% gasoline
    - 22% gas oil

  Since its capacity does not meet local market needs, studies indicated that it would not be economically feasible to rehabilitate the Tripoli refinery. MoEW conducted a study and concluded that it could be feasible to renovate it under some low oil price scenario and increase in capacity. This however requires a thorough evaluation of its technical and economic viability and current condition.

- Zahrani Refinery: commissioned in 1950 with a total area reaching 313,000 m² and a capacity reaching 17,500 bpd until it was closed in1989. Its products included LPG, gasoline, kerosene, gas oil and fuel oil.

  In its current state, its renovation would need comprehensive repair and maintenance. In its study, the MoEW concluded that it will not be viable to renovate the Zahrani refinery under any oil price.

6.7.3.4 Fuel Stations

In 2015, it was estimated that there are around 3,050 licensed gas station in Lebanon as shown in Table 6-12.

Table 6-12 Number and Location of Gas Stations in Lebanon (*Directorate General of Petroleum. 2015)*

No.	Governorate	Number of Gas Stations
1	Baalbek-Hermel	241
2	Bekaa	345
3	Beirut	108
4	Mount Lebanon	1,185
5	South Lebanon	335
6	North Lebanon	603
7	Nabatieh	233
	Total	**3,050**

6.7.3.5 Power Plants

Thermal and hydroelectric power plants operate in Lebanon.

- **Thermal Power plants:**

There are a total of 7 thermal power plants in Lebanon. With the exception of Baalbek power plant that is located inland, all the power plants are located on the coastline. Overall they have a total installed capacity of 2,038 MW (2010) of which about 78% is available. A summary of the power plants is presented in Table 6-13.

Table 6-13 Summary of existing Power Plants in Lebanon (ILF/UNDP, 2018)

Power Plant	Lifetime	Installed Capacity (MW)	Available Capacity (MW)	Fueling Method	Fuel Type	Plant Type	Totals (MW)
Zouk	1984/1986 - 2015	607	410	Sea line	HFO	ST	Steam 1,028
Jieh	1970/1981 - 2010	346	195	Sea line	HFO	ST	
Hreicheh	1975 - 2010	75	30	Trucks	HFO	ST	
Zahrani	1998/2001-2025-2031	435	412	Sea line	Diesel Oil	CCGT	CCGT 870
Deir Ammar	1998-2002 then 2015-2031	435	410	Sea line	Diesel Oil	CCGT	
Tyre	1996 - 2021	70	70	Trucks	Diesel Oil	OCGT	OCGT 140
Baalbek	1996 - 2021	70	70	Trucks	Diesel Oil	OCGT	
Total		**2,038**	**1,597**	-			

Additionally, since 2013 the Lebanese government has leased two powerships from the Turkish energy company Karadeniz Holding as temporary solutions to allow the rehabilitation of the existing conventional power plants at Jiyeh and Zouk and provide additional generation capacity to the grid. One powership is operating in Jiyeh supplying a total capacity of 82 MW and the other is operating in Zouk and supplying a total capacity of 188 MW. An additional powership became operation in Zouk since July 2018.

Plans to implement new power plants as Independent Power Producers (IPP) of up to 1500 MW capacity through a Public Private Partnership (PPP) scheme are underway.

- **Hydro Power plants:**

Five hydro power plants exist in Lebanon with a total combined capacity of about 280 MW. However, the actual generation capacity is 190 MW due to need for maintenance and rehabilitation since some of the plants have been in service for several decades. In order to increase hydropower generation the rehabilitation of the existing plants or the construction of new plants is required.

It was estimated that at least 15% of additional generation capacity is possible from rehabilitating the existing hydropower plants in Lebanon. This corresponds to additional electricity generation of about 129 GWh per year and an increase of the average capacity factor of all plants to 42.3% (from the current 37.2%).

A Master Plan studying the hydroelectric potential of Lebanon along the main river streams has been prepared. The study identified the potential arising from 32 new sites, split into two categories: Run of river schemes with potential capacity of 263 MW (1,271 GWh/y) and peak schemes (with dams) with potential capacity of 368 MW (1,363 GWh/y).

7. ECONOMIC ACTIVITIES

7.1 OVERVIEW

The Lebanese economy has been witnessing a reduction in growth since 2004 due to political and security uncertainties. In more recent years, this has been accelerated by the Syrian crisis which increased the pressure on Lebanon.

During the period 2007-2010, and after the 2006 war, real Gross Domestic Product (GDP) growth averaged 9.2%, before it dropped to 1.8% between 2011and 2015 as a result of the geopolitical developments in the region (MoE/UNDP/GEF, 2017). GDP growth dropped to 0.9% in 2011. It increased to 2.8% in 2012, slowed again in 2013 with a drop to 2.6% and 2% in 2014 to reach 0.8% in 2015 before increasing again as of 2016 as shown in Figure 7-1.

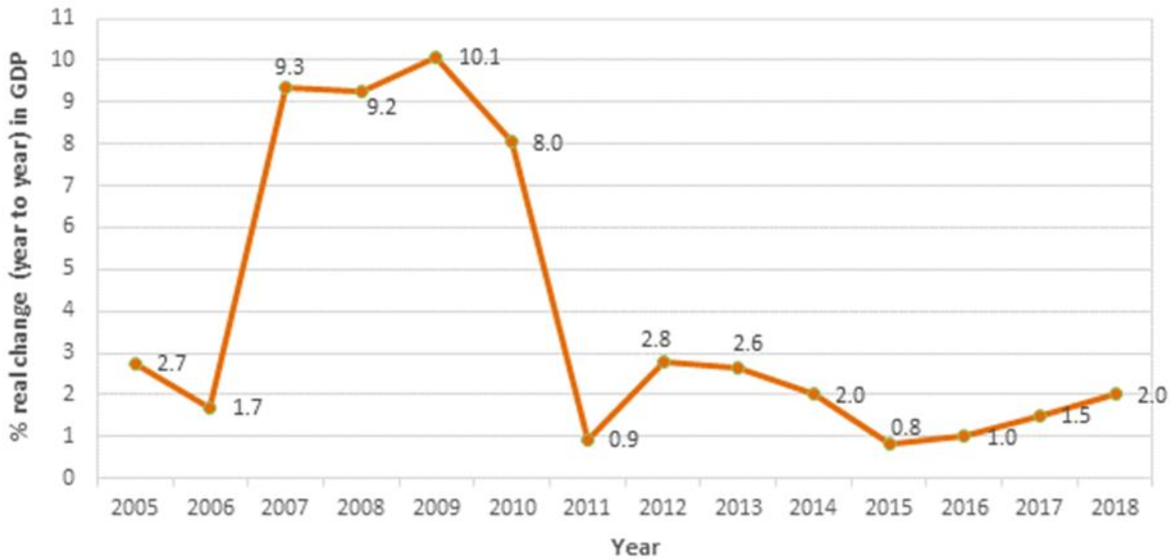


Figure 7-1 Real Change in GDP (%) (based on CAS and IoF[2] figures)

[2] IoF refers to Institut des Finances Basil Fuleihan

In Lebanon, trade, manufacturing, construction and real estate and finance form the pillars of the economy. They represent around half of the economy with a 49 % share of GDP in 2015 as shown Figure 7-2 (CAS, 2016).

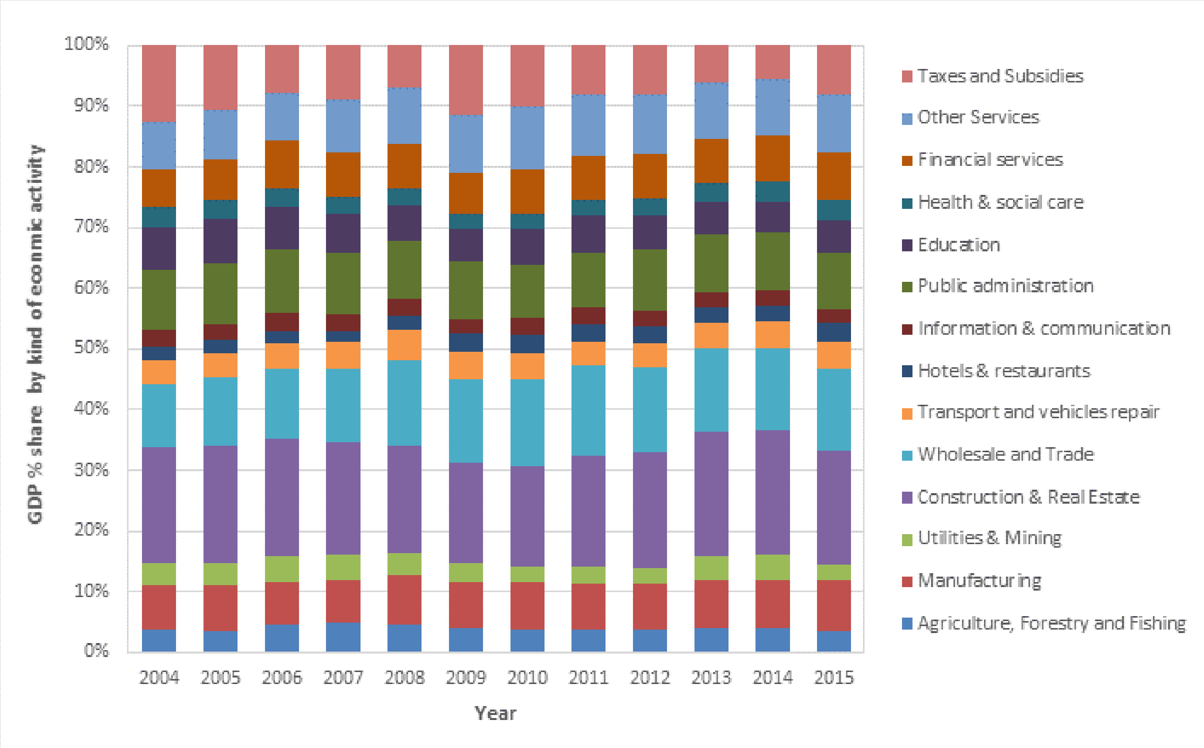


Figure 7-2 % share in GDP by Type of Economic Activity

Figure 6-1 presents the predicted indicators for Lebanon from 2018 to 2020 (IoF, 2018).

Table 7-1 Macro-economic indicators supported in Medium Term Financial Outlook (IoF, 2018)

Macro-economic Indicators	2018	2019	2020
Growth rate (%)	2.13	2.91	2.13
Inflation rate (%)	1.69	1.72	2.02
GDP (mUSD)	57,106	59,341	62,068
Total expenditure (%)	27.4	27.01	26.3
Total Budget revenues (%)	17.79	17.86	17.91
Total Balance (%)	-8.36	-7.9	-7.14

Table 7-2 presents the national expenses, revenues and budget deficit for the past 5 years. As it can be noted, expenses are higher than revenues, leading to deficit in the annual budget.

Table 7-2 Annual Deficit in National Budget

Billion L.L.	2014	2015	2016	2017	2018*
Expenses	21,032	20,393	22,412	23,906	23,891
Revenues	16,400	14,435	14,959	16,247	18,686
Deficit	-4,632	-5,958	-7,453	-7,659	-5,205

*2018 figures are forecasts.

Figure 7-3 shows Lebanon's inflation rate for the past 10 years, which averaged 2.65%. However, inflation rate reached its highest of 11.10% in October 2012 and recorded low of -4.67% in September 2015.

Figure 7-3 Inflation Rate (Trading Economics, 2018)

Based on the economic vision (not yet endorsed by the Lebanese government), if implemented (it does not consider the impacts from the oil and gas sector), economic growth would improve by primarily investing into agriculture, industry, tourism, knowledge economy, financial services and diaspora support. Targets for the year 2025 are to reach 5 to 6 % real GDP growth, 80 billion USD GDP, and an additional 370,000 jobs.

7.2 TOURISM

Tourism is a priority industry for economic development in the country. Around 1.9 million tourists arrived to Lebanon in 2017, as shown in Figure 7-4, which is 23% more than in 2012. Most tourists are from Europe (34.5%), Arab countries (30%) and America (17.5%) (CAS, 2017). Tourism infrastructure in terms of accommodation is considered sufficient with an average occupancy rate of Beirut Hotels in 2016 was 59%.

Lebanon's vigorous tourism sector is a major source of income and employment in Lebanon. In 2016, it was estimated that there as around 338,600 tourism-related jobs within the economy (Bankmed, 2017).

Tourism currently contributes 1.6 billion USD to the national GDP (roughly 3% of total GDP) and according to the Economic Vision, tourism contribution to GDP could increase to 3.7 billion USD in 2025 and 5.4 billion USD in 2035. Number of jobs offered by the sector could also increase from around 89,000 in 2017 to 185,000 in 2025 and 211,000 in 2035. Total number of tourists could also increase from the current 1.9 million to 4.2 million in 2035 and 6.5 million in 2035.

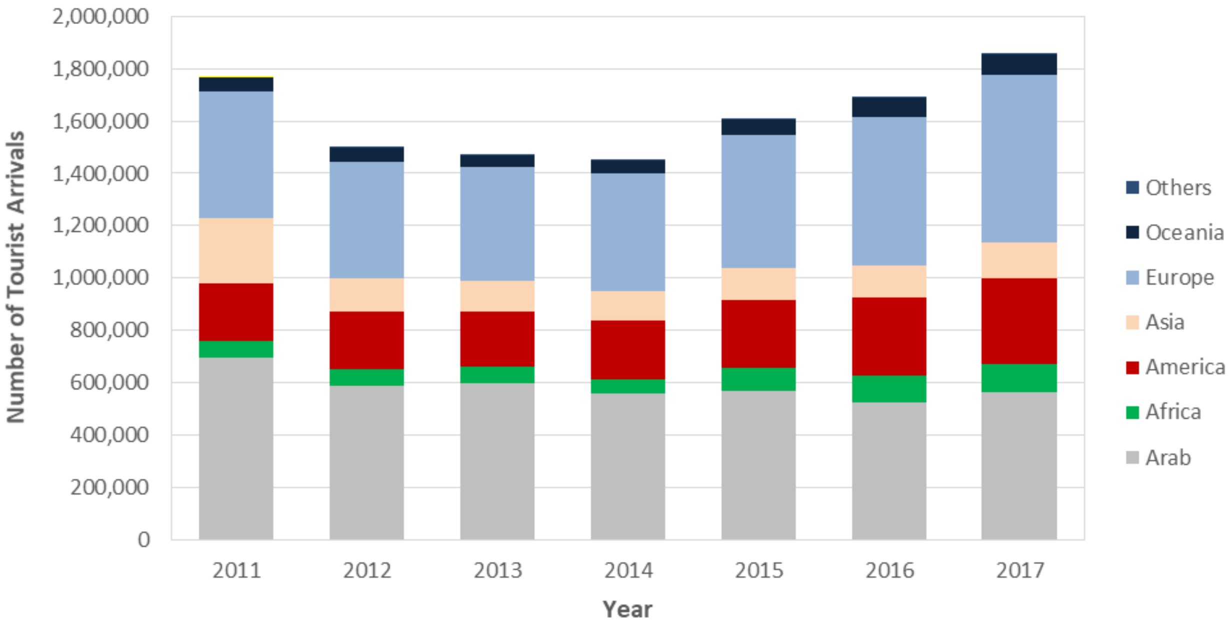


Figure 7-4 Number of Tourist Arrivals (excluding Lebanese and Syrian Nationals)
(Data obtained from CAS, based on records of General Directorate of General Security)

7.3 FISHERIES SECTOR

Lebanese fisheries are artisanal or traditional in nature, with the country's coastal waters containing more than 80 fish species being of commercial importance. However, Lebanon also relies heavily on imported fish with around 20,100 tons/ year of demand with an average of 6.03 kg per capita/year (Pinello & Dimech, 2013).

The main fishing gear include: trammel nets, gill nets, long lines, purse seine nets (lampara) and beach seines (Majdalani, 2005). Fishing usually occurs to a maximum depth of up to 200 m, while most activities take place at an average depth of 50 m. Fishers[3] in Lebanon are part of the lower class of society, i.e. poor community, while certain fisher-owners[4] are present in the

[3] A fisher is a person who performs the fishing activities (Pinello & Dimech, 2013)

[4] A fisher-owner is a fisher who also owns the fishing vessel (Pinello & Dimech, 2013)

lower-middle class. Most of the fish catch is sold fresh on auction markets. According to the Department of Fisheries and Wildlife at the MOA (DFW-MOA), the number of licensed fishing vessels in 2015 stood at 2193 boats operating from 44 fishing harbors and landing sites along the entire Lebanese coastline (Majdalani, 2005; Pinello & Dimech, 2013; Nader el al., 2014).

A preliminary assessment of the economic situation of the Lebanese fisheries sector was undertaken in 2012-2013 funded and supported by the FAO-EastMed project. In order to undertake such an assessment, an economic survey based on direct interviews was conducted from March to May 2012. The results showed that in general the Lebanese fishing fleet is making a profit of about 24% of the revenue which is comparable to other fleets in the Mediterranean of similar characteristics. The income per fisher-owner (7,400 USD) and fisher (3,000 USD) is 20% and 70% respectively less than the national GDP per capita. Furthermore, a fisher earns about 25% less than the minimum wage of the Country (Pinello & Dimech, 2013).

The Lions Club International, District 351 and Rotary Lebanon, in coordination with the MoE, Ministry of Defense (MoD), Ministry of Public Works and Transport (MoPWT) and in collaboration with the MCR-IOE-UOB, deployed in June 2012, and for the first time in Lebanon, an artificial reef in the Abdeh region (North Lebanon). It was the first project of its kind in the Country making it a pioneer in its relevant field. Such a project can also be considered as an important milestone to Integrated Coastal Zone Management (ICZM) which requires major attention in Lebanon.

In addition, a platform was established at Tyre ("Tyre Caza Platform for Fisheries Legislation Application") as a result of the empowerment of stakeholders on marine management planning. This platform is constituted by concerned ministries, security forces, municipalities, union of municipalities, fishermen cooperatives and syndicates, NGOs and the TCNR. Its vision is to promote sustainable marine ecosystems while fostering economic prosperity across fisheries and the maritime sector. Its main goal is to reduce the use of destructive fishing techniques and landing of protected species, through collaborations and coordination, in order to achieve long-term sustainable fisheries management (www.IUCN.org).

In 2017, the biodiversity of the Abdeh Artificial Reef was assessed under a Masters thesis at the Department of Environmental Sciences, Faculty of Sciences – UOB and under the full supervision of the MCR-IOB-UOB. Over 90 species of motile and sessile marine organisms were identified further validating the importance of artificial reefs marine biological conservation and enhancement.

Several initiatives have been launched in the past few years to properly and sustainably manage marine and coastal resources while taking into consideration the well-being of coastal communities. Building on these successive initiatives, the knowhow related to the fisheries sector in Lebanon have increased significantly but more is required to draw policy, especially as it relates to other sectors. Biological studies and stock assessments for several species are awaiting publication. In addition, all newly available information about the sector, scientific and otherwise, are submitted yearly by the Directorate of Fisheries and Wildlife at the Ministry of Agriculture (DFW-MOA) to the FAO - General Fisheries Commission of the Mediterranean (GFMC).

7.4 SMEs

Lebanon is considered a strong ground for SMEs growth who are significantly contributing to its economy. In order to boast entrepreneurial activity, the government put in place several incentive mechanisms and programs to encourage lending for small and medium enterprises. Hence Lebanon has developed an enabling environment for the emergence of SMEs, through providing subsidized loans directed by Banque du Liban, establishing national champions such as Kafalat and IDAL, and more recently through the private sector led support and BDL's new initiative allowing banks to invest in startups (MOET, 2014).

It is difficult to estimate the exact contribution of SMEs to the GDP and employment, however, SMEs constitute 93% to 95% of all enterprises in Lebanon. As per the adopted classification of SMEs in Lebanon, micro enterprises constitute the majority of SMEs (73%) (Figure 7-5) (Hamdar et al, 2017).

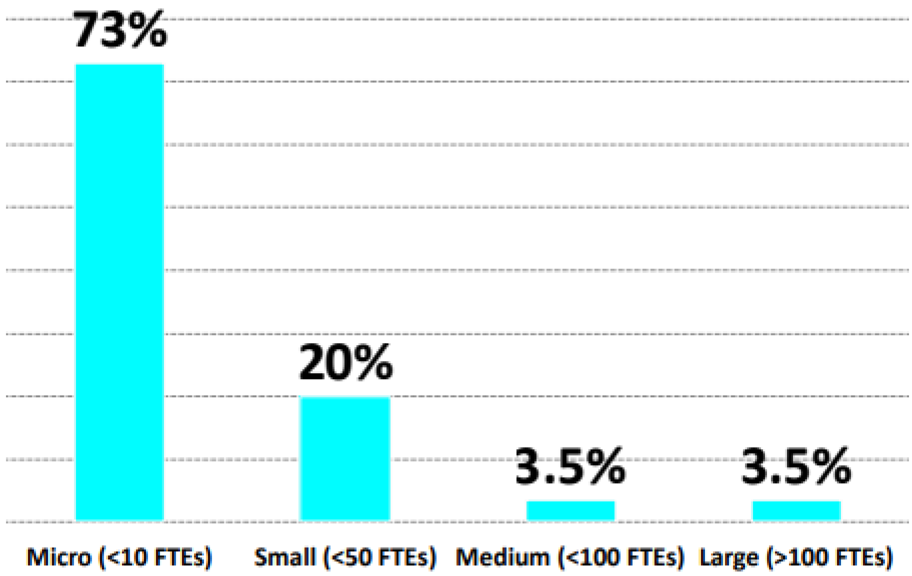


Figure 7-5 Classified SMEs Constitution of all Enterprises in Lebanon (MOET, 2018)

The chambers of commerce, industry and agriculture located in Beirut and Mount Lebanon, North Lebanon, South Lebanon and Bekaa serve as independent legal entities intended to support the development of business enterprises. Their strategy aims to promote and improve business environment through providing several services including the provision of business information and training (ETF, 2015).

Additionally, the Association of Lebanese Industrialists (ALI) is the main national association of manufacturing companies operating in Lebanon. ALI is committed to foster the development of Lebanese industries through creating a favorable environment that encourages industrial investment, and contributes to job creation, growth and development. It is involved in policy making consultations that tackle economic and social issues, labor legislation, social security, healthcare, taxation and policies for SMEs (ETF, 2015).

8. ENERGY CONSUMPTION NEEDS AND SUPPLY IN LEBANON

Lebanon relies on imported fossil fuels for energy supply. The power sector uses fuel oil and diesel. The industrial, commercial and the residential sector use oil based products for heating, power generation as well as production processes, while LPG is used for cooking purposes as well as for heating. Other types of energy supplies use is relatively low (UNDP, 2018) as shown in Figure 8-1.

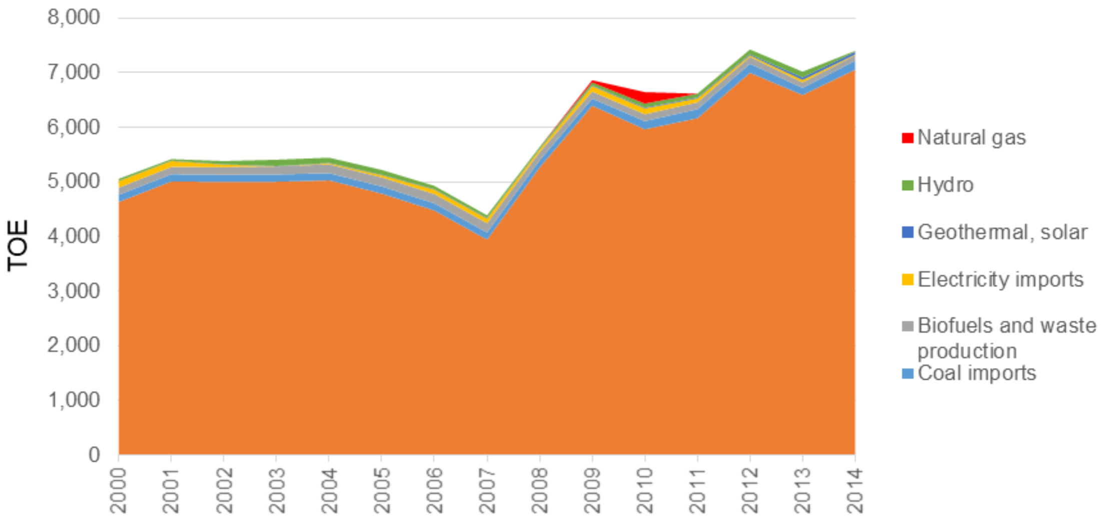


Figure 8-1 Historical total primary energy supply in Lebanon (TPES) in tons of oil equivalent
(IEA and ALMEE (2013-2014))

8.1 THE POWER SECTOR

The main consumer of fuels in Lebanon is the power sector. Ever since the end of the Civil War in the early 1990s, power demand substantially grew and surpassed the supply capacity leading to a chronic state of energy crisis. Power shortages are the norm with some regions barely receiving 12 hours of electricity supply such as in North Lebanon, South Lebanon and Bekaa region. The electricity demand in 2014 was estimated at 15,000 GWh where EDL was able to provide about 12,500 GWh, including 138 GWh from imported electricity and 190 GWh from hydro generation.

Key obstacles in the Lebanese power sector are spread across the whole power system value chain and set up. Shortage in power supply is reflected in round the year power cuts. Private power self-generation for industry, residential, institutional and commercial sectors is common. Still, electricity demand is not met.

The grid requires upgrade to increase geographical coverage. Furthermore tariffs are highly subsidized and do not cover generation costs where the share of losses in the transmission and distribution networks is also substantially high.

Inefficiencies in the power sector occur since the CCGTs in Deir Ammar and Zahrani are not functioning on natural gas as primarily planned and two major TPPs (Zouk and Jieh plants) already reached the end of their design lifetime. Additionally inefficiencies cause deviation from the design value has a significant impact on the fuel bill, reflecting an increase in fuel cost.

With the aim to overcome the constant power shortages, the MoEW set the Policy Paper for the Electricity Sector in 2010. The paper targeted to increase installed capacity to 5,000 MW after 2015 through the establishment of new gas fired plants. Unfortunately, to date, these targets were not met, as a matter of fact few initiatives from the paper have been implemented.

There are currently three power plants under construction or that have just been commissioned:

- Zouk 2 with a capacity of 194 MW on natural gas / HFO (commissioned);
- Jieh 2 with a capacity of 94 MW on natural gas / HFO (78.2 MW) (commissioned);
- Deir Ammar 2, which is a combined cycle plant with a capacity of 538 MW on natural gas / HFO (535 MW) (under construction).

The engines at the new Zouk and Jieh plants are designed to run on tri-fuel basis of HFO, diesel oil, and natural gas when available. The plant at Deir Ammar 2 is designed to run on a dual fuel basis and shall fire HFO at a de-rated capacity of 525MW until natural gas is available to the plant. Moreover, as part of an operation and maintenance contract, the gas turbines at Zahrani and Deir Ammar power plants were upgraded by the end of 2013; the works resulted in a capacity addition of 63 MW as well as enhancements in efficiency and lifetime extension of the power plants.

In addition, the Policy Paper for the Electricity Sector (2010) included plans for five IPPs of 1,500 MW. These plants, once and if built, shall contribute to the national demand for natural gas.

Two of such plants are currently being assessed for implementation under a PPP scheme. IFC has been appointed as a transaction advisor by MoEW to attract private investors.

Last but not least, the Lebanese Oil Installations (LoI) have launched a tender to procure three (3) offshore LNG terminals with Floating Storage and Regasification Units (FSRUs) to import Natural Gas as LNG (import capacity of up to 3.5 million tonnes of LNG) to be able to gasify the existing power plants. Tenders are due to be submitted by interested developers by October 2018.

8.2 FORECASTED GAS DEMAND

Electricity demand projections were carried out based on several assumptions (ECA, 2017):

- High growth scenario at 5.4% per year
- Low growth scenario at 3.5% per year
- Syrian refugees demand will dimish by 2025
- Private Generation witll be covered by centralized demand

As such it was found that the total potential gas to power demand is 4 BCM short-term; 4.5 to 5 BCM medium term and 6 to 8 BCM long-term as shown in Figure 8-2.

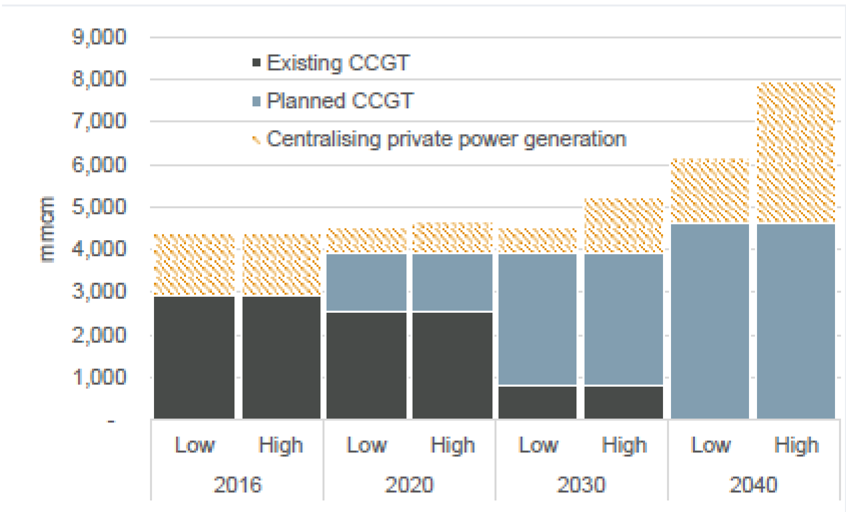


Figure 8-2 Gas to Power Demand (ECA, 2017)

It was found that the coastal gas demand in a high scenario will be a maximum of 9 BCM by 2040 where CCGT will consume the most gas followed by cement industry (assuming natural gas can compete with the current sources of energy used by the industry, which are coal and petcoke) as shown in Figure 8-3 (ECA, 2017).

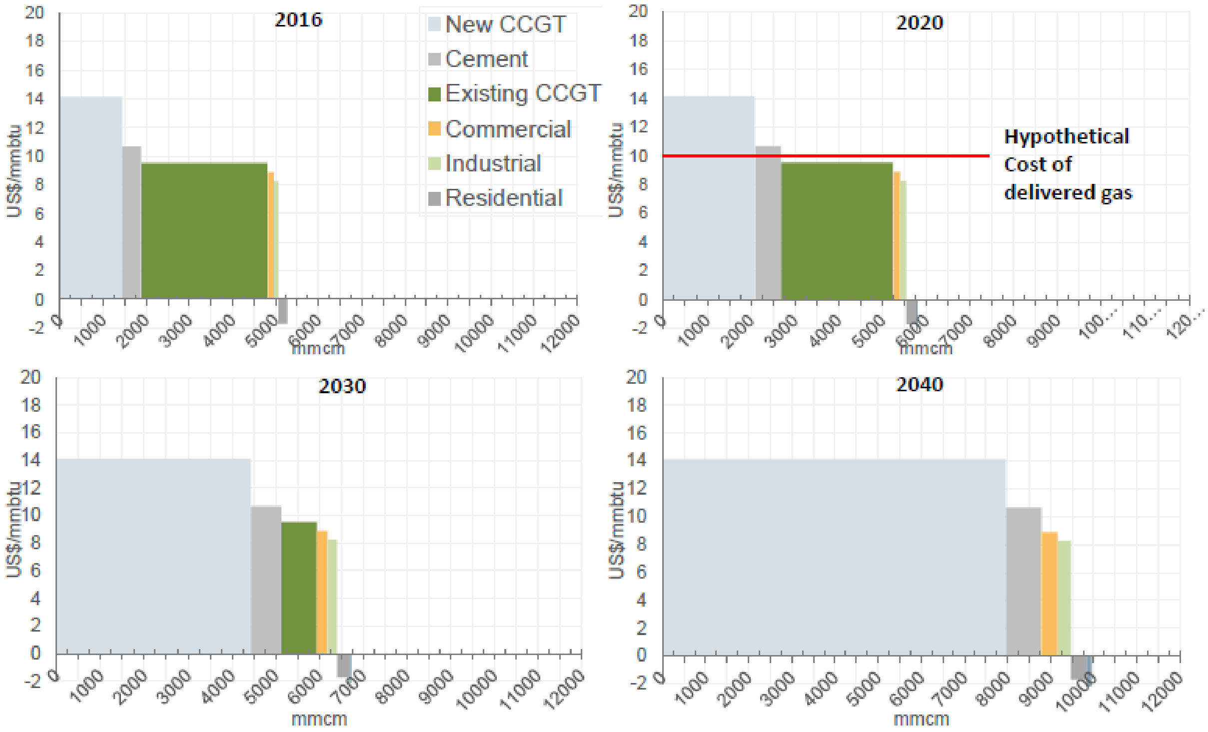


Figure 8-3 Coastal Gas Demand (ECA, 2017)

REFERENCES

Abbas, I., Chaaban, J., Al-Rabaa, A.R., Shaar, A. (2017).Solid Waste Management in Lebanon: Challenges and Recommendations. Journal of Environment and Waste Management Vol. 4(3), pp. 235-243.

Abboud-Abi Saab, M. (2012). Marine biodiversity in coastal waters. National Centre for Marine Sciences, National Council for Scientific Research, Batroun, Lebanon

Abboud-Abi Saab, M. (2008 a.). Tintinnids of the Lebanese Coastal Waters (Eastern Mediterranean). CNRS-Lebanon/UNRP/MP/RAC/SPA. MPA, 1925pp.

Abboud-Abi Saab M., Fakhri M., Sadek E., and Matar N. (2008 b). An Estimate of the Environmental Status of Lebanese Littoral Waters Using Nutrients and Chlorophyll-a as Indicators. Lebanese Science Journal, 9(1): 43-60.

Abboud Abi Saab, M., Fakhri, M., Kassab, M-T., et Matar *N. (2008c)*. Phenomene Exceptionnel D'eaux Colorees Au Printemps 2007 dans la Zone Cotiere Libanaise de Zouk-Nahr El Kelb. *Lebanese Science Journal, Vol. 9, No. 1,* 61.

Abboud-Abi Saab, M., Fakhri M., Romano J.-C., Kassab M.-T. (2006). Influence des Apports Fluviaux et Industrielles sur les Populations Phytoplanctoniques dans la Région de Selaata (Mer Levantin). WATMED 3, 1-3 Novembre, 158.

Abboud-Abi Saab, M. (2002). Annual cycle of the microzooplankton communities in the waters surrounding the Palm Island Nature Reserve (north Lebanon), with special attention to tintinnids. Mediterranean Marine Science Vol. 3/2, 55-76.

Abi-Ghanem, C., Mahfouz, C., Khalaf, G., Najjar, E., El-Zakhem, H., and anneh, R. (2016).Pb, Cd and Cu Distribution and Mobility in Marine Sediments from two Ports in Lebanon: Beirut Army Naval Port and Tripoli Fishing Port.Lebanese Science Journal, Vol. 17, No. 1, 2016 57.

Aguilar, R., García, S., Perry, A.L., Alvarez, H., Blanco, J., Bitar, G. 2018. 2016 Deep-sea Lebanon Expedition: Exploring Submarine Canyons. Oceana, Madrid. 94 p. DOI: 10.31230/osf.io/34cb9

Alves, T.M., Kokinou, E., Zodiatis, G., Lardner, R., Panagiotakis, C. & Radhakrishnan, H. (2015). Modelling of oil spills in confined maritime basins: The case for early response in the Eastern Mediterranean Sea. Environmental Pollution 206 (2015) pp. 390e399

Aoun, N.S., Harajali, H.A., Queffeulou, P. (2013). Preliminary appraisal of wave power prospects in Lebanon. Elsevier. Retrieved from https://www.journals.elsevier.com/renewable-energy

Arnaud,P.(2005), Les routes de la navigation antique. Itinéraires en Méditerrannée. Edition Errance, 2005.

Bakalowicz, M. (2014). Karst at depth below the sea level around the Mediterranean due to the Messinian crisis of salinity. Hydrogeological consequences and issues. GEOLOGICA BELGICA (2014) 17/1: 96-101

BankMed. (2013). Lebanon economic outlook 2013. Retrieved from http://www.bankmed.com.lb/LinkClick.aspx?fileticket=QCr9CVzsq4c%3D&portalid=0

Bankmed (2015). Analysis of Lebanon's Maritime Market. Beirut, Lebanon

Bankmed (2017). Analysis of Lebanon's Travel and Tourism Sector. Beirut, Lebanon

Bariche, M., (2006). Diet of the Lessepsian fishes, Siganus rivulatus and S. luridus (Siganidae) in the Eastern Mediterranean: a bibliographic analysis. Cybium, 30 (1): 41-49.

Bariche M (2012) Field identification guide to the living marine resources of the Eastern and Southern Mediterranean. http://www.fao.org/docrep/017/i1276b/i1276b00.htm .

Bariche M., Sadek R. and Azzurro E. (2009). Fecundity and condition of successful invaders: Siganus rivulatus and S. luridus (Actinopterygii: Perciformes: Siganidae) in the Eastern Mediterranean. Acta Ichthyologica et Piscatoria, 39 (1): 11-18.

Bariche, M., Sadek, R., Al-Zein, M., El-Fadel, M. (2007). Diversity of juvenile fish assemblages in the pelagic waters of Lebanon (eastern Mediterranean).Hydrobiologia, Volume 580, Number 1, April 2007 , pp. 109-115(7).

Bertoni, C., Cartwright, J., Messinian evaporites and fluid flow, Marine and Petroleum Geology (2015), doi: 10.1016/j.marpetgeo.2015.02.003.

Beyond/EU/Transtec, (2015). Mapping Civil Society Organizations in Lebanon.

Bianchi, C.N. and Morri, C. (2000). "Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research." Marine pollution bulletin 40.5 (2000): 367-376.

Bigagli, E., Samaha, Z., Sevin-Allouet, MA., 2018. Deep Sea Lebanon, results of the 2016 expidition exploring submarine canyons. IUCN, Spain-Lebanon 2018.

Bitar G. (2010). La flore marine benthique introduite de la cote Libanaise: état actuel de trois espèces envahissantes. BAE Conference-INOC, Lattakia, Syria, 107-115.

BirdLife International (2018) Country profile: Lebanon. Available from http://www.birdlife.org/datazone/ country/lebanon. Checked: 2018-07-17

Boustany, L., Indary S. and Nader, M. (2015).Biological characteristics of the lessepsian pufferfish Lagocephalus sceleratus (gmelin, 1789) off Lebanon.Cahier de Biologie Marine 56 : 137-142.

CAS (2011). The labour market in Lebanon, Statistics in Focus (SIF), Central Administration of Statistics, Lebanon, Issue number 1, October 2011.

CAS (2012). Population and housing characteristics in Lebanon, Statistics in Focus (SIF), Central Administration of Statistics, Lebanon, Issue number 2, April 2012.

CAS (2014). Monthly Data per Year from 2000 to 2012. Central Administration of Statistics. Retrieved from www.cas.gov.lb

CAS/WB (2015). Measuring poverty in Lebanon using 2011 HBS.

CAS (2016). Monthly Data per Year from 2000 to 2016. Central Administration of Statistics. Retrieved from www.cas.gov.lb

CAS (2016). National Accounts 2004-2015. Central Administration of Statistics, Lebanon,

CAS (2017). Annual Tourism Data per Year from 2010 to 2017. Central Administration of Statistics. Retrieved from www.cas.gov.lb

CBD/UNEP (2014).EBSA Workshop, Malaga Spain, April 2014)

CERD (2017). 2016-2017 Statistical Bulletin. Center for Educational Research and Development. Retrieved from http://www.crdp.org/stat-details?id=25998&la=en

CERD (2018). Schools in Lebanon: Numbers and Indicators 2011-2017 Statistical Bulletin. Center for Educational Research and Development Retrieved from http://www.crdp.org/studies?la=en

Chemello, Renato & Silenzi, Sergio. (2011). Vermetid reefs in the Mediterranean Sea as archives of sea-level and surface temperature changes. Chemistry and Ecology. 27. 121-127.

CMU (2014). Characteristics and Features of NPTP Extreme Poor Lebanese House Holds. Frist Statistical Report of the NPTP. The Central Management Unit. The Council of Ministers, Lebanon.

Codina-García, M., Militão, T., Moreno, J. González-Solís, J. (2013). Plastic debris in Mediterranean seabirds. Marine Pollution Bulletin. 77: 220–226. DOI: 10.1016/j.marpolbul.2013.10.002.

Couturier, C.I.E., Bennett M.B., Richardson A.J. (2013). Mystery of giant rays off the Gaza Strip solved. Oryx 47 (4):479-482

Cross, H., Rizk, C., Khalil, M. and Venizelos, L. (2006). Population Status and Conservation Activities on Sea Turtle Nesting Beaches in South Lebanon, 2005. Retrieved from http://www.seaturtle.org/PDF/CrossH_2006_BCGFFEMMEDASSETMEDWESTCOASTMELRACSPAUNEPMAPUNDPTechReport.pdf

Cubadda, S., Colloca, F., Carpentieri, P. and Cicinelli, L. (2005). Socioeconomic Development of the Fishing Community of Tyre, Lebanon. Retrieved from http://www.ongrc.org/lang/ita/images/tyre_a_c ase_study.pdf

Crocetta, F., Zibrowius, H., Bitar, G., Templado, J. and Oliverio, M. (2013). Biogeographical homogeneity in the eastern Mediterranean Sea - I: the opisthobranchs (Mollusca: Gastropoda) from Lebanon. Mediterranean Marine Science. Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS. The journal is available on line at http://www.medit-mar-sc.net. DOI: http://dx.doi.org/10.12681/mms.404

Dedel, A., Saad, A., Fakhri, M., Öztürk, B. (2012). Cetacean sightings in the Eastern Mediterranean Sea during the cruise in summer 2008. J. Black Sea/Mediterranean Environment; Vol. 18, No. 1: 49-57 (2012)

DGLM (2013). Public Transport Sector in LEBANON Strategy & Pilot Project Implementation. Directorate General of Land & Maritime Transport. Ministry of Public Works & Transport. Presented on October 1, 2013 in France.

Danovaro R, Company JB, Corinaldesi C, D'Onghia G, Galil B, Gambi C, et al. (2010) Deep-Sea Biodiversity in the Mediterranean Sea: The Known, the Unknown, and the Unknowable. PLoS ONE 5(8): e11832. https://doi.org/10.1371/journal.pone.0011832

Earth Trends (2003). Coastal and Marine Ecosystems – Lebanon. Retrieved from http://earthtrends.wri.org/pdf_library/country_ profiles/coa_cou_422.pdf

ECA (2017). Lebanon Gas Development Plan- Presentation of Final Recommendations. September 2017. Economic Consulting Associates, UK.

Ecodit (2015). Strategic Environmental Assessment for the New Water Sector Strategy for Lebanon.

El-Geziry, T.M. & Bryden, I.G. (2010) The circulation pattern in the Mediterranean Sea: issues for modeller consideration, Journal of Operational Oceanography, 3:2, 39-46, DOI: 10.1080/1755876X.2010.11020116

El Kareh G. (1981). Le Nil et les sédiments côtiers de la Méditerranée Sud-Orientale et du Liban. Annales de Géographie, Université Saint Joseph, Volume 2, pp 69-96.

El Kareh G. (1984). Contribution à l'étude des sédiments côtiers du Liban (essaie de corrélation des paramètres granulométriques). Thèse, Institut National Polytechnique de Lorraine, Ecole Nationale Supérieure de Géologie appliquée et de Prospection minière, 607p.

Elias, A., Tapponnier P., Singh S.C., King G.C.P., Briais A., Daëron M., Carton H., Sursock A., Jacques E., Jomaa R. & Klinger Y. (2007). "Active thrusting offshore Mount Lebanon: Source of the tsunamigenic A.D. 551 Beirut-Tripoli earthquake". Geology 35 (8): 755–758. doi:10.1130/G23631A.1. Retrieved 2 March 2011

Emery K.O., George C.J. (1963): The shores of Lebanon. Woods Hole Oceanographic Institution, Collected reprints, 1385, 10 p., ann.

ETF (2015). Labour Market and Employment Policy in Lebanon. ISBN 978-92-9157-623-4 doi:10.2816/710560

Fallah, R., Olama, Z., Holail, H. (2016). Marine Quality Assessment of Northern Lebanese Coast: Microbiological and Chemical Characteristics and their Impact on the Marine Ecosystem. International Journal of Current Microbiology and Applied Sciences.

Farajalla, N., Haddad, E., Camargo, M., Lopes, R., & Vieira, F. (2014). Climate Change in Lebanon: Higher-order Regional Impacts from Agriculture. Retrieved from https://website.aub.edu.lb/ifi/publications/Documents/working_papers/20140722_Higher_order_CC.pdf

Fordham, S., Fowler, S.L., Coelho, R., Goldman, K.J. & Francis, M. (2006). Squalus acanthias (Mediterranean subpopulation). In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>.

FRANSABANK (2018). The Policies and Actions Needed to Face the Growing Water Security Challenges in Lebanon. Center for Economic studies. Beirut, Lebanon.

Garziglia, S., Migeon, S., Ducassou, E., Loncke, L. and Mascle, J. (2008). Marine Geology, 250 (2008), pp 180–198.

Genesis Oil and Gas Consultants LTD (2011). Review and Assessment of Underwater Sound Produced from Oil and Gas Sound Activities and Potential Reporting Requirements under the Marine Startagey Framework Directive.

Ghalayini, R., Nader, F.H., Bou Daher, S., Hawie, N. and Chbat, W.E. (2018). Petroleum Systems of Lebanon: An Update and Review. Journal of Petroleum Geology, Vol. 41(2). pp 18-214

Ghannam, J., Ayoub, G. M. & Acra, A. (1998). A Profile of the Submarine Springs in Lebanon as a Potential Water Resource, Water International, 23:4, 278-286, DOI: 10.1080/02508069808686783

GIZ Tunisia /SWEEP-Net/ D-Waste (2014). *Country Report on the Solid Waste Management in Lebanon*. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2014)

GoL/UN (2018). Lebanon Crisis Response Plan. Government of Lebanon and the United Nations. January 2018. Retrieved from http://www.LCRP.gov.lb

Hamdar, B.C., Najjar, R., & Karameh, K. (2017). The Lebanese Perception of the Impact of Small & Medium Enterprises (SMEs) on the National Economy. Journal of Economics and Public Finance

Hartley Anderson Ltd (2005). Deep Water Environment to the West of Ireland. Report to the Irish Shelf Petroleum Studies Group. Project ISO3/21. Draft report, December 2005.

Hilal, N., Fadlallah, R., Jamal, D., El-Jardal,i F. (2015).K2P Evidence Summary: Approaching the Waste Crisis in Lebanon: Consequences and Insights into Solutions.Knowledge to Policy (K2P) Center. Beirut, Lebanon.

Hraoui, B.-S., Sadek, R., Sindaco, R. & Venchi, A.(2002). The herpetofauna of Lebanon: new data on distribution.Zoology in the Middle East 27, pp. 35-46

Huijer, C., Harajli, M., and Sadek, S. (2011). Upgrading the Seismic Hazard of Lebanon in Light of the Recent Discovery of the Offshore Thrust System Fault System. Lebanese Science Jounal, Vol.s, No.2, 2011.

Hulla/CHD (2017). Land Transport Sector Workshop: Land Transport Sector's Strategy and Other Achievements. Ministry of Public Works and Transport.

International Alert/LCPS (2014). Security Threat Perceptions in Lebanon. Retrieved from https://www.international-alert.org/sites/default/files/Lebanon_SSRSecurityThreatPerceptions_EN_2014_1.pdf

ILF/UNDP (2017). Cost Benefit Analysis for the Use of Natural Gas and Low Carbon Fuels: Infrastructure Analysis Report. Sustainable Oil and Gas Development in Lebanon (SODEL).

IoF (2018). Citizen Budget Report. The Institut des Finances Basil Fuleihan. Ministry of Finance. Beirut, Lebanon.

IUCN, (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marine habitats and species in Lebanon. Beirut, Lebanon, Gland, Switzerland y Malaga, Spain: the Lebanese Ministry of Environment / IUCN, 2012.64 pp.

IUCN (2018). The IUCN Red List of Threatened Species. Version 2018-1. Redtreieved from <http://www.iucnredlist.org>

Jabali, Y., Millet, M., El Hoz, M.(2017). Determination of 48 pesticides in water by using DI-SPME coupled with GC/MS15th International Conference on Environmental Science and Technology - Rhodes, Greece, 31 August to 2 September 2017.

Kabbara N. (2005). Wind and Wave Data Analysis for the Lebanese Coastal Area-Preliminary Results.Lebanese Science Journal, Vol. 6, No. 2, 2005 45.

Kanaan, H., and Belous, O. (2016).Marine Algae of the Lebanese Coast.Hauppauge, New York: Nova Science Publishers.

Khalaf, G. and Fakhri, M. (2017). Biodiversity in the Eastern Mediterranean Sea, including its impact on aquatic animal health in the Middle East, CNRS. Istanbul, Turkey

Khalaf G, Saad A., Jemaa S., Sabour W., M. and Lelli S. (2014). Population Structure and Sexual Maturity of the Pufferfish Lagocephalus sceleratus (Osteichthyes: Tetraodontidae) in the Lebanese and Syrian Waters (Eastern Mediterranean). Journal of Earth Science and Engineering, 4 : 236-244.

Korfali S. I., Al Hakawati N., and Khadra W. (2014).Evaluation of Metals and their Potential Hazard in the Awali River Surface Sediments. Conference Paper, 30th SEGH International Conference. At Newcastle, UK. June 30th, 2014.

Kouyoumjian H. and Hamze M. (2012). Review and Perspectives of Environmental Studies in Lebanon.INCAM-EU/CNRS Lebanon pp 328.

Kukrety, N. and Al Jamal, S. (2016). POVERTY, INEQUALITY AND SOCIAL PROTECTION IN LEBANON. Published by the Issam Fares Institute for Public Policy and International Affairs, American University of Beirut

Lakkis, S. (2011). "Le phytoplancton marin du Liban (Méditerranée orientale): biologie, biodiversité, biogéographie." Aracne, Roma.

Lakkis, S., Novel-Lakkis, V., and Zeidane, R. (2011). Le zooplancton marin du liban (méditerranée orientale): biologie, biodiversité, biogéograhie. Publications de L'Université Libanaise.

Lteif M.(2015). Biology, distribution and diversity of cartilaginous Fish species along the Lebanese Coast, eastern Mediterranean (Universitie de Perpignan).

Makhzoumi, J., Chmaitelly, H., and Lteif, C. (2012). "Holistic conservation of bio-cultural diversity in coastal Lebanon: A landscape approach." Journal of Marine and Island Cultures1.1 (2012): 27-37.

Majdalani S., (2004). The present status of fishery and information system in Lebanon.GCP/INT/918/EC - TCP/INT/2904/TD-4.1. MedFisis Technical Document No. 4.1: 45pp.

Majdalani S. (2005). Census of Lebanese fishing vessels and fishing facilities. Ministry of Agriculture, Lebanon.144 p.

Mascle, J., Mary, F., Praeg, D., Brosolo, L., Camera, L., Ceramicola, S. and Dupré, S. (2014). Distribution and Geological Control of Mud Volcanoes and other Fluid/Free Gas Seepage Features in the Mediterranean Sea and nearby Sulf of Cadiz. Geo-Marine Letters, 2014, Volume 34, Number 2-3, Page 89-110.

Martín J, Puig P, Palanques A, Masqué P, García-Orellana J (2008) Effect of commercial trawling on the deep sedimentation in a Mediterranean submarine canyon. Mar Geol 252: 150–155.

Mcheik, A., Fakih, M., Trabulsi, H., Toufail, J., Hamieh, T., Garnier-Zarli, E., Bousserrhine, N. (2015). Metal Pollution Assessment of Sediment and Water in Al-Ghadir River: Role of Continuously Released Organic Matter and Carbonate and Their Purification Capacity. International Journal of Environmental Monitoring and Analysis3(3): 162-172.

Mytilineou et al. (2016) New Mediterranean Biodiversity Records (November, 2016). Mediterranean marine science 17(3): 794-821, 10.12681/mms.1976

MoE (2015). Lebanon's Intended Nationally Determined Contribution under the United Nations Framework Convention on Climate Chang. Retrieved from http://climatechange.moe.gov.lb/Library/Files/Uploaded%20Files/Republic%20of%20Lebanon%20-%20INDC%20-%20September%202015.pdf

MoE/IUCN (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marinehabitats and species in Lebanon. Beirut, Lebanon,Gland, Switzerlandy Malaga, Spain: the Lebanese Ministry of Environment / IUCN. 64 pp.

MoE/UNDP/ECODIT, (2011).State and trends of the Lebanese environment 2010.Beirut Lebanon.

MOE/UNDP/GEF, (2014). State of and IBAs Lebanon's Birds. By SPNL, 153 pp.

MoE/UNDP/GEF (2015). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Energy Sector in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon.

MoE/UNDP/GEF (2017). Lebanon's second biennial update report to the UNFCCC. Beirut, Lebanon

MoE/URC/GEF (2012). Lebanon Technology Needs Assessment Report for Climate Change. Ministry of Environment. Beirut, Lebanon.

MoE/EU/UNDP (2014). Lebanon Environmental Assessment of the Syrian Conflict and Priority Interventions. September 2014.

MoE/EU/GFA (2017). Assessment of Solid Waste Management Practices in Lebanon in 2015. Support to Reforms – Environmental Governance, Beirut, Lebanon.

MoE, (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marine habitats and species in Lebanon. Beirut, Lebanon, Gland, Switzerland y Malaga, Spain. IUCN. 64 pp.

MoE (2006). Protected Areas in Lebanon - Stable Institutional Structure for protected Areas management (SISPAM). Retrieved from http://www.moe.gov.lb/protectedareas/categories.htm

MoE (2017). Lebanon's National Strategy for Air Quality Management for 2030. Beirut, Lebanon.

MoEW (2012). SEA for Petroleum Activities in Lebanese Waters 2011-2012. Beirut, Lebanon

MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016.

MoE/UNDP/GEF (2017). Lebanon's second biennial update report to the UNFCCC. Beirut, Lebanon.

MoE/UNEP/GEF (2017) - National Implementation Plan on Persistent Organic Pollutants. Lebanon

MoE/UNEP/UNDP (2012). Identification and Assessment of Coastal Sensitive Areas in Lebanon, ERML, Dec, 2012

MOET (2018). SMEs in Lebanon: Status, strategy and outocmes. Prepared by Johnny M. Matta April 2018.

MOET/Inventis (2014).Lebanon SME Startegy - A roadmap to 2020. Beirut, Lebanon.

MoPH/ WHO (2016). Non Communicable Diseases Prevention and Control Plan (NCD-PCP)- Lebanon 2016-2020. Ministry of Public Health. Beirut, Lebanon.

MoPH (2015). Mental Health and Substance Use- Prevention, Promotion, and Treatment- Situation Analysis and Strategy for Lebanon 2015-2020. Ministry of Public Health. Beirut, Lebanon

MoPH (2016). Statistical Bulletin 2016. Ministry of Public Health. Retrieved from https://www.moph.gov.lb/en/Pages/8/327/statistical-bulletins

MoE/UNEP/GEF (2015). 5th National Report (5NR) To the Convention on Biological Diversity (CBD). Lebanon

MoE/UNEP/GEF (2016). National Biodiversity Strategy and Action Plan – NBSAP

MoE/UNEP/GEF (2017) - National Implementation Plan on Persistent Organic Pollutants. Lebanon

Mouawad R. 1, Daou C. , Khalaf G. , Hage K. and Lteif M., (2014). The Study of Meiofaunal Communities on Lebanese Snady Beaches and Evaluation of Water Quality. INOC-CNRS, International Conference on "Land-Sea Interactions in the Coastal Zone" Jounieh - LEBANON, 06-08 November – 2012

MOPWT-DGLMT, 2017. The National Oil Spill Contingency Plan (NOSCP) in the Lebanese Waters. Verison1. , responsible for its development, maintenance, updating, revisions and

Nader M. (2011). National document aiming at the identification of important ecosystem properties and assessment of ecological status and pressures to Mediterranean marine and coastal biodiversity of Lebanon.50 p.

Nader, M., Indary, S.., and Stamatopoulos C. (2012).Assessment of the commercial fish species of the coast of north Lebanon 2006-2011.International Conferences on "Land-Sea Interactions in the Coastal Zone", November, 2012, Lebanon.

Nader, M., Indary, S. and Moniri, N.R. (.(2014). Historical Fisheries Catch Reconstruction for Lebanon (GSA 27), 1950-2010. UoB and UoBC Fisheries Center. Vancouver, Canada

Nader M., Mireille Jazi M., Abou Dagher M., and Indary S., (2013). Environmental Resources Monitoring in Lebanon project, Identification and Assessment of Coastal Sensitive Areas in Lebanon, UNEP-Ministry of Environment, 2013.

Nader M., Indary S., Boustany L., (2012). FAO EastMed The Puffer Fish Lagocephalus sceleratus (Gmelin, 1789) in the Eastern Mediterranean. GCP/INT/041/EC – GRE – ITA/TD-10

Newton, R.S., Cunningham, R.C., & Schubert, C.E. (1980). Mud Volcanoes And Pockmarks: Seafloor Engineering Hazards Or Geological Curiosities? Offshore Technology Conference, 5-8 May, Houston, Texas

Notarbartolo di Sciara, G., Bradai, M.N., Morey, G., Marshall, A.D., Compagno, L.J.V., Mouni, A., Hicham, M., Bucal, D., Dulvy, N., Heenan, A. & Rui Coelho (2007). Rhinobatos rhinobatos. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2.<www.iucnredlist.org>

NG-IA (2017). Sailing Directions (Enroute)- Eastern Mediterranean. National Geospatial-Intelligence Agency. Retrieved from https://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/SD/Pub132/Pub132bk.pdf

NOAA (2016). Ocean Noise Strategy Roadmap. Retrieved from http://cetsound.noaa.gov/ons

OCEANA MedNet.2011. MPA Network proposal for the Mediterranean Sea.

Ouba, A., Abboud-Abi Saab, M., Stemmann, L. (2016). Temporal Variability of Zooplankton (2000-2013) in the Levantine Sea: Significant Changes Associated to the 2005-2010 EMT like Event PLOS ONE. DOI:10.1371/journal.pone.0158484.

Palanques A, Marín J, Puig P, Guillén J, Company JB, et al. (2006) Evidence of sediment gravity flows induced by trawling in the Palamós (Fonera) submarine canyon (northwestern Mediterranean). Deep Sea Res I 53: 201–214.

Piante C., Ody D. (2015). Blue Growth in the Mediterranean Sea: the Challenge of Good Environmental Status. MedTrends Project. WWF-France. 192 pages.

Pinello D., and Dimech M. (2013). Socio-Economic Analysis of the Lebanese Fishing Fleet.GCP/INT/041/EC – GRE – ITA/TD-16.

Praeg, D., Geletti, R., and Wardel, N. (2011). The Mediterranean Sea: A Natural Laboratory to Study Gas Hydrate Dynamics? Proceedings of the 7th International Conference on Gas Hydrates (ICGH 2011), Edinburgh, Scotland, United Kingdom, July 17-21, 2011.

RAC/SPA –UN Environment/MAP, 2017. Ecological characterization of potential new MPAs in Lebanon: Batroun, Medfoun and Byblos. By Ramos-Esplá, A.A., Bitar, G., Forcada, A., Valle, C., Ocaña,O., Sghaier, Y.R., Samaha, Z. & Limam A., Ed SPA/RAC. MedMPA Network Project, Tunis: 120 pages+ annexes.

RAC/SPA - UNEP/MAP, 2014. Ecological characterization of sites of interest for conservation in Lebanon: Enfeh Peninsula, , RAS CHEKAA cliffs, RAOUCHEH, SAIDA, TYRE AND NAKOURA. By RAMOS-ESPLÁ A.A ., BITAR G., Khalaf G, El Shaer H., Forcada a., Limam A., Ocaña O., Sghaier Y.R. & Valle C. Ed. RAC/SPA - MedMPAnet Project, Tunis. 168 pages + annexes.

Ramadan-Jaradi, G.., Ramadan-Jaradi, M. & Bara, T. (2008). The revised checklist of the birds of Lebanon (Sandgrouse 30 (1) 22-69.

Ramadan-Jaradi, G. (2017a). Mediterranean Monk Seal – Baseline Study.Society for the Protection of Nature in Lebanon.14 p.p.

Ramadan-Jaradi, G. (2017). Status and distribution of migrating and breeding Marine birds in North Lebanon. Lebanese Science Journal. Vol. 18, No. 2: 156-165.Robalino, D., & Sayed, H. (2012). Lebanon: good jobs needed. World Bank.

Sacchi J., Dimech M., 2011. Report of the FAO EastMed Assessment of the Fishing Gears in Lebanon.GCP/INT/041/EC – GRE – ITA/TD-09

Salhab, R., Z. Olama, and H. Holail (2016). "The Effect of Organic Pollution and Risk Factor along the Tripoli Harbour-North Lebanon." Int. J. Curr. Microbiol. App. Sci 5.1 (2016): 318-333

Serebryakov, V.A., Robertson, J.O., & Chilingarian, Jr. G.V. (2002). Origin and Prediction of Abnormal Formation Pressures. Volume 50. 1st Edition.

Shaban, A., and Khalaf-Keyrouz, L. (2013). The geological controls of geothermal groundwater sources in Lebanon. International Journal of Energy and Environment, Volume 4, Issue 5, 2013 pp.787-796.Journal homepage: www.IJEE.IEEFoundation.org. ISSN 2076-2895 (Print), ISSN 2076-2909 (Online) ©2013

Shanmugam, G. (2012). New Perspectives on Deep-water Sandstones. Volume 9, 1st Edition.SINGH Satish (2003). SHALIMAR cruise, RV Le Suroît, http://dx.doi.org/10.17600/3020120

Toropova C., Meliane I., Laffoley D., Matthews E., Spalding M. (2010) Global ocean protection: present status and future possibilities. Agence des aires marines protegees, IUCN WCPA, UNEP-WCMC, TNC, UNU, WCS, Brest, France; Gland, Switzerland; Washington D.C. & New York, USA; Cambridge, U.K.; Arlington, U.S.A.; Tokyo, Japan.

TRAGSA/ AECID / MOE. 2009 Physical-Chemical and Biological Characterization of the Marine Ecosystem – Palm Island Nature Reserve, Lebanon. July 2009. 473pp.).

UNDP (2015). Spotlight on Youth in Lebanon. Beirut, Lebanon.

UNHCR (2018). Figures at a Glance. United Nations High Commissioner for Refugees (UNHCR), Retrieved from: http://www.unhcr.org/figures-at-a glance.html, retrieved on March 15, 2018

UNHCR/UNICEF/WFP (2017). Vulnerability Assessment of Syrian Refugees in Lebanon.

UNRWA (2015). Relief and Social Services Registration records. United Nations Relief and Works Agency.

UOB/UNEP/MOE (2013).Environmental Resources Monitoring in Lebanon (ERML) project, Improved Understanding, Management and Monitoring in the Coastal Zone.

Union for the Mediterranean (2015). Blue Economy for the Mediterranean. European Union. Brussels, Belgium.

United States Geological Survey (USGS) earthquake hazard program (website).

Walker, P., Cavanagh, R.D., Ducrocq, M. and Fowler, S.L. (2005). Chapter 7 – Regional Overviews: NortheastAtlantic (including Mediterranean and Black Sea). P86. In: Fowler, S.L., Cavanagh, R.D., Camhi, M., Burgess, G.H.,Cailliet, G.M., Fordham, S.V., Simpfendorfer, C.A. andMusick, J.A. (comp. and ed.). (2005). Sharks, Rays andChimaeras: The Status of the Chondrichthyan Fishes.IUCN SSC Shark Specialist Group. IUCN, Gland,Switzerland and Cambridge, UK. Agregations of smalltooth sandtiger shark Odontaspis ferox offshore Beirut and wider area.

Waked, A., Afif C., Seigneur C. (2012). An atmospheric emission inventory of anthropogenic and biogenic sources for Lebanon, Atmos. Environ., 50, 88-96.

Waked, A., Afif, C. (2012). Emissions of air pollutants from road transport in Lebanon and other countries in the Middle East region, Atmos. Environ., 61, 446-452.

WEF (2016). The Global Competitiveness Report 2016–2017. The World Economic Forum. ISBN-13: 978-1-944835-04-0. Geneva.

WHO (2014). Noncommunicable Diseases (NCD) Country Profiles 2014. World Health Organization. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/128038/9789241507509_eng.pdf;jsessionid=C7097FC23FF130AC58867DE72F5DFE38?sequence=1

Wu, P. and Haines, K. (1998). The general circulation of the Mediterranean Sea from a 100-year simulation. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 103, NO. C1, pp. 1121-1135, JANUARY 15, 1998.

Würtz M. (ed.) (2012). Mediterranean Submarine Canyons: Ecology and Governance.Gland, Switzerland and Málaga, Spain: IUCN. 216 pages

WWF/IUCN, World Wildlife Fund/International Union for Conservation of Nature (2004) The Mediterranean deep-sea ecosystems: An overview of their diversity, structure, functioning and anthropogenic impacts. Málaga: IUCN and Rome: WWF. 64 p.

Yin-can, Y.E. (2017). Submarine Landslides (Submarine slope Instability): Submarine slope instability can be defined as a variety of down slope movements of the material composing slope. Marine Geo-Hazards in China,1st Edition.

APPENDIX A: SUMMARY OF BASELINE CONDITIONS AND LIKELY TREND WITHOUT THE OFFSHORE PETROLEUM ACTIVITIES

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
Bathymetry	• The Draft National Oil Spill Contingency Plan (NOSCP) in the Lebanese Waters.	The water depth off the coast of Lebanon increases westward, reaching 2,000 m in the abyssal plain of the Levant basin. The Lebanese continental shelf itself is relatively narrow and can be divided into 3 main parts: 1) the widest part (18 Km) and falls between Enfeh and Akkar; 2) falls between Enfeh and Ras Beirut where the coastal plain is very narrow or almost non-existent. In this part, the continental shelf does not extend to more than 3 Km; and 3) extends from Ras Beirut till Naqouora where the continental shelf widens up again reaching 7 Km. Between Beirut and Batroun, the shelf is extremely narrow and the margin exhibits its steepest slope, with the water depth dropping from 100 to 1500 m in less than 5 km in some areas.	Bathymetry offers possible constraints to development options	NA
Air quality and Greenhouse Gases Emissions	• MoE (2017). Lebanon's National Strategy for Air Quality Management for 2030. Beirut, Lebanon. • MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon. • MoE/UNDP/GEF (2017). Lebanon's second biennial update report to the UNFCCC. Beirut, Lebanon • Waked, A., Afif C., Seigneur C. (2012). An atmospheric emission inventory of anthropogenic and biogenic sources for Lebanon, Atmos. Environ., 50, 88-96.	Transportation is the main source of air pollution in Lebanon. Power plants and industrial sources are also contributors to air pollution: 73% of the emissions of Sulphur Dioxide (SO_2), 62% of Particulate Matter (PM10) emissions and 59% of PM2.5 are estimated to originate from power plants and industrial sources.	Air emissions expected to be generated from E&P from primary and secondary sources (such as venting, flaring,	Since Lebanon has put forward the National Strategy for Air Quality Management that tackles air quality within various Initiatives, and given the planned gasification of the

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Waked, A., Afif, C. (2012). Emissions of air pollutants from road transport in Lebanon and other countries in the Middle East region, Atmos. Environ., 61, 446-452.	A large fraction of the emissions is concentrated in main coastal cities such as Beirut city, Zouk Mikael, Jiyeh, and Chekka. The Lebanese Air Quality Monitoring Network (AQMN) launched in 2013 has 15 monitoring stations that were installed between 2013 and 2017; 3 monitoring stations installed in Urban Community of Al-Fayhaa. The main contributor to greenhouse gas (GHG) emissions is the energy sector with 56% of GHG emissions, followed by transport (23%), industrial processes (10%) and waste sector (7%) (MoE/UNDP/GEF, 2017). A recalculated time series for 1994-2013 indicates an increase in GHG emissions in Lebanon with carbon dioxide being the most significant.	blowouts, etc.) include the following: • Criteria pollutants (CO, SOx, NOx, PM10, VOCs) • GHGs (CO_2, CH_4) • Hazardous & toxic air pollutants (H2S, formaldehyde, organo-metallic compounds, polycyclic aromatic HCs (benzene, toluene, ethylbenzene and xylene (BTEX)) • Heavy metals (Hg,	energy sector, CO, SO_2 NO_2 and Benzene emissions are expected to decrease, however, PM emissions are yet expected to increase mostly due the transport sector. With the planned gasification of the energy sector and the commitment to Lebanon's Nationally Determined Contributions (NDC) submitted under Paris Agreement, considering the calculation of the BAU and emission trajectories of the 15% and 30% in the NDC, even if Lebanon achieves the 30% GHG emission reduction by 2030, GHG emissions will not go below the emission in 2011 base year.

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
			Ar, Pb, Cu, Ag) + methyl mercury • Fugitive emissions	
Acoustic Environment	• Environmental, Social and Traffic Assessment for the Coastal Railway between Tripoli and the Syrian border (2016-2017) • ESIA and the Resettlement Action Plan (RAP) for the Bus Rapid Transit (BRT) system between Beirut and Tabarja and Feeder Buses Services within Beirut (2016) • Environmental Baseline Monitoring and City Profiles - CHUD Phase III Intervention Area (2016-2017) • NOAA (2016). Ocean Noise Strategy Roadmap.	There is no data on underwater noise levels, however all marine animals are susceptible to behavioural harassment at rms sound pressure level of 160 dB from impulse sources and at 180 dB from continuous sources. The monitoring locations are spread along the coastline from North (Kobet Al Choumra) to South Lebanon (Tyre). The measurements were carried out during day times (7.00 am – 6.00 pm). Exceedences in noise levels with respect to national standards (MoE Decision No. 52/1/1996) were witnessed in 17 points out of 33 monitoring points.	Onshore E&P facilities/ support activities will pose additional pressure on coastal areas and could lead to further increase in noise levels Increase in underwater noise levels which could negatively affect marine fauna	o systematic monitoring records of ambient noise levels to determine evolution. o data on underwater noise levels and affected marine mammals from underwater noise
Waves, winds, currents and tides	• NG-IA (2017). Sailing Directions (Enroute)- Eastern Mediterranean. National Geospatial-Intelligence Agency. Retrieved from	Waves in the Mediterranean are generated by winds (wind-waves), and therefore they follow the general direction of the prevailing wind. Wave height is proportional to the square of wind velocity	Current profiles affect the movement of pollution in	NA

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	https://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/SD/Pub132/Pub132bk.pdf • MOPWT-DGLMT, 2017. The National Oil Spill Contingency Plan (NOSCP) in the Lebanese Waters. Verison1. , responsible for its development, maintenance, updating, revisions and • Aoun, N.S., Harajali, H.A., Queffeulou, P. (2013). Preliminary appraisal of wave power prospects in Lebanon. Elsevier. Retrieved from https://www.journals.elsevier.com/renewable-energy • Tedo-Tripoli Weather Station (2017) • Chemello, Renato & Silenzi, Sergio. (2011). Vermetid reefs in the Mediterranean Sea as archives of sea-level and surface temperature changes. Chemistry and Ecology. 27. 121-127.	with higher wind velocities creating higher waves and generally rougher seas. Mean monthly wave heights vary between 1 and 0.2 meters; yet waves exceeding 5 meters have been recorded. More forceful are expected in windier areas, specifically in northern Lebanon since average offshore winds were found to be strongest with speeds reaching 7 m/sec. The general circulation along the Lebanese coastline is northward in line with the general counter-clockwise gyre of the Eastern Mediterranean. Localized clockwise eddies and small gyres occur as a result of bays, submarine canyons, and headlands. Tidal activity on the Lebanese coast is weak and ranges between 30 and 40 cm. The general East current on the Northern coast of Africa turns North Eastern and North on the coasts of Lebanon and Syria, where it becomes weak and variable and affected by the winds. The speed of the North current has been recorded to exceed 1 knot during strong Western winds. Based on the tidal progression, flood currents in the Mediterranean Sea set East and ebb currents set West. Winds blowing	sea, including from spills	

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		from the West accelerate the flood current, and winds blowing from the East hinder it; whereas the opposite applies for the ebb current. The Mediterranean regional seas dynamics (the Adriatic and the Aegean…), and the transport through its straits (Gibraltar and Sicily…) are very important to water circulation in the deep Mediterranean Sea. The Aegean deep water (AeDW) and Adriatic deep water (AdDW) form the Eastern Mediterranean Deep Water (EMDW) while the Tyrrhenian deep water (TDW) and the Gulf of Lions deep waters form the Western Mediterranean Deep Water (WMDW). The EMDW is formed at 1000 to 1500 m depth in the southern Aegean and southern Adriatic, and then it outflows to fill the total depth of the Eastern Mediterranean basin of 4000–5000m. Under the Coriolis force influence, the EMDW flows to the western Mediterranean basin at the deepest point of the Sicily Strait and mainly on the Tunisian side where temperature and salinity slowly decrease with depth indicating a very low static stability. The deep-waters of the Mediterranean are renewed approximately every 126 years		

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		(considering that the upper boundary of the deep regime is of 1200 m).		
Submarine canyons	• Toropova C., Meliane I., Laffoley D., Matthews E., Spalding M. (2010) Global ocean protection: present status and future possibilities. Agence des aires marines protegees, IUCN WCPA, UNEP-WCMC, TNC, UNU, WCS, Brest, France; Gland, Switzerland; Washington D.C. & New York, USA; Cambridge, U.K.; Arlington, U.S.A.; Tokyo, Japan; . • CBD/UNEP (2014).EBSA Workshop, Malaga Spain, April 2014) • Würtz M. (ed.) (2012). Mediterranean Submarine Canyons: Ecology and Governance.Gland, Switzerland and Málaga, Spain: IUCN. 216 pages • Elias, A., Tapponnier P., Singh S.C., King G.C.P., Briais A., Daëron M., Carton H., Sursock A., Jacques E., Jomaa R. & Klinger Y. (2007). "Active thrusting offshore Mount Lebanon: Source of the tsunamigenic A.D. 551 Beirut-Tripoli earthquake". Geology 35 (8): 755–758. doi:10.1130/G23631A.1. Retrieved 2 March 2011 • Shaban, A., and Khalaf-Keyrouz, L. (2013). The geological controls of geothermal groundwater sources in Lebanon. International Journal of Energy and Environment, Volume 4, Issue 5, 2013 pp.787-796.Journal homepage: www.IJEE.IEEFoundation.org. ISSN 2076-2895 (Print), ISSN 2076-2909 (Online) ©2013 • Bakalowicz, M. (2014). Karst at depth below the sea level around the Mediterranean due to the Messinian crisis of salinity. Hydrogeological consequences and issues. GEOLOGICA BELGICA (2014) 17/1: 96-101 • Jihad G., 1998	Deep canyons characterize the continental slope of the Lebanese coast. Almost 518 large submarine canyons have been identified in the Mediterranean Sea and are considered as key structures for its ecosystem functioning. Deep canyons play a fundamental role in fundamental role in "Deep Oceans-Shelf Exchanges" and in biological diversity. The east Mediterranean is characterized by its deep canyons all along the Lebanese and Syrian coasts several hydrothermal vents, submarine freshwater springs in addition to it being of particular importance biologically.	Drilling discharge causing sediments accumulation Pipelines waste	Not enough baseline data to determine evolution

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• IUCN, (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marine habitats and species in Lebanon. Beirut, Lebanon, Gland, Switzerland y Malaga, Spain: the Lebanese Ministry of Environment / IUCN, 2012.64 pp. • Nader, M., Indary, S., and Stamatopoulos C. (2012).Assessment of the commercial fish species of the coast of north Lebanon 2006-2011.International Conferences on "Land-Sea Interactions in the Coastal Zone", November, 2012, Lebanon. • Bariche, M., (2006). Diet of the Lessepsian fishes, Siganus rivulatus and S. luridus (Siganidae) in the Eastern Mediterranean: a bibliographic analysis. Cybium, 30 (1): 41-49. • Bariche, M., Sadek, R., Al-Zein, M., El-Fadel, M. (2007). Diversity of juvenile fish assemblages in the pelagic waters of Lebanon (eastern Mediterranean).Hydrobiologia, Volume 580, Number 1, April 2007 , pp. 109-115(7). • Crocetta, F., Zibrowius, H., Bitar, G., Templado, J. and Oliverio, M. (2013). Biogeographical homogeneity in the eastern Mediterranean Sea - I: the opisthobranchs (Mollusca: Gastropoda) from Lebanon. Mediterranean Marine Science. Indexed in WoS (Web of Science, ISI Thomson) and SCOPUS. The journal is available on line at http://www.medit-mar-sc.net. DOI: http://dx.doi.org/10.12681/mms.404 • Couturier, C.I.E., Bennett M.B., Richardson A.J. (2013). Mystery of giant rays off the Gaza Strip solved. Oryx 47 (4):479-482			

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Walker, P., Cavanagh, R.D., Ducrocq, M. and Fowler, S.L. (2005). Chapter 7 – Regional Overviews: NortheastAtlantic (including Mediterranean and Black Sea). P86. In: Fowler, S.L., Cavanagh, R.D., Camhi, M., Burgess, G.H.,Cailliet, G.M., Fordham, S.V., Simpfendorfer, C.A. andMusick, J.A. (comp. and ed.). (2005). Sharks, Rays andChimaeras: The Status of the Chondrichthyan Fishes.IUCN SSC Shark Specialist Group. IUCN, Gland,Switzerland and Cambridge, UK. Agregations of smalltooth sandtiger shark Odontaspis ferox offshore Beirut and wider area. • Fordham, S., Fowler, S.L., Coelho, R., Goldman, K.J. & Francis, M. (2006). Squalus acanthias (Mediterranean subpopulation). In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. • Notarbartolo di Sciara, G., Bradai, M.N., Morey, G., Marshall, A.D., Compagno, L.J.V., Mouni, A., Hicham, M., Bucal, D., Dulvy, N., Heenan, A. & Rui Coelho (2007). Rhinobatos rhinobatos. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2.<www.iucnredlist.org> • Dedel, A., Saad, A., Fakhri, M., Öztürk, B. (2012). Cetacean sightings in the Eastern Mediterranean Sea during the cruise in summer 2008. J. Black Sea/Mediterranean Environment; Vol. 18, No. 1: 49-57 (2012) • SINGH Satish (2003). SHALIMAR cruise, RV Le Suroît, http://dx.doi.org/10.17600/3020120			

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
Sediments quality	• Kareh G. (1981). Le Nil et les sédiments côtiers de la Méditerranée Sud-Orientale et du Liban. Annales de Géographie, Université Saint Joseph, Volume 2, pp 69-96. • El Kareh G. (1984). Contribution à l'étude des sédiments côtiers du Liban (essaie de corrélation des paramètres granulométriques). Thèse, Institut National Polytechnique de Lorraine, Ecole Nationale Supérieure de Géologie appliquée et de Prospection minière, 607p. • UOB/UNEP/MOE (2013).Environmental Resources Monitoring in Lebanon (ERML) project, Improved Understanding, Management and Monitoring in the Coastal Zone. • Korfali S. I., Al Hakawati N., and Khadra W. (2014).Evaluation of Metals and their Potential Hazard in the Awali River Surface Sediments. Conference Paper, 30th SEGH International Conference. At Newcastle, UK. June 30th, 2014. • Mcheik, A., Fakih, M., Trabulsi, H., Toufail, J., Hamieh, T., Garnier-Zarli, E., Bousserrhine, N. (2015). Metal Pollution Assessment of Sediment and Water in Al-Ghadir River: Role of Continuously Released Organic Matter and Carbonate and Their Purification Capacity. International Journal of Environmental Monitoring and Analysis3(3): 162-172. • Ghanem, C., Mahfouz, C., Khalaf, G., Najjar, E., El-Zakhem, H., and anneh, R. (2016).Pb, Cd and Cu Distribution and Mobility in Marine Sediments from two Ports in Lebanon: Beirut Army Naval Port and Tripoli Fishing Port.Lebanese Science Journal, Vol. 17, No. 1, 2016 57.	Dams construction on several Lebanese rivers is aiming to prevent the natural interaction between rivers and the sea for the benefit of beach replenishment and biological productivity. This, coupled with extreme coastal artificialization through sea-filling activities is leading to extensive disturbance in the sediment intake of beaches that is translated into erosion and disequilibrium in coastal dynamics including nutrient transport. Sediments deposited in rivers and washing into coastal areas seldom lead to beach construction since most of these sediments are not of the proper size and shape to replenish eroded beaches. In addition, this type of sedimentation highly affects coastal and marine fauna and flora. Due to the lack of infrastructure and proper management of urban/domestic, industrial and agricultural effluents, most of these land-based sources of pollution will find their way to waterways and eventually to coastal waters and habitats. In a recent study, Pb, Cd and Cu concentrations indicated the wide dispersion of the pollutants in the sediments of Beirut Army	Pollution for offshore petroleum activities may affect sediments quality.	Not enough baseline data to determine evolution

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Jabali, Y., Millet, M., El Hoz, M.(2017). Determination of 48 pesticides in water by using DI-SPME coupled with GC/MS15th International Conference on Environmental Science and Technology - Rhodes, Greece, 31 August to 2 September 2017.	Naval Port And Tripoli Fishing Port; the highest values were detected inside the ports.		
Physical characteristics of seawater (i.e.: T, Salinity, density, transparency and colour)	• Ecodit (2015). Strategic Environmental Assessment for the New Water Sector Strategy for Lebanon. • UOB/UNEP/MOE (2013).Environmental Resources Monitoring in Lebanon (ERML) project, Improved Understanding, Management and Monitoring in the Coastal Zone. • Korfali S. I., Al Hakawati N., and Khadra W. (2014).Evaluation of Metals and their Potential Hazard in the Awali River Surface Sediments. Conference Paper, 30th SEGH International Conference. At Newcastle, UK. June 30th, 2014. • Mcheik, A., Fakih, M., Trabulsi, H., Toufail, J., Hamieh, T., Garnier-Zarli, E., Bousserrhine, N.(2015). Metal Pollution Assessment of Sediment and Water in Al-Ghadir River: Role of Continuously Released Organic Matter and Carbonate and Their Purification Capacity,International Journal of Environmental Monitoring and Analysis3(3): 162-172. • Jabali, Y., Millet, M., El Hoz, M.(2017). Determination of 48 pesticides in water by using DI-SPME coupled with GC/MS15th International Conference on Environmental Science and Technology - Rhodes, Greece, 31 August to 2 September 2017. • MoE/UNDP/ECODIT, (2011).State and trends of the Lebanese environment 2010.Beirut Lebanon.	Salinity fluctuate between 39.25 PSU in April and 39.75 PSU in September. Averages of sea water surface temperature vary from a minimum of 17 °C in February to a maximum of 30°C in August. The Levantine Basin is known to be oligotrophic and is characterized by the succession of two annual thermal phases: cold phase in Winter and warm phase in Summer, separated by two short inter-seasonal periods in Spring and Autumn.	These characteristics can affect movement of spills and hydrocarbons Offshore petroleum activities may affect physical water characteristics	Not enough baseline data to determine evolution

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Hilal, N., Fadlallah, R., Jamal, D., El-Jardal,i F. (2015).K2P Evidence Summary: Approaching the Waste Crisis in Lebanon: Consequences and Insights into Solutions.Knowledge to Policy (K2P) Center. Beirut, Lebanon. • Abbas, I., Chaaban, J., Al-Rabaa, A.R., Shaar, A. (2017).Solid Waste Management in Lebanon: Challenges and Recommendations. Journal of Environment and Waste Management Vol. 4(3), pp. 235-243. • Fallah, R., Olama, Z., Holail, H. (2016). Marine Quality Assessment of Northern Lebanese Coast: Microbiological and Chemical Characteristics and their Impact on the Marine Ecosystem. International Journal of Current Microbiology and Applied Sciences.			
Chemical characteristics of seawater		Several sources of pollution affect water quality in the Eastern Mediterranean Sea including Lebanon, ranging from river discharge, to industrial effluent, to untreated wastewater amongst others. Increasing values of pollution in seawater over the years was reported especially in front of major coastal cities of Lebanon, thus reflecting the negative impact of anthropogenic sources (discharge of untreated sewage, solid waste, port activities, etc.).	Pollution from offshore, coastal and onshore petroleum activities may affect water quality.	Not enough baseline data to determine evolution
Nutrienets				

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
Phyto-planktons and Zoo-planktons	Phytoplanktons • Lakkis, S. (2011). "Le phytoplancton marin du Liban (Méditerranée orientale): biologie, biodiversité, biogéographie." Aracne, Roma. • MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016. • Abboud-Abi Saab, M. (2012). Marine biodiversity in coastal waters. National Centre for Marine Sciences, National Council for Scientific Research, Batroun, Lebanon • Ouba, A., Abboud-Abi Saab, M., Stemmann, L. (2016). Temporal Variability of Zooplankton (2000-2013) in the Levantine Sea: Significant Changes Associated to the 2005-2010 EMT like Event PLOS ONE. DOI:10.1371/journal.pone.0158484. • Khalaf, G. and Fakhri, M. (2017). Biodiversity in the Eastern Mediterranean Sea, including its impact on aquatic animal health in the Middle East, CNRS. Istanbul, Turkey • Piante C., Ody D. (2015). Blue Growth in the Mediterranean Sea: the Challenge of Good Environmental Status. MedTrends Project. WWF-France. 192 pages. Zooplankton • MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016.	**Phytoplanktons:** Due to the physical characteristics of the Lebanese coast, the seawater shows a highly diversified plankton community contrasting with poor plankton biomass. Special attention has been given lately to toxic and alien species and their relationships with environmental conditions. Every year, new alien species are recorded in the Mediterranean and the introduction rate is expected to increase in the future due to factors such as the enlargement of the Suez Canal, increased maritime transport (ballast water, fouling organisms), climate change, and aquarium pet trade. **Zooplankton:** This group comprises most of marine zoological groups like protozoans and chordates. It is the most studied group of plankton in Lebanese waters where they have been monitored for the last 35 years (1969-2004). Their ecology is affected by the hydrological, hydro-biological and physical/chemical characteristics of the water they inhabit. Certain species are considered as biological indicator species and are therefore of particular ecological importance.	Induced pressure from E&P may lead to increased risks of eutrophication and changes in composition of phyto and zoo-plankton population Risk of invasive species from platforms and vessels	The research, knowledge and conservation measures are expected to improve as per the following targets of the NBSAP: • Target 1: By 2030, the status of 75% of known flora and fauna species is identified and conservation actions are implemented on 50% of threatened species • Target 11: By 2030, effective measures are in place to control the introduction and diffusion of Invasive Alien Species (IAS) into the Environment • Target 15: By 2030, research on biodiversity is improved in

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Khalaf, G. and Fakhri, M. (2017). Biodiversity in the Eastern Mediterranean Sea, including its impact on aquatic animal health in the Middle East, CNRS. Istanbul, Turkey • Lakkis, S., Novel-Lakkis, V., and Zeidane, R. (2011). Le zooplancton marin du liban (méditerranée orientale): biologie, biodiversité, biogéograhie. Publications de L'Université Libanaise. • Abboud-Abi Saab, M. (2012). Marine biodiversity in coastal waters. National Centre for Marine Sciences, National Council for Scientific Research, Batroun, Lebanon	In total more than 780 species are reported in the Lebanese waters, 220 of those being Microzooplankton and 563 Macrozooplankton. Special attention has been given to alien species and their relationships with the surrounding environment. Every year, new alien species are recorded in the Mediterranean and the introduction rate is expected to increase in the future due to factors such as the enlargement of the Suez Canal, increased maritime transport (ballast water, fouling organisms), climate change, aquarium pet trade. Bacterioplankton are minute heterotrophic and autotrophic bacteria ranging in size from 0.02 µm to 2 µm while viroplankton that are considered a relatively new discovery, range from 0.02 µm to 0.2 µm in size and are thought to be most photosynthetic organisms in early biomass production. No reports or publications related to these two groups were found for Lebanese marine waters.		Lebanon, and research outputs and biodiversity related reports are shared through a centralized platform (from both public and private institutions), which is updated and made accessible to the public (CHM)
Benthos	Marine Macroalgae: • Bianchi, C.N. and Morri, C. (2000). "Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research." Marine pollution bulletin 40.5 (2000): 367-376.	Lebanon's varied benthic biodiversity allows it to allocate habitats to many groups of phytobenthos and zoobenthos. Many of the species though are unknown with some attention being paid to few groups like Sponges, Cnidaria, Nemerta,	Induced pressure from E&P may lead to changes in composition of phyto and zoo-	The research, knowledge and conservation measures are expected to improve

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Bitar G. (2010). La flore marine benthique introduite de la cote Libanaise: état actuel de trois espèces envahissantes. BAE Conference-INOC, Lattakia, Syria, 107-115. • Kanaan, H., and Belous, O. (2016).Marine Algae of the Lebanese Coast.Hauppauge, New York: Nova Science Publishers. Angiosperm/Phanerogames: • Bitar G. (2010). La flore marine benthique introduite de la cote Libanaise: état actuel de trois espèces envahissantes. BAE Conference-INOC, Lattakia, Syria, 107-115. • Kanaan, H., and Belous, O. (2016).Marine Algae of the Lebanese Coast.Hauppauge, New York: Nova Science Publishers. • MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016. • Kouyoumjian H. and Hamze M. (2012). Review and Perspectives of Environmental Studies in Lebanon.INCAM-EU/CNRS Lebanon pp 328. Meiofauna: • Mouawad R. 1, Daou C. , Khalaf G. , Hage K. and Lteif M., (2014). The Study of Meiofaunal Communities on Lebanese Snady Beaches and Evaluation of Water Quality. INOC-CNRS, International Conference on "Land-Sea Interactions in the Coastal Zone" Jounieh - LEBANON, 06-08 November – • Kouyoumjian H. and Hamze M. (2012). Review and Perspectives of Environmental Studies in Lebanon.INCAM-EU/CNRS Lebanon pp 328	Polychaetes, Sipunculiens, Mollusks, Brachiopoda, Crustacea, Echinoderma, Asidies. Nevertheless, the Mediterranean Sea accounts for 18% of the world's benthic biodiversity. For a sea that encompasses only 0.32% in volume of the world ocean, there are various reasons why the species biodiversity is high. • The Mediterranean Sea has been more intensively studied than almost any other sea,; • Its tormented geological history that led to a rate of environmental change and species occurrence,; and • the current variety of climatic and hydrologichydrological situations that are found in the Mediterranean yield temperate and subtropical biota (Marine biodiversity in the med sea). **Macroalgae** • Studies on macroalgae along the Lebanese coast are fairly limited. Many studies reported on the biodiversity of macroalgae from 1976 up to this day. • In the earlier years, around 200 species were described, followed by more than 230 species in a more recent studies. All studies agreed on the fact that the	benthic population and increase the risk of invasive species from platforms and vessels. Nevertheless steel structured platform will be an artificial reef and therefore an increase in the density of certain species might occur by colonizing the new created habitat.	as per the following targets of the NBSAP: • Target 1: By 2030, the status of 75% of known flora and fauna species is identified and conservation actions are implemented on 50% of threatened species • Target 15: By 2030, research on biodiversity is improved in Lebanon, and research outputs and biodiversity related reports are shared through a centralized platform (from both public and private institutions), which is updated and made accessible to the public (CHM)

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Abboud-Abi Saab, M. (2012). Marine biodiversity in coastal waters. National Centre for Marine Sciences, National Council for Scientific Research, Batroun, Lebanon Macrofauna: • Abboud-Abi Saab, M. (2012). Marine biodiversity in coastal waters. National Centre for Marine Sciences, National Council for Scientific Research, Batroun, Lebanon • Khalaf, G. and Fakhri, M. (2017). Biodiversity in the Eastern Mediterranean Sea, including its impact on aquatic animal health in the Middle East, CNRS. Istanbul, Turkey	impact of pollution on their abundance created a negative outcome. At present, certain alien species forming permanent populations are competing with native species and colonizing their habitats. **Angiosperm /Phanerogames** • Marine seagrasses form a unique ecological entity; however, they encompass various taxonomic groups. • In coastal waters, the occurrence of Monocotyledone is a rare scarcity. Among the marine flora, three species of Phanerogams (Cymodocea nodosa, Halophila stipulacea and Zostera nana) occupy Lebanese coastal waters, especially sandy bottoms, especially in the Chekka area. • They provide keyforming meadows. These meadows are considered of great importance as breeding and feeding grounds for an array of marine species. **Meiofauna** • Meiofauna are described as motile organisms that can move within sediments. Their presence of meiofauna is an indicator of the health or pollution of its respective environment.		

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		• The CNRS conducted a study in 2011 on meiofaunal communities in Antelias looking at physicochemical and biological parameters within the study group. The study shows a significant difference in the number of diversity of the meiofaunal taxa. The count of nematodes, surpassing 1000 individuals/cm², in a polluted station in Antelias contradicts the results found in Ramle al Bayda and Sidon at 60 individuals/10cm² and 128 individuals/cm² respectively. • These results are great indicators of the water quality of the studied environment with respect to the species abundance of nematodes. Meiofauna and the quality of the water column are directly correlated. **Macrofauna** Throughout a campaign done between 2012 and 2016 using a Remotely Operated Underwater Vehicle (ROV) on the CANA research boat with the collaboration of the CNRS, the biodiversity of macrobenthos was mapped. The findings represent 430 different species of which 75 flora counts, 14 fauna of invertebrates, 99 species of molluscs, 82 species of polychaetes, 45		

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		species of crustaceans, 44 species of sponges and 22 species of cnidarians.		
Marine Ichtyofauna	• Kouyoumjian H. and Hamze M. (2012). Review and Perspectives of Environmental Studies in Lebanon.INCAM-EU/CNRS Lebanon pp 328 • Lteif M.(2015). Biology, distribution and diversity of cartilaginous Fish species along the Lebanese Coast, eastern Mediterranean (Universitie de Perpignan).	Ichtyofauna in Lebanon and Eastern Mediterranean is constantly changing due to Lessepsian migration. Every year, new species are recorded in the Mediterranean and the migration rate is expected to increase with the new expansion of the Suez Canal. Lebanese Ichtyofauna includes 357 species comprising 44 Chondrichthyes. Nevertheless, a recent study on Chondrichthyian along the Lebanese coast narrowed down the list from 44 to 25 species. It is believed that at present, this is the most comprehensive and realistic list of Chondrichthyes. On the other hand, for Osteichthyes, no revised checklist is currently available. Every year, new alien species are recorded in the Mediterranean and the introduction rate is expected to increase in the future due to factors such as increased maritime transport (ballast water, fouling organism), climate change, aquarium pet trade.	Induced pressure from E&P activity may lead to disturbance of the trophic levels and therefore may alternate the fish population. Nevertheless steel structured platform will be an artificial reef and therefore an increase in the density of certain species might occur.	The research, knowledge and conservation measures are expected to improve as per the following targets of the NBSAP: • Target 1: By 2030, the status of 75% of known flora and fauna species is identified and conservation actions are implemented on 50% of threatened species • Target 15: By 2030, research on biodiversity is improved in Lebanon, and research outputs and biodiversity related reports are shared through a centralized platform (from both public and private

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
				institutions), which is updated and made accessible to the public (CHM)
Sea mammals	• MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016. • MoE/IUCN (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marinehabitats and species in Lebanon. Beirut, Lebanon,Gland, Switzerlandy Malaga, Spain: the Lebanese Ministry of Environment / IUCN. 64 pp. • Khalaf, G. and Fakhri, M. (2017). Biodiversity in the Eastern Mediterranean Sea, including its impact on aquatic animal health in the Middle East, CNRS. Istanbul, Turkey • Abboud-Abi Saab, M. (2012). Marine biodiversity in coastal waters. National Centre for Marine Sciences, National Council for Scientific Research, Batroun, Lebanon • Mytilineou et al. (2016) New Mediterranean Biodiversity Records (November, 2016). Mediterranean marine science 17(3): 794-821, 10.12681/mms.1976 • Ramadan-Jaradi, G. (2017). Mediterranean Monk Seal – Baseline Study.Society for the Protection of Nature in Lebanon.14 p.p.	Dolphin species are the most represented in the Lebanese water. Previously, occurrence of some of these species in Lebanon was probably inferred based on their presence in adjacent Mediterranean waters, rather than on confirmed local sightings. Nevertheless, and due to the signature ACCOBAMS Agreement in 2004, regular and systematic work began. Among the three orders of marine mammals, studies have shown that dolphins are the most represented with 7 species recorded in the country: Short-beaked common dolphin (*Delphinus delphis*), Common bottlenose dolphin (*Tursiops truncates*), fin whale (*Balaenoptera physalus*), Cuvier's beaked whale (*Ziphius cavirostris*), Risso's dolphin (*Grampus griseus*), Striped dolphin (*Stenella coeruleoalba*). The only species of seals present in Lebanon is the Mediterranean monk seal (*Monachus monachus*). *Several scientific records and confirmed sightings (n = 25, from 2003 to 2016), corroborated by photos and videos, have*	E&P activities and particularly seismic surveys can lead to behavior changes or auditory trauma to sea mammals and turtles In addition, vessels activity will increase the risk of collision with these species. Structures lighting and oil spills could have impacts on sea birds.	The research, knowledge and conservation measures are expected to improve as per the following targets of the NBSAP: • Target 1: By 2030, the status of 75% of known flora and fauna species is identified and conservation actions are implemented on 50% of threatened species • Target 15: By 2030, research on biodiversity is improved in Lebanon, and research outputs and biodiversity related reports are shared through a centralized

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		been reported from the Lebanese coastline and has lead to the re-evaluation of the status of Monachus monachus in the country (Mytilineou et al., 2016).		platform (from both public and private institutions), which is updated and made accessible to the public (CHM)
Marine Herpetofauna	• MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016. • Cross, H., Rizk, C., Khalil, M. and Venizelos, L. (2006). Population Status and Conservation Activities on Sea Turtle Nesting Beaches in South Lebanon, 2005. Retrieved from http://www.seaturtle.org/PDF/CrossH_2006_BCGFFEMMEDASSETMEDWESTCOASTMELRACSPAUNEPMAPUNDPTechReport.pdf • MoE/IUCN (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marinehabitats and species in Lebanon. Beirut, Lebanon,Gland, Switzerlandy Malaga, Spain: the Lebanese Ministry of Environment / IUCN. 64 pp. • Hraoui, B.-S., Sadek, R., Sindaco, R. & Venchi, A.(2002). The herpetofauna of Lebanon: new data on distribution.Zoology in the Middle East 27, pp. 35-46	There are relatively few reptiles that are apt to life in a marine environment. Three species of marine turtles are found in Lebanese waters: the Loggerhead turtle (Caretta caretta), the Green turtle (Chelonia mydas) and the Leatherback turtle (Dermochelys coriacea). The Loggerhead and Green sea turtles nest on Lebanese sandy shores while the Leatherback turtle is just a visitor to the Mediterranean Sea. In addition, the Hawksbill Sea turtle (*Eretmochelys imbricate*) is considered as vagrant and is very rarely recorded in the Eastern Mediterranean; also another species of turtles, the Nile softshell turtle (*Trionyx triunguis*) is also recorded in Lebanese waters. Even though it is a large fresh water turtle, it has been found in saline coastal waters at the mouth of rivers. These reptiles are under severe pressure due to mortality by catch in fishing nets, floating solid waste, and/or by the		The research, knowledge and conservation measures are expected to improve as per the following targets of the NBSAP: • Target 1: By 2030, the status of 75% of known flora and fauna species is identified and conservation actions are implemented on 50% of threatened species • Target 15: By 2030, research on biodiversity is improved in Lebanon, and research outputs and biodiversity related reports are

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		destruction of their nesting habitats on sandy beaches.		shared through a centralized platform (from both public and private institutions), which is updated and made accessible to the public (CHM)
Marine Ornithofauna (Seabirds)	• MoE/UNEP/GEF (2016). National Biodiversity Strategy and Action Plan – NBSAP • Ramadan-Jaradi, G.., Ramadan-Jaradi, M. & Bara, T. (2008). The revised checklist of the birds of Lebanon (Sandgrouse 30 (1) 22-69. • BirdLife International (2018) Country profile: Lebanon. Available from http://www.birdlife.org/datazone/country/lebanon. Checked: 2018-07-17 • MoE/GEF (2016). Updating the 2002 SAP-BIO National Report for the Country of Lebanon. Prepared by Nader M., and Talhouk S. May 2016. • MOE/UNDP/GEF, (2014). State of and IBAs Lebanon's Birds. By SPNL, 153 pp. • Codina-García, M., Militão, T., Moreno, J. González-Solís, J. (2013). Plastic debris in Mediterranean seabirds. Marine Pollution Bulletin. 77: 220–226. DOI: 10.1016/j.marpolbul.2013.10.002. • Ramadan-Jaradi, G. (2017). Status and distribution of migrating and breeding Marine birds in North Lebanon. Lebanese Science Journal. Vol. 18, No. 2: 156-165.Robalino, D., & Sayed, H. (2012). Lebanon: good jobs needed. World Bank.	Lebanon is considered as a bottle-neck along a major flyway route for birds twice per year and is located on one of the world's key migratory bird corridors. • According to a study conducted by Ramadan-Jaradi et al. (2008) 395 species in total have been recorded in the Country including 186 coastal and marine species observed near the coast of which 144 have marine affinity . • According to the IUCN Red List, Lebanon hosts bird species of international significance, with 2 being endangered, 8 vulnerable, and 17 near threatened • Numbers of coastal and marine bird species have not changed between 2002 and 2016.	Structures lighting and oil spills could have impacts on sea birds.	The research, knowledge and conservation measures are expected to improve as per the following targets of the NBSAP: • Target 1: By 2030, the status of 75% of known flora and fauna species is identified and conservation actions are implemented on 50% of threatened species • Target 15: By 2030, research on biodiversity is improved in Lebanon, and research outputs

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
				and biodiversity related reports are shared through a centralized platform (from both public and private institutions), which is updated and made accessible to the public (CHM)
Important Biodiversity Areas	• MoE/IUCN (2012). Lebanon's Marine Protected Area Strategy: Supporting the management of important marinehabitats and species in Lebanon. Beirut, Lebanon,Gland, Switzerlandy Malaga, Spain: the Lebanese Ministry of Environment / IUCN. 64 pp. • RAMSAR Convention on Wetlands	**- Existing MPAs declared by law are:** 1. Palm Islands Nature Reserve (PINR) 2. Tyre Coast Nature Reserve (TCNR) **- Proposed MPAs include:** 1. Nakoura; 2. Sidon Rocks; 3. Raoucheh Cliffs and Caves; 4. Beirut Port Outer Platform; 5. Byblos; 6. Medfoun Rocky Area; 7. Batroun Phoenician Wall; 8. Ras El Chekaa Cliffs ; 9. Enfeh Peninsula ; 10. Litani Estuary ; 11. Awally Estuary; 12. Damour Estuary; 13. Nahr Ibrahim Estuary ; 14. Areeda Estuary; **- OCEANA (2010) proposed 4 sites in deep water inside Lebanon's territorial waters:** 1. Beirut Escarpment, 2. Saint Georges Canyon, 3. Junieh Canyon and 4. Sour Canyon.	Declared MPAs pose restrictions to E&P activities. Protection and preservation of declared and proposed MPAs should be taken into consideration in any offshore/onshore activity.	Coverage of protected areas and preservation of characteristics of MPAs and proposed MPAs are expected to increase as a result of: • NBSAP, Target 4: By 2030, at least 20% of natural terrestrial and marine ecosystems are protected and all types of ecosystems are represented in the PA network • NBSAP, Target 6: By 2030, 50% of all natural ecosystems are sustainably

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		- ERML's priority ranking: Fifteen sensitive sites scored as high priority for protection and were mapped as follows: eight ecological sites; three cultural sites; and four clustered ecological and cultural sites.		managed and properly considered in spatial planning implementation • SDGs, Target 14.5: By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
Areas of special significance (coastal)		1. Aarqa river estuary (MOE, Decision no. 188/1998) 2. Terraces and Beach of southern Tripoli towards Qalamoun (Decree No. 3362/1972) 3. El Jawz River estuary (MOE, Decision no. 22/1998) 4. Batroun National Marine Hima at the National Centre for Marine Sciences (MOA, Decision no. 129 of 1991) 5. Ibrahim River estuary (and archaeological sites (MOE, Decision no. 34/1997)	Restricted areas for E&P activities	Coverage of protected areas and preservation of characteristics of MPAs and proposed MPAs are expected to increase as a result of: • NBSAP, Target 4: By 2030, at least 20% of natural terrestrial and marine ecosystems are protected and all

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		6. Coastal Front Rocks and terraces of Wata Slim (Tabarja)(MOE, Decision no. 200/1997) 7. El Kelb River estuary and historical site (MOE, Decision no. 97/1998) 8. Beirut River estuary (MOE, Decision no. 130/1998) 9. Awally river estuary (MOE, Decision no. 131/1998; CDR/DAR/IAURIF, 2005)		types of ecosystems are represented in the PA network • NBSAP, Target 6: By 2030, 50% of all natural ecosystems are sustainably managed and properly considered in spatial planning implementation • SDGs, Target 14.5: By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information
Fisheries and fish resources	• Majdalani S. (2005). Census of Lebanese fishing vessels and fishing facilities. Ministry of Agriculture, Lebanon.144 p. • Pinello D., and Dimech M. (2013). Socio-Economic Analysis of the Lebanese Fishing Fleet.GCP/INT/041/EC – GRE – ITA/TD-16.	Lebanese fisheries are artisanal or traditional in nature, with the country's coastal waters containing more than 80 fish species being of commercial importance.	E&P activities may impact fish catch in important reproduction zones.	The Fish catch is expected to increase as a result of the proposed fishing Law, extending fishing grounds to 12 nautical miles.

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• Nader, M., Indary, S. and Moniri, N.R. (.(2014). Historical Fisheries Catch Reconstruction for Lebanon (GSA 27), 1950-2010. UoB and UoBC Fisheries Center. Vancouver, Canada • Nader, M., Indary, S., and Stamatopoulos C. (2012).Assessment of the commercial fish species of the coast of north Lebanon 2006-2011.International Conferences on "Land-Sea Interactions in the Coastal Zone", November, 2012, Lebanon. • Kouyoumjian H. and Hamze M. (2012). Review and Perspectives of Environmental Studies in Lebanon.INCAM-EU/CNRS Lebanon pp 328. • Boustany, L., Indary S. and Nader, M. (2015).Biological characteristics of the lessepsian pufferfish Lagocephalus sceleratus (gmelin, 1789) off Lebanon.Cahier de Biologie Marine 56 : 137-142. • Khalaf G, Saad A., Jemaa S., Sabour W., M. and Lelli S. (2014). Population Structure and Sexual Maturity of the Pufferfish Lagocephalus sceleratus (Osteichthyes: Tetraodontidae) in the Lebanese and Syrian Waters (Eastern Mediterranean). Journal of Earth Science and Engineering, 4 : 236-244. • Bariche M., Sadek R. and Azzurro E. (2009). Fecundity and condition of successful invaders: Siganus rivulatus and S. luridus (Actinopterygii: Perciformes: Siganidae) in the Eastern Mediterranean. Acta Ichthyologica et Piscatoria, 39 (1): 11-18. • Bariche, M., Sadek, R., Al-Zein, M., El-Fadel, M. (2007). Diversity of juvenile fish assemblages in the pelagic waters of Lebanon (eastern	Fishing usually occurs to a maximum depth of up to 200 m, while most activities take place at an average depth of 50 m. The main gears include trammel nets, gill nets, long lines, purse seine nets (lampara) and beach seines (Majdalani, 2005). The number of licensed fishing vessels in 2015 stood at 2005 boats operating from 44 fishing harbors and landing sites along the entire Lebanese coastline. Lebanon also relies heavily on imported fish with around 20,100 tons/ year of demand with an average of 6.03 kg per capita/year Due the importance of the fisheries sector and in order to improve the fishermen's wellbeing, several initiatives were launched addressing the problems plaguing the sector: • Catch/Effort initiatives • Biological parameters and stock assessment initiatives • Socio-Economic initiatives • Capacity building and Awareness initiatives • Management initiative	Pollution from E&P activities may affect fish	

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	Mediterranean).Hydrobiologia, Volume 580, Number 1, April 2007 , pp. 109-115(7).			
Seismicity (earthquakes & tsunamis)	• Khair, K G.F. Karakaisis, and E.E. Papadimitriou, Seismic Zonation of the Levant (Dead Sea) Transform Fault area, Ann. Geofis., 43, 61-79, 2000 • Ghalayini, R., Nader, F.H., Bou Daher, S., Hawie, N. and Chbat, W.E. (2018). Petroleum Systems of Lebanon: An Update and Review. Journal of Petroleum Geology, Vol. 41(2). pp 18-214 • United States Geological Survey (USGS) earthquake hazard program (website). • Huijer et al., 2011. Upgrading the seismic hazard of Lebanon in light of the recent discovery of the offshore thrust system.	• The most recent earthquake that occurred in Lebanon was on June 29, 2016 at around 19 km WSW of Beirut. This earthquake had a magnitude of 3.7 on the Richter scale and occurred at a depth of 13.8 km below the surface • Lebanon is a country of moderate to high seismic hazard and that the expected Peak Ground Acceleration (PGA) with a 10% probability of exceedance in 50 years varies mostly between 0.20 g and 0.3 g.	Potential impact on drilling and production facilities as well as health and human life. Potential impact on the environment in case of event causing disruption to operation and destruction of facilities leading to potential spills.	
Gas Hydrates	• Praeg et al. 2011. THE MEDITERRANEAN SEA: A NATURAL LABORATORY TO STUDY GAS HYDRATE DYNAMICS?	• The thickness of the stable gas hydrate zone can reach up to 150-200 m offshore Lebanon. • It was reported that in the southern part of the Levant Basin, the predicted existence of methane hydrates stability zone (MHSZ) in the seafloor sediments at water depths 1.2 km can	Potential hazard on drilling operations safety	

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		have a thickness ranging between 1 and 600 m.		
Overpressured Zones	• Garziglia, S., Migeon, S., Ducassou, E., Loncke, L. and Mascle, J. (2008). Marine Geology, 250 (2008), pp 180–198. • Bertoni, C., Cartwright, J., Messinian evaporites and fluid flow, Marine and Petroleum Geology (2015), doi: 10.1016/j.marpetgeo.2015.02.003. • Garfunkel, Z., 1984. Large-scale submarine rotational slumps and growth faults in the eastern Mediterranean. Mar. Geol. 55, 305–324 • Ghalayini et al, 2018. PETROLEUM SYSTEMS OF LEBANON: AN UPDATE AND REVIEW • Mascle et al., 2014. istribution and geological control of mud volcanoes and other fluid/free gas seepage features in the Mediterranean Sea and nearby Gulf of Cadiz • Gvirtzman, Z., Reshef, M., Buch-Leviatan, O., Ben-Avraham, B., 2013. Intense salt deformation in the Levant Basin in the middle of the Messinian Salinity Crisis. Earth and Planetary Science Letters 379, 108–119 • Kopf A (2002) Significance of mud volcanism. Rev Geophys 40(2):1± 51. doi:10.1029/2000RG000093 • Gontharet, S., Pierre, C., Blanc-Valleron, M.M., Rouchy, J.M., Fouquet, Y., Bayon, G., 621 Foucher, J.P., Woodside, J., Mascle, J., the Nautical scientific party, 2007. Nature 622 and origin of the diagenetic carbonate crusts and concretions from mud volcanoes 623 and pockmarks of the Nile deep-sea fan (eastern	• One of the early interpretations suggested that the high reflectivity layers within the salt to be overpressurized clastics • Gas chimneys and pockets were observed through interpretation of seismic data acquired offshore Lebanon • The eastern basins of the Mediterranean Sea are the sectors where mud volcanoes and related fluid expulsion features are the most abundant.	Potential hazard on drilling operations safety if not prepared for.	

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	Mediterranean sea). Deep-Sea 624 Research part II, in press. • Judd & Hovland, 2007. Seabed Fluid Flow: The Impact on Geology, Biology and the Marine Environment			
Submarine Landslides	• Urgeles and Camerlenghi, 2013. Submarine landslides of the Mediterranean Sea: Trigger mechanisms, dynamics, and frequency-magnitude distribution. • J. Frey-Martínez, J. Cartwright, B. Hall3D seismic interpretation of slump complexes: examples from the continental margin of Occupied Palestine Basin Res., 17 (2005), pp. 83-108	447 small to medium submarine landslides and numerous fault scars exposed on the surface of the continental slope of eastern Mediterranean were mapped in the southern part of the Levant Basin.	The major hazards related to submarine landslides include destruction of seabed infrastructure, collapse of coastal areas into the sea and landslide-generated tsunamis.	
Population, demographics and living conditions	• MoPH (2016). Statistical Bulletin 2016. Ministry of Public Health. Retrieved from https://www.moph.gov.lb/en/Pages/8/327/statistical-bulletins • MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon. • UNRWA (2015). Relief and Social Services Registration records. United Nations Relief and Works Agency. • CAS/WB (2015). Measuring poverty in Lebanon using 2011 HBS.	Total Lebanese population estimate is 4.3 Million. Total displaced persons from Syria is around 1.5 Million. Total of Palestine displaced persons in around 495,985 Average population growth rate is 1.5% Age segregation: 27.4% of Lebanon's resident population is youth; aged between 15-29 years. Life expectancy at Birth: 81.2 years	Creation of job opportunities Enhanced education Enhanced living standards	As per the commitment to the SDGs indicators related to poverty, government spending on essential services and Unemployment are expected to improve, however, this is subject to the

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• CMU (2014). Characteristics and Features of NPTP Extreme Poor Lebanese House Holds. Frist Statistical Report of the NPTP. The Central Management Unit. The Council of Ministers, Lebanon. • UNDP (2015). Spotlight on Youth in Lebanon. Beirut, Lebanon. • GoL/UN (2018). Lebanon Crisis Response Plan. Government of Lebanon and the United Nations. January 2018. Retrieved from http://www.LCRP.gov.lb	2,871 schools, one public university and 47 private universities in addition to vocational schools Unemployment rate: about 11% of active population; 21.6% are youth. Around 11% of the labor force is unemployed, unemployment rates are particularly high for women (18 %) and youth (21.6%). According to the draft Economic Vision, unemployment rates could decrease to 8% by 2025 and 6% by 2035. Around 27 to 28.5% of the population were considered poor and were living below 3.884 USD per person per day between 2008 and 2011. While, 10% of the population were extremely poor. This has risen by 6% between 2011 and 2015, after the Syrian crisis in 2011. According to the National Poverty Targeting Program (NPTP), every household living below 3.84$/capita/day is classified as an extreme poor Lebanese households. Until December 2013, a total of 42,703 households were classified as extremely poor.	Increased population pressure Regional migration seeking for jobs	national efforts towards achieving the targets. No exact data on population with university degrees and skills in majors related to petroleum sector and other relevant fields, however, there is a reported increase in majors related to petroleum and environmental sector and other relevant fields

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
Crime	Directorate General of the Internal Security Forces	An increase in the number of annual detainees to reach around 22,300 in 2014-2015.	An increase in crime rates could be recorded as foreign O&G personnel become targets of crime	Based on hitorical trends, crime rates are expected to increse. An increase in crime rate has been witnessed since 2011 particularly in drug-related crime and murder.
Archaeology and Cultural Heritage	• MoE (2006). Protected Areas in Lebanon - Stable Institutional Structure for protected Areas management (SISPAM). Retrieved from http://www.moe.gov.lb/protectedareas/categories.htm • UOB/UNEP/MOE (2013).Environmental Resources Monitoring in Lebanon (ERML) project, Improved Understanding, Management and Monitoring in the Coastal Zone. • DGA (2018) – verbal communication	According to the framework of the Stable Institutional Structure for Protected Areas Management (SISPAM) Project (MoE, 2006), protected areas in Lebanon area generally classified into: 8 Nature Reserves, 24 Natural sites, 5 Himas, 12 Protected Forests, 14 touristic sites, and multitude of sites that is worth protection (Wetlands, Grottos, Holes, Natural Bridges and Rocks, summits, mountains, etc.) The Environmental Resources Monitoring in Lebanon (ERML) project: eight ecological sites; three cultural sites; and four clustered ecological and cultural sites.	Subsea activities and spills may affect archaeological resources	Not enough data to determine the trend without the petroleum sector.
Health	• MoPH (2016). Statistical Bulletin 2016. Ministry of Public Health. Retrieved from https://www.moph.gov.lb/en/Pages/8/327/statistical-bulletins	The main bulk of morbidity and health care costs are burdened by NCDs, namely cardiovascular diseases (CVDs), cancers, respiratory conditions and diabetes. Occurrence of NCDs among males is more	Increased demand for health services Possible increased rates of	Increase in Cancer and Cardiovascular diseases. Stable for diabetes.

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• WEF (2016). The Global Competitiveness Report 2016–2017. The World Economic Forum. ISBN-13: 978-1-944835-04-0. Geneva. • WHO (2014). Noncommunicable Diseases (NCD) Country Profiles 2014. World Health Organization. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/128038/9789241507509_eng.pdf;jsessionid=C7097FC23FF130AC58867DE72F5DFE38?sequence=1 • MoE (2017). Lebanon's National Strategy for Air Quality Management for 2030. Beirut, Lebanon • MoPH (2015). Mental Health and Substance Use-Prevention, Promotion, and Treatment- Situation Analysis and Strategy for Lebanon 2015-2020. Ministry of Public Health. Beirut, Lebanon • MoPH/ WHO (2016). Non Communicable Diseases Prevention and Control Plan (NCD-PCP)- Lebanon 2016-2020. Ministry of Public Health. Beirut, Lebanon.	than females, which has been increasing over the past years. In terms of mental health 25.8% of the population experiences at least one mental disorder at some point in their lives while 10.5% experienced more than one.	morbidity and mortality Safety at work is very important in this industry; need to build safety culture Increase in STDs Increased risks of introduction of eradicated diseases Increased rates of health conditions typical to oil industry (such as trauma, psychological, from handling of radioactive wastes, burns)	Historical evolution (2000-2012) of mortality rates in Lebanon show increase in deaths from cancer and Cardiovascular diseases especially among men. Not enough data to detemrine evolution in chornic respiratory diseases especially after the solid waste crises in 2015.
Tourism	• CAS (2017). Annual Tourism Data per Year from 2010 to 2017. Central Administration of Statistics. Retrieved from www.cas.gov.lb • Bankmed (2017). Analysis of Lebanon's Travel and Tourism Sector. Beirut, Lebanon	Tourism is priority industry for economic development in the country. Around1.9 million tourist arrivals to Lebanon in 2017 which increased since 2012.	Perception of polluting industry reducing attractiveness	Based on historical trends, tourist arrivals are expected to increase (Annual

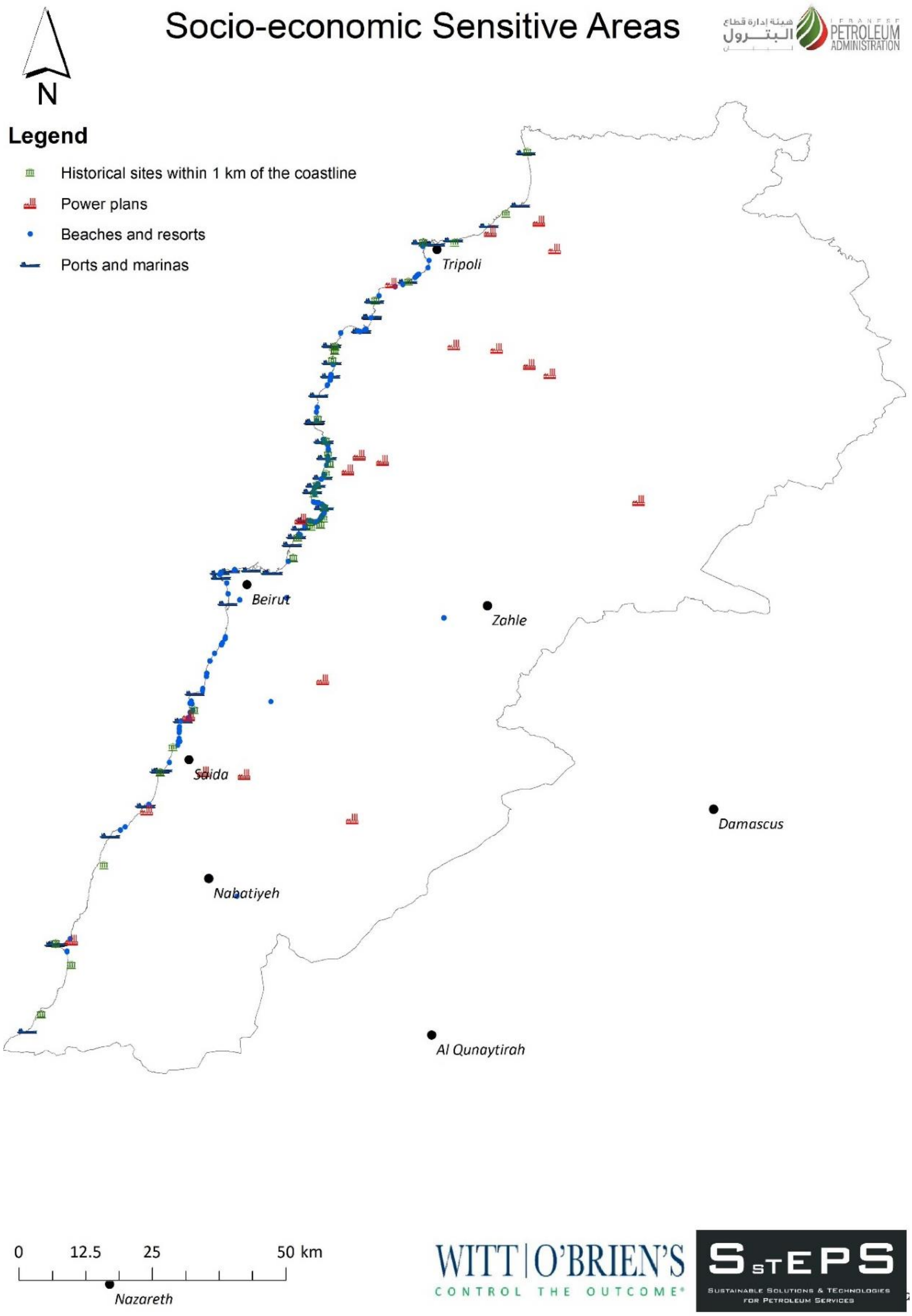
Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• CAS, based on records of General Directorate of General Security	Mostly from Europe (34.5%), Arab countries (30%) and America (17.5%). Tourism infrastructure in terms of accommodation is considered sufficient with an average occupancy rate of Beirut Hotels in 2016 was 59%. Tourism currently contributes 1.6 billion USD to the national GDP (roughly 3% of total GDP) and according to the Economic Vision, tourism contribution to GDP could increase to 3.7 billion USD in 2025 and 5.4 billion USD in 2035. Number of jobs offered by the sector could also increase from around 89,000 in 2017 to 185,000 in 2025 and 211,000 in 2035. Total number of tourists could also increase from the current 1.9 million to 4.2 million in 2035 and 6.5 million in 2035.	of the country as a destination Possible conflict with nautical tourism Opportunity to increase tourism related to workers and staff from Oil companies` Risk of damaging tourism resources from E&P activities Restriction of oil and gas activities location on-shore to minimize interference with tourism industry	tourist arrivals on the increase since 2014)
Econom y	• MoE/UNDP/GEF (2017). Lebanon's second biennial update report to the UNFCCC. Beirut, Lebanon	The Lebanese economy has been witnessing a reduction in growth since 2004	Increased revenues from	GDP growth rate is expected to increase due to

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
	• IoF (2018). Citizen Budget Report. The Institut des Finances Basil Fuleihan. Ministry of Finance. Beirut, Lebanon. • CAS (2016). National Accounts 2004-2015. Central Administration of Statistics, Lebanon,	due to political and security uncertainties. In more recent years, this has been accelerated by the Syrian crisis which increased the pressure on Lebanon. GDP growth dropped to 0.9% in 2011. It increased to 2.8% in 2012, slowed again in 2013 with a drop to 2.6% and 2% in 2014 to reach 0.8% in 2015 before increasing again as of 2016. GDP in 2016: 74,560 Billion LBP or 49.45 Billion USD In 2015, percent share of GDP of economic activities was: Agriculture/ Forestry and Fisheries: 3% GDP; Manufacturing: 8% GDP; Utilities & Mining: 3% GDP ;Construction & Real Estate: 19% ; Wholesale and Trade: 13%; Transport and vehicles repair: 4%; Hotels & restaurants: 4%; Information & communication: 2%; Public administration:9%; Education: 5%; Health & social care: 3%; Other Services: 17%; Taxes and Subsidies: 8%; Inflation: about 2.6% Net exports: -20% Deficit in National Budget in 2017 was 5, 205 Billion L.L.	Oil and Gas activities. Potential positive impacts on other economic sectors.	economic improvement, less pressure from the Syrian Crisis and obligation to SDGs.
Infrastructure (ports,	• MoE/URC/GEF (2012). Lebanon Technology Needs Assessment Report for Climate Change. Ministry of Environment. Beirut, Lebanon.	Land transport system mostly reliant on motorized vehicles. Road infrastructure	Increased demand for infrastructure	hese indicators are expected to increase as a result of

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
waterways, airports, roads)	• MoE/UNEP/GEF (2017) - National Implementation Plan on Persistent Organic Pollutants. Lebanon • MoE/UNDP/GEF (2017). Lebanon's second biennial update report to the UNFCCC. Beirut, Lebanon • Bankmed (2015). Analysis of Lebanon's Maritime Market. Beirut, Lebanon • CAS (2016). Monthly Data per Year from 2000 to 2016. Central Administration of Statistics. Retrieved from www.cas.gov.lb • Hulla/CHD (2017). Land Transport Sector Workshop: Land Transport Sector's Strategy and Other Achievements. Ministry of Public Works and Transport. • DGLM (2013). Public Transport Sector in LEBANON Strategy & Pilot Project Implementation. Directorate General of Land & Maritime Transport. Ministry of Public Works & Transport. Presented on October 1, 2013 in France. • Data provide by LPA (2018)	already overloaded and not sufficient to cope with higher loads. One airport located in the capital Beirut. Five commercial Ports that include two main ports: Beirut and Tripoli ports that receive respectively around 65.5% and 27% of incoming ships to Lebanon. Saida, Tyre and Jounieh ports are secondary. New dry dock for vessels in Abdeh Seven ports dedicated for fuel, oil and others. 31 recreational ports. Four main methods to transport petroleum products in Lebanon exist, these are: • Water transport • Pipelines (IPC, TAPLINE, GASYLE) • Road transport • Rail • Or a combination of two or more of the above methods.	including airport, port and road capacity	the implementation of the ISWM policy and implementation of the Public Transport Sector Strategy.
Waste and wastewater management	• Policy on ISWM • MoE/EU/GFA (2017). Assessment of Solid Waste Management Practices in Lebanon in 2015. Support to Reforms – Environmental Governance, Beirut, Lebanon. • MoE/UNEP/GEF (2017) - National Implementation Plan on Persistent Organic Pollutants. Lebanon	Domestic waste generation is 6,500 tons per day or 2,263,000 tons per year. Three existing landfills for waste disposal currently exist in Lebanon. Hazardous solid waste generation rate is 50,000 tons per year including industrial	Increased pressure on waste and wastewater infrastructure	Not applicable if the sector does not exist. However, generally, the absence of heavy industries in Lebanon limits the quantities of

Aspect	Sources of Data	Baseline Conditions	Relation with the Plan	Expected Evolution without the Plan (Secerion 0)
		and medical waste. No existing hazardous waste management facilities. Around 248 million m3 of wastewater is generated daily in Lebanon, only 8% is treated.		produced hazardous waste and radioactive waste. The proper management and recycling are obligations under the national ISWM policy.
Energy Consumption needs in Lebanon	• ILF/UNDP (2018). Cost Benefit Analysis for the Use of Natural Gas and Low Carbon Fuels: Infrastructure Analysis Report. Sustainable Oil and Gas Development in Lebanon (SODEL). • ECA (2017). Lebanon Gas Development Plan- Presentation of Final Recommendations. September 2017. Economic Consulting Associates, UK.	Lebanon relies on imported fossil fuels for energy supply. The power sector uses fuel oil and diesel. The industrial, commercial and the residential sector use oil based products for heating, power generation as well as production processes, while LPG is used for cooking purposes as well as for heating.	The sector will secure power sources for national use.	Renewable energy share in the total final energy consumption is expected to increase after the implementation of the renewable energy policy and obligations to INDC and SDGs. 12% by 2020 (Ref: National RE Action Plan 2016-2020) 15% by 2030 unconditional)/ 20% (conditional) (Ref: INDC by 2030)

APPENDIX B: SOCIO-ECONOMIC SENSITIVE SITES (MOPWT-DGLMT, 2017)



APPENDIX C: LIST OF SPECIES IDENTIFIED DURING OCEANA 2016 EXPEDITION IN THE LEBANESE WATERS

Annex 1

TABLE A1. LIST OF SPECIES IDENTIFIED

Species are listed according to survey area, and to sampling method. (#) Species spotted incidentally from/at the deck of the research vessel; (+) Exotic species; (*) Possible new species; (~) Possible dead coralligenous formations.

CHLOROPHYTA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Caulerpa scalpelliformis +	61.3	82.4			X			X	
Chlorophycea indet.	36.0	483.7		X	X	X		X	
Codium bursa	64.4	64.4			X			X	
Palmophyllum crassum	67.2	67.2				X		X	
Ulva sp.	58.5	58.5				X		X	
Valonia macrophysa	59.9	59.9				X		X	

OCHROPHYTA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Dictyota dichotoma	62.7	71.4			X			X	
Lobophora variegata	49.2	71.4			X	X		X	
Sargassum vulgare	62.7	68.6			X			X	
Zanardinia typus	68.6	68.6			X			X	

RHODOPHYTA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Amphiroa rigida	48.4	63.6				X		X	
cf. Corallinales indet.	59.9	61.3		X				X	
cf. Corallinales indet. (x)	86.6	255.4	X			X	X	X	
Corallinales indet.	36.0	122.6	X	X		X	X	X	X
Lithophyllum sp.	63.0	100.4	X		X			X	
Lithophyllum incrustans	46.1	80.4					X	X	
Lithothamnion sp.	61.3	71.4			X			X	
Mesophyllum lichenoides	63.6	68.9				X		X	
Mesophyllum sp.	36.0	85.5			X	X	X	X	X
Peyssonnelia rubra	66.4	66.4			X			X	
Peyssonnelia sp.	68.3	75.1			X			X	
Peyssonneliaceae indet.	36.0	90.9				X		X	
Phymatolithon calcareum	45.6	71.7			X		X	X	
Phymatolithon sp.	61.6	61.6			X			X	
Rhodophyta indet.	36.3	82.4			X	X		X	
Rhodophyta indet. (dead)	297.0	297.0				X		X	
Rhodymenia sp.	63.6	70.0				X		X	
Spongites fruticulosa	45.6	71.7					X	X	

FORAMINIFERA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Adelosina sp.	76.0	76.0		X					X
Ammodiscus cretaceous	76.0	76.0		X					X
Foraminifera indet.	99.3	102.9	X	X				X	
Heterostegina depressa +	63.0	63.0				X			X
Komokioidea indet.	53.7	175.2		X			X	X	
cf. Komokioidea indet.	61.9	80.7		X				X	
Miniacina miniacea	56.8	344.8	X	X	X	X	X	X	X
Miliolinella subrotunda	63.0	63.0				X			X
Pelosina cf. *arborescens*	53.7	905.0	X	X	X	X	X	X	
Pyrgo inornata	906.0	1015.0			X	X			X
Pyrgo sp.	63.0	63.0				X			X
Quinqueloculina sp.	64.0	76.0		X	X		X		X
Thurammina papillata	63.0	63.0				X			X

PHORONIDA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Phoronis australis	113.9	113.9			X			X	

PORIFERA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Aaptos aaptos	79.9	79.9			X			X	
Agelas oroides	47.0	180.0	X	X	X	X	X	X	
Amphilectus fucorum	64.1	64.1			X			X	
Antho sp.	87.5	96.5	X					X	
Axinella damicornis	36.0	82.1			X	X		X	
Axinella sp.	36.0	298.4	X	X	X	X	X	X	
Axinella sp.*	525.9	525.9			X			X	
Axinella verrucosa	82.1	82.1			X			X	
Biemna variantia	178.3	178.3				X		X	
cf. *Biemna variantia*	122.6	124.0				X		X	
Calyx nicaeensis	78.7	83.2			X			X	
cf. *Chelonaplysilla noevus*	171.3	171.3				X		X	
Chondrosia reniformis	53.7	74.5		X	X			X	
cf. *Chondrosia reniformis*	122.6	124.0				X		X	
Clathrina clathrus	73.4	85.5	X	X	X		X	X	
Clathrina coriacea	82.4	82.4			X			X	
Cliona rhodensis	64.1	64.1	X					X	
Corticium candelabrum	62.7	90.0	X			X		X	
Crambe crambe	36.0	78.7	X		X	X	X	X	
cf. *Crambe crambe*	46.4	133.6		X		X	X	X	

Demospongiae indet.	46.1	377.1	X	X	X	X	X	X	X
Diplastrella bistellata	127.7	127.7		X				X	
Dysidea fragilis	63.0	82.4	X		X			X	
Farrea bowerbanki	857.0	857.0		X				X	
Fasciospongia cavernosa	59.9	83.5	X	X	X	X	X	X	X
Haliclona cf. *(Gellius) angulata*	70.9	70.9	X					X	
Haliclona (Reniera) mediterranea	68.6	78.2			X			X	
Haliclona sp.	48.4	88.3		X	X	X	X	X	
Hexactinellida indet.	863.4	863.4		X				X	
Hexadella dedritifera	167.6	167.6			X			X	
cf. *Hexadella detritifera*	148.5	148.5					X	X	
cf. *Hexadella pruvoti*	133.6	174.9				X	X	X	
Hymedesmia sp.	76.0	76.0		X					X
Ircinia sp.	49.5	97.6	X	X	X		X	X	
cf. *Ircinia* sp.	53.7	133.6		X		X		X	
Ircinia variabilis	59.9	100.4		X		X		X	
Mycale sp.	172.7	172.7				X		X	
Myxilla sp.	207.8	207.8	X					X	
Oscarella lobularis	67.2	68.9	X					X	
Petrosia (Petrosia) ficiformis	36.0	37.4				X		X	
Phorbas fictitius	56.0	64.1	X	X				X	
Plakina monolopha	127.7	207.8	X	X				X	
Plakortis simplex	173.0	173.0					X	X	
Pleraplysilla spinifera	78.5	100.4	X	X	X			X	
Porifera indet.	46.4	773.7	X	X		X	X	X	
Prosuberites longispinus[39]	76.0	76.0		X					X
Sarcotragus foetidus	71.2	102.1		X			X	X	
Sarcotragus sp.	60.7	88.9	X	X			X	X	
Sarcotragus spinosulus	46.1	116.1	X	X	X		X	X	X
Scalarispongia scalaris	71.7	78.7			X		X	X	
Spongia (Spongia) officinalis	65.0	82.4		X	X		X	X	
Thenea sp.	525.9	533.5		X				X	
Timea geministellata	90.0	90.0					X	X	
Timea stellata	90.0	90.0					X	X	
Topsentia calabrisellae[39]	76.0	76.0		X					X
Ulosa stuposa	70.6	71.7	X					X	

CNIDARIA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
cf. *Abietinaria abietina*	126.0	126.0				X		X	
Actinaria indet.	65.8	674.4	X			X		X	
Actiniidae indet.	529.3	529.3		X				X	
Adamsia palliata	86.6	113.9	X					X	

Aglaophenia octodonta	107.1	107.1	X					X	
Aglaophenia pluma	60.2	74.0		X		X		X	
Aglaophenia sp.	61.3	72.6		X	X			X	
Alcyonacea indet.	207.8	207.8	X					X	
Alcyonium palmatum	138.6	377.1	X	X	X	X	X	X	
Alcyonium sp.	175.2	215.4	X				X	X	
cf. *Anomocora* sp.*	48.4	144.5	X	X		X	X	X	
Anthozoa indet.	729.2	729.2	X					X	
Arachnanthus sp.	537.4	776.5	X	X				X	
Caryophyllia (Caryophyllia) calveri	433.7	773.7	X	X	X	X	X	X	
Caryophyllia (Caryophyllia) cf. *inornata*	287.1	287.1					X	X	
Caryophyllia (Caryophyllia) cyathus	151.3	177.7	X				X	X	
Caryophyllia (Caryophyllia) smithii	61.6	175.2	X	X			X	X	
Caryophyllia (Caryophyllia) sp.	127.2	729.2	X	X		X	X	X	
Ceriantharia indet.	822.0	822.0	X					X	
Cerianthus lloydii	885.3	885.3	X					X	
Cerianthus membranaceus	55.7	977	X	X	X	X	X	X	
cf. *Cerianthus membranaceus*	703.6	703.6		X				X	
Cerianthus sp.	61.9	849.0		X	X	X		X	
Cnidaria indet.	448.3	529.3		X				X	
Dendrophyllia ramea	172.4	172.4					X	X	
Desmophyllum dianthus	682.8	682.8				X		X	
cf. *Edwardsiella* sp.	521.1	521.1		X				X	
Epizoanthus sp.	441.3	664.0		X				X	
Eudendrium sp.	48.4	175.2	X	X	X	X	X	X	
Funiculina quadrangularis	506.2	604.4	X				X	X	
cf. Haloclavidae indet.	438.4	438.4				X		X	
Hormathia alba	473.3	979.8		X	X			X	
cf. *Hormathia digitata*	510.7	510.7				X		X	
cf. *Hydroidolina* sp.	91.1	91.1		X				X	
Hydrozoa indet.	49.2	703.6	X	X	X	X	X	X	X
cf. Hydrozoa indet.	845.7	845.7			X			X	
Lytocarpia myriophyllum	70.9	126.6	X		X			X	
cf. *Lytocarpia myriophyllum*	122.9	122.9			X			X	
Madracis pharensis	61.3	221.9	X	X		X	X	X	X
Nausithoe sp.	192.4	771.7	X	X		X	X	X	
cf. *Nausithoe* sp.	531.0	531.0		X				X	
Nemertesia antennina	46.1	121.2				X	X	X	
Nemertesia sp.	68.1	119.2	X		X			X	
Pachycerianthus sp.	860.3	860.3			X			X	
cf. *Pachycerianthus* sp.	244.7	244.7		X				X	
Paralcyonium spinulosum	173.2	192.4				X	X	X	

Pennatula rubra	65.0	206.1	X	X		X	X	X	
Pennatula sp.	126.0	198.3				X	X	X	
Pteroeides griseum	171.5	172.7					X	X	
Scleractinia indet.	175.2	175.2					X	X	
Sertularella sp.	65.2	90.0	X				X	X	
Sideractis glacialis	457.3	457.3		X				X	
Swiftia pallida	531.0	606.6		X				X	
Virgularia mirabilis	66.1	131.9	X	X	X	X		X	

	Min. depth	**Max. depth**	**Beirut**	**Jounieh**	**Sayniq**	**St. George**	**Tarablus/ Batroun**	**ROV**	**Grab**
ANNELIDA									
Annelida indet.	254.6	359.7				X		X	
Bonellia viridis	59.9	977.8	X	X	X	X	X	X	
Branchiomma bombyx	93.6	93.6		X				X	
Ditrupa arietina	76.0	858.9	X	X	X			X	X
cf. *Ditrupa arietina*	846.2	846.2			X			X	
Errantia indet.	344.8	344.8				X		X	
Filograna implexa	60.7	185.6	X	X	X		X	X	
cf. *Filograna implexa*	63.6	63.6			X			X	
Hermodice carunculata	53.2	167.6	X	X	X	X	X	X	
Lanice conchilega	255.4	405.3				X	X	X	
cf. *Lanice conchilega*	295.0	774.5		X			X	X	
Myxicola aesthetica	69.5	74.5					X	X	
Myxicola infundibulum	66.4	66.4		X					
Polychaeta indet.	56.8	976.7	X	X	X	X	X	X	X
Protula intestinum	77.3	77.3	X					X	
Protula sp.	110.0	379.4	X			X		X	
Protula tubularia	120.4	644.9		X		X		X	
cf. *Protula tubularia*	192.4	491.0		X		X		X	
Sabella cf. *discifera*	172.7	172.7					X	X	
Sabella pavonina	70.6	177.7		X		X		X	
Sabella sp.	77.3	77.3	X					X	
Sabella spallanzanii	80.1	82.1			X			X	
Sabellidae indet.	63.6	472.2	X	X	X	X	X	X	X
Seraphsidae indet.	65.5	92.2	X	X		X		X	
Serpula sp.	138.6	138.6				X		X	
Serpula vermicularis	74.5	602.4	X	X		X	X	X	
Serpulidae indet.	60.2	906.0	X	X	X	X	X	X	X
Spirorbis sp.	63.8	63.8			X			X	
cf. *Vermiliopsis monodiscus*	435.6	674.4		X		X		X	

ARTHROPODA/ CHELICERATA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
cf. Pycnogonida	618.7	618.7		X				X	

BRACHIOPODA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Argyrotheca cuneata	63.0	101.0		X	X	X	X		X
Brachiopoda indet.	73.1	167.6			X	X		X	
Gryphus vitreus	462.3	975.0					X	X	
Megathiris detruncata	76.0	220.0		X			X		X
Megerlia truncata	122.3	221.9	X	X		X	X	X	X
Novocrania anomala	63.0	101.0			X	X	X		X

BRYOZOA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Adeonella pallasii	65.2	107.1		X	X		X	X	X
Adeonella sp.	63.0	121.2	X	X	X	X		X	X
Alcyonidium sp.	68.1	68.1	X					X	
cf. *Amathia* sp.	71.4	71.7					X	X	
Bryozoa indet.	63.0	545.3	X	X	X	X	X	X	X
Bugula sp.	171.5	171.5					X	X	
Caberea boryi	138.6	138.6				X		X	
Caberea ellisii	56.8	75.4	X	X		X	X	X	
Caberea sp.	61.6	113.6		X	X	X		X	
Cellaria cf. *fistulosa*	64.4	102.9		X			X	X	
Cellepora sp.	63.0	63.0				X			X
Celleporina sp.	76.0	76.0		X					X
Crisia sp.	56.8	119.2	X	X	X		X	X	
Dentiporella sardonica	76.0	76.0		X					X
cf. *Escharina* sp.	76.0	76.0		X					X
Exidmonea atlantica	76.0	76.0		X					X
Frondipora verrucosa	64.0	101.0			X		X		X
Hornera frondiculata	70.0	124.0	X	X	X		X	X	X
cf. *Licornia vieirai*	101.0	101.0					X		X
Margaretta cereoides	64.0	76.0		X			X		X
Parasmittina sp.	101.0	101.0					X		X
Pentapora fascialis	83.2	83.2			X			X	
Reteporella grimaldii	55.7	117.6	X	X	X		X	X	X
Reteporella sp.	60.7	122.6	X	X	X	X	X	X	X
cf. *Reteporella* sp.	59.9	59.9		X				X	
Rhynchozoon neapolitanum	63.0	97.3	X		X			X	

Schizomavella (Schizomavella) cf. *mamillata*	63.6	63.6	X					X	
Schizomavella sp.	56.0	69.5		X		X	X	X	
Schizoporella sp.	74.5	74.5					X	X	
Schizoretepora sp.	76.0	76.0		X					X
Scrupocellaria cf. *scrupea*	76.0	76.0		X					X
Scrupocellaria sp.	101.0	101.0					X		X
Smittina cervicornis	63.6	67.2				X		X	
Smittina sp.	68.1	120.4	X			X		X	

CHAETOGNATHA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
cf. *Sagitta* sp.	784.6	784.6			X			X	

NEMERTEA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Phoronis australis	979.0	979.0					X	X	

ECHINODERMATA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Antedon mediterranea	59.9	107.1	X	X	X	X	X	X	
cf. *Antedon mediterranea*	133.6	133.6				X		X	
Asteroidea indet. (buried)	84.4	84.4		X					
Astropecten sp.	327.6	327.6			X			X	
Brissopsis lyrifera	76.0	517.0			X				X
Centrostephanus longispinus	56.0	94.2	X	X	X	X	X	X	X
Ceramaster granularis	73.4	148.5					X	X	
Chaetaster longipes	70.6	70.6		X				X	
Cidaris cidaris	62.7	949.7	X	X	X	X	X	X	X
Coscinasterias tenuispina	67.5	98.0	X	X				X	X
Echinaster (Echinaster) sepositus	49.2	133.6	X		X	X	X	X	
cf. *Echinaster (Echinaster) sepositus*	58.8	139.5				X		X	
Echinocardium sp.	64.0	64.0					X		X
Echinocyamus pusillus	101.0	101.0					X		X
Echinodermata indet.	45.6	979.2	X	X	X	X	X	X	X
Echinoidea indet.	65.2	133.6	X	X		X		X	
Genocidaris maculata	76.0	76.0		X					X
Gracilechinus acutus	520.3	834.7		X				X	
Gracilechinus cf. *elegans*	755.7	755.7	X					X	
Hacelia attenuata	65.2	221.9	X	X		X	X	X	
Hacelia sp.	121.2	121.2		X				X	

Hacelia superba	260.4	260.4		X				X	
Hymenodiscus coronata	617.8	930.3		X	X		X	X	
Leptasterias sp.	827.7	827.7		X				X	
Luidia sp.*	69.7	99.8	X		X			X	
Luidia ciliaris	71.2	71.2				X		X	
Mesothuria intestinalis	544.2	979.2	X	X	X		X	X	
cf. *Ophiopsila aranea*	59.9	59.9		X				X	
Mesothuria sp.	650.5	780.7		X				X	
Ophiopsila aranea	56.0	85.8	X	X				X	X
Ophiothrix fragilis	63.0	77.1	X	X	X			X	X
cf. *Ophiothrix* sp.	177.7	177.7				X		X	
Ophiuroidea indet.	60.2	60.2	X					X	
Peltaster placenta	86.9	269.1	X			X	X	X	
Penilpidia ludwigi	791.7	1,005.4	X		X	X	X	X	
Stylocidaris affinis	86.1	148.5		X			X	X	
cf. *Stylocidaris* sp.	431.4	431.4		X				X	
Tethyaster subinermis	194.0	367.3	X					X	

ARTHROPODA/ CRUSTACEA	**Min. depth**	**Max. depth**	**Beirut**	**Jounieh**	**Sayniq**	**St. George**	**Tarablus/ Batroun**	**ROV**	**Grab**
Amphibalanus amphitrite	82.0	82.0		X					X
Amphipoda indet.	63.0	939.2	X		X	X		X	X
Anomura indet.	60.5	833.8	X	X	X	X	X	X	
Aristeus antennatus	302.0	827.9	X	X		X	X	X	
Balanus sp.	56.8	65.8				X		X	
Bathynectes maravigna	465.2	766.1	X	X	X		X	X	
cf. *Bathynectes maravigna*	521.1	521.1		X				X	
cf. *Bathynectes* sp.	674.4	674.4				X		X	
Brachyura indet.	77.3	781.5	X					X	
Cirripedia indet.	75.6	75.6		X				X	
Copepoda indet.	845.7	845.7			X			X	
Dardanus arrosor	212.0	212.0	X					X	
Decapoda indet.	289.7	1,012.4	X	X	X	X	X	X	
Ebalia deshayesi	95.6	95.6		X					X
Ebalia granulosa	74.0	74.0			X				X
Ethusa mascarone	90.0	90.0	X					X	
Eumalacostraca indet.	606.3	606.3	X					X	
Euphausiacea indet.	345.9	345.9				X		X	
Galathea squamifera	193.2	193.2					X	X	
Homola barbata	300.1	300.1					X	X	
Inachus sp.	56.0	73.7	X	X	X			X	
Liocarcinus depurator	76.2	76.2		X					
Macropipus tuberculatus	230.0	230.0		X				X	

cf. *Macropipus tuberculatus*	180.0	180.0			X			X	
Munida sp.	82.1	158.0			X	X	X	X	
Munidopsis marionis	551.2	800.7	X	X				X	
Munidopsis sp.	448.3	937.1		X		X	X	X	
Mysidacea indet.	291.1	979.5	X	X	X	X	X	X	
cf. Mysida indet.	691.3	695.2		X				X	
Neomaja goltziana	418.8	752.8	X			X	X	X	
cf. *Pagurus alatus*	850.4	850.4			X			X	
Pagurus alatus	284.3	979.8		X	X	X		X	
Pagurus prideaux	86.6	113.9			X			X	
cf. *Pagurus* sp.	396.8	396.8				X		X	
Parapenaeus longirostris	286.9	799.6	X	X	X	X	X	X	
cf. *Parapenaeus longirostris*	305.1	562.2		X		X		X	
Periclimenes sp.	59.9	604.4		X			X	X	
Plesionika antigai	354.9	373.2				X		X	
Plesionika edwardsii	256.2	618.7	X	X	X	X	X	X	
Plesionika gigliolii	318.9	598.5	X	X	X	X	X	X	
Plesionika heterocarpus	227.8	535.2	X	X	X	X	X	X	
cf. *Plesionika heterocarpus*	366.7	366.7				X		X	
Plesionika narval	119.5	300.1	X	X		X	X	X	
Plesionika sp.	239.3	599.9		X	X	X		X	
Scyllarus arctus	287.1	287.1					X	X	
Eusergestes arcticus	372.1	502.3	X					X	
Spinolambrus macrochelos	230.0	526.2		X	X	X		X	
Stenopus spinosus	287.1	287.1					X	X	

MOLLUSCA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Abra alba	74.0	906.0		X	X				X
Abra longicallus	74.0	1015.0	X	X	X	X	X		X
Abra nitida	64.0	101.0					X		X
Abra prismatica	74.0	76.0		X	X				X
Abra sp.	74.0	74.0		X	X				X
Acanthocardia paucicostata	82.0	82.0		X					X
Aequipecten opercularis	64.0	101.0	X	X	X		X		X
Anadara corbuloides	74.0	74.0			X				X
Anadara gibbosa	74.0	74.0			X				X
Anadara cf. *inaequivalvis* +	74.0	74.0			X				X
Anadara cf. *transversa* +	74.0	74.0			X				X
Anomia ephippium	90.0	175.2	X				X	X	
Antalis dentalis	74.0	1015.0			X	X	X		X
Antalis inaequicostata	64.0	101.0		X			X		X
Aporrhais pespelecani	74.0	74.0			X				X

Aporrhais serresianus	91.4	517.0	X		X			X	X
Arca noae	74.0	74.0			X				X
Argonauta argo	634.2	634.2					X	X	
Asperarca nodulosa	64.0	101.0		X			X		X
Astarte fusca	74.0	74.0			X				X
Astarte sp.	76.0	76.0		X					X
Astarte sulcata	74.0	76.0		X	X				X
Barbatia barbata	64.0	76.0		X	X		X		X
Basisulcata lepida	460.4	460.4					X	X	
Berthella cf. *stellata*	113.6	113.6				X		X	
cf. *Berthella* sp.	111.1	111.1				X		X	
Bittium latreillii	63.0	265.0		X	X	X	X		X
Bittium reticulatum	74.0	74.0			X				X
Bittium sp.	66.4	107.1	X	X	X		X	X	X
Bivalvia indet.	72.8	906			X			X	X
Bolinus brandaris	74.0	212.0	X	X	X			X	X
Bolma rugosa	76.0	76.0		X					X
cf. *Brachioteuthis riisei*	444.6	444.6		X				X	
Calliostoma sp.	76.0	906.0		X	X	X		X	X
Cardiidae indet.	74.0	173.0			X		X	X	X
Cardiomya costellata	74.0	76.0		X	X				X
Cassidae indet.	71.2	71.2	X					X	
Centrocardita aculeata	63.0	101.0		X	X	X	X		X
Cephalaspidea indet.	300.0	300.0		X					X
Cephalopoda indet.	403.6	647.2	X			X		X	
Cerithidea indet.	63.0	906.0		X	X	X			X
Cerithidium submammillatum	64.0	64.0					X		X
Cerithiopsidae indet.	63.0	76.0		X	X				X
Cerithiopsis sp.	74.0	74.0			X				X
Cerithium cf. *nodulosum* +	64.0	64.0					X		X
Circenita callipyga +	101.0	101.0					X		X
Clanculus corallinus	668	668		X					X
Clio pyramidata	63.0	544.2	X	X	X	X		X	X
Coccopigya viminensis	688.0	688.0		X					X
Copulabyssia corrugata	688.0	688.0		X					X
Corbula gibba	64.0	101.0			X		X		X
cf. *Crassopleura maravignae*	76.0	76.0		X					X
Creseis sp.	906.0	906.0			X				X
Creseis virgula	76.0	76.0		X					X
Ctena decussata	101.0	101.0					X		X
Cuspidaria cuspidata	74.0	220.0		X	X				X
Cuspidaria rostrata	74.0	74.0			X				X
Decapodiformes indet.	799.5	1,018.6		X			X	X	
Dentaliidae indet.	906.0	906.0			X				X

Digitaria digitaria	63.0	63.0				X			X
Dosinia lupinus	906.0	906.0			X				X
cf. *Dosinia lupinus*	76.0	76.0		X					X
Emarginula huzardi	63.0	76.0		X		X			X
Ennucula corbuloides	1015.0	1015.0				X			X
Ennucula tenuis	74.0	74.0			X				X
Entalina tetragona	911.0	911.0	X						X
Euspira catena	74.0	76.0		X	X				X
Flabellina sp.	138.6	138.6				X		X	
Flexopecten hyalinus	76.0	82.0		X					X
Fulvia fragilis +	74.0	76.0		X	X				X
Fusinus sp.	66.4	66.4			X			X	
Galeodea sp.	531.8	976.7			X		X	X	
Gastropoda indet.	56.0	833.8	X	X	X		X	X	X
Glans trapezia	76.0	76.0		X					X
Goodallia triangularis	74.0	74.0			X				X
Hadriania craticulata	76.0	76.0		X					X
Haedropleura flexicosta	76.0	76.0		X					X
Haminoeidae indet.	906.0	906.0			X				X
Homalopoma sanguineum	63.0	63.0				X			X
Japonactaeon pusillus	76.0	76.0		X					X
Jujubinus sp.	552.1	552.1					X	X	
Karnekampia sulcata	76.0	76.0		X					X
Kurtziela serga	906.0	906.0			X				X
Lepetellidae indet.	76.0	76.0		X					X
cf. *Licornia vieirai*	101.0	101.0					X		X
Lima lima	76.0	76.0		X					X
Limaria tuberculata	74.0	74.0			X				X
Limatula gwyni	74.0	74.0			X				X
cf. *Loligo vulgaris*	646.3	646.3		X				X	
Loligo vulgaris	90.8	90.8	X					X	
Macomangunus tenuis	76.0	76.0		X					X
Mactra olorina +	101.0	101.0					X		X
Mactra sp.	76.0	76.0		X					X
Malleus sp.	76.0	76.0		X					X
Melanella sp.	64.0	64.0					X		X
Metaxia metaxa	63.0	63.0				X			X
Mimachlamys varia	74.0	906.0		X	X				X
Mitra sp.	101.0	101.0					X		X
Mitrella coccinea	76.0	76.0		X					X
Mitrella minor	906.0	906.0			X				X
Murex forskoehlii +	70.0	70.0	X					X	X
Muricidae indet.	289.9	289.9					X	X	
Nassarius sp.	64.0	906.0		X	X	X	X		X

Naticarius stercusmuscarum	279.3	533.8					X	X	
Naticidae indet.	74.0	74.0			X				X
Neopycnodonte cochlear	55.7	178.3	X	X	X	X		X	
Nucula hanleyi	74.0	74.0			X				X
Nucula nitidosa	74.0	1,015.0		X	X	X			X
Nucula nucleus	74.0	1,015.0		X	X	X			X
Nucula sp.	82.0	82.0		X					X
Nucula sulcata	64.0	906.0		X	X		X		X
Nuculidae indet.	74.0	74.0			X				X
Nudibranchia indet.	82.7	82.7			X			X	
Ocinebrina sp.	63.0	63.0				X			X
Octopus vulgaris	65.5	358.0	X	X	X			X	
Ommastrephes bartramii	877.2	877.2	X					X	
Ommastrephes sp.	820.1	820.1			X			X	
Onychoteuthis banksii #						X			X
Pagodula echinata	300.0	300.0		X					X
Palliolum sp.	64.0	64.0					X		X
Papillicardium papillosum	63.0	101.0				X	X		X
Parvicardium exiguum	74.0	76.0		X	X				X
Parvicardium minimum	64.0	76.0		X	X		X		X
Parvicardium scabrum	74.0	74.0			X				X
Parvicardium sp.	74.0	74.0			X				X
Pecten jacobaeus	74.0	74.0			X				X
Pectinidae indet.	74.0	76.0		X	X				X
Petalopoma elisabettae	76.0	76.0		X					X
Pinna rudis	58.8	61.3					X	X	
Pododesmus patelliformis	90.0	192.9	X					X	
Pseudamussium peslutrae	161.0	161.0					X		X
Pteroctopus tetracirrhus	260.4	260.4		X				X	
Pyramidellidae indet.	76.0	76.0		X					X
Retusidae indet.	906.0	906.0			X				X
Ringicula sp.	906.0	906.0			X				X
Rissoidae indet.	75.1	83.5			X			X	
Rossia macrosoma	666.8	666.8		X				X	
cf. *Rossia macrosoma*	396.8	396.8				X		X	
Roxania sp.	906.0	906.0			X				X
Saccella commutata	64.0	1015		X	X	X	X		X
Scaphopoda indet.	76.0	879.4	X	X	X			X	X
Semisaccis granulata	170.4	170.4			X			X	
Sepia officinalis	67.8	91.4	X	X				X	
Sepia orbignyana	172.7	358.3				X	X	X	
Sepiidae indet.	521.1	811.1	X	X			X	X	
Siliquariidae indet.	74.0	74.0			X				X
Similipecten similis	74.0	76.0		X	X				X

Spondylus gussonii	756.5	756.5					X	X	
cf. *Spondylus gussoni*	477.0	477.0			X			X	
Striarca lactea	74.0	76.0		X	X				X
Taranis moerchii	668.0	668.0		X					X
Tellinidae indet.	465.7	465.7		X				X	
cf. *Tenagodus* sp.	76.0	76.0		X					X
Teuthida indet.	458.7	488.2		X				X	
Thracia convexa	76.0	76.0		X					X
Thyasira cf. *subovata*	101.0	101.0					X		X
Thyasira flexuosa	668.0	668.0		X					X
Thyasira sp.	64.0	64.0					X		X
Thylaeodus semisurrectus	63.0	63.0				X			X
Timoclea ovata	64.0	161.0		X	X		X		X
Tonna galea	239.3	239.3		X				X	
Tritia cf. heynemanni	302.0	302.0				X			X
Trochidae indet.	674.9	701.7				X		X	
Turritella turbona	63.0	76.0		X	X	X			X
Tylodina perversa	76.0	76.0			X				X
Veneridae indet.	76.0	76.0		X					X
Venus verrucosa	101.0	906.0			X		X		X
Vermetidae indet.	59.9	74.0	X	X	X			X	X
Volvarina mitrella	76.0	76.0		X					X

CHORDATA	**Min. depth**	**Max. depth**	**Beirut**	**Jounieh**	**Sayniq**	**St. George**	**Tarablus/ Batroun**	**ROV**	**Grab**
Anguilliformes indet.	794.8	794.8			X			X	
Anthias anthias	70.6	293.6	X	X	X	X	X	X	
Argentina sphyraena	304.6	581.3	X	X	X	X	X	X	
Arnoglossus laterna	179.7	216.5			X			X	
Arnoglossus rueppelii	226.1	366.7	X	X	X	X	X	X	
Arnoglossus sp.	458.7	458.7	X					X	
Aulopus filamentosus	193.5	193.5		X				X	
Bathypterois dubius	780.7	931.4	X	X	X		X	X	
Benthocometes robustus	531.8	531.8			X			X	
Callanthias ruber	132.7	221.9				X	X	X	
Capros aper	238.5	418.5	X			X		X	
Carangidae indet.	82.4	82.4			X			X	
Chauliodus sloani	590.3	892.4		X	X	X		X	
cf. *Cheilodipterus novemstriatus* +			X						
Chelidonichthys cuculus	87.2	87.2		X				X	
Chelidonichthys lastoviza	78.5	180.0	X		X		X	X	
Chimaera monstrosa	881.5	881.5				X		X	

Chlorophthalmus agassizi	187.6	887.0	X	X	X	X	X	X	
Citharus linguatula	68.1	223.3	X	X		X		X	
Coelorinchus caelorhincus	267.7	788.0	X	X	X	X	X	X	
Coelorinchus sp.	418.8	930		X				X	
Conger conger	164.5	164.5				X		X	
Coris julis	46.1	82.4		X	X		X	X	
Coryphaenoides cf. *mediterraneus*	1014.7	1014.7		X				X	
Cottoidei indet.	471.9	471.9		X				X	
Dalophis imberbis	869.6	869.6		X				X	
Dentex macrophthalmus	151.3	460.7	X	X	X	X	X	X	
Dipturus oxyrinchus	421.8	421.8				X		X	
Electrona risso	464.4	464.4		X				X	
Epigonus constanciae	255.4	359.7		X			X	X	
Epinephelus marginatus	82.1	82.1			X			X	
Equulites klunzingeri +	71.2	71.2	X					X	
Etmopterus spinax	952.8	952.8	X					X	
Facciolella oxyrhyncha	799.3	799.3	X					X	
Fistularia commersonii +	56.8	56.8		X				X	
Gobiidae indet.	71.2	128.0	X	X		X		X	
Gobius gasteveni	82.7	82.7			X			X	
Gobius geniporus	58.8	71.7				X	X	X	
Gobius niger	110.0	110.0	X					X	
Gobius sp.	61.9	81.9	X		X			X	
Gobius vittatus	77.1	77.3	X		X			X	
Helicolenus dactylopterus	177.7	842.6	X	X	X	X	X	X	
Hoplostethus mediterraneus	363.1	991.6	X	X	X	X	X	X	
Hymenocephalus italicus	358.8	979.5	X	X	X	X	X	X	
Hymenocephalus sp.	415.1	491.0		X				X	
Lampanyctus crocodilus	477.2	833.0	X	X			X	X	
Lappanella fasciata	124.0	174.9	X	X			X	X	
Lepidopus caudatus	432.5	747.5	X	X		X		X	
Lepidorhombus boscii	582.7	582.7	X					X	
Lepidorhombus whiffiagonis	285.2	424.7	X	X		X	X	X	
Lepidotrigla cavillone	89.4	114.2	X					X	
Lesueurigobius friesii	72.6	340.3	X	X	X			X	
Lesueurigobius sp.	60.7	320.9		X	X		X	X	
Lesueurigobius suerii	90.0	241.9	X					X	
Lobotes surinamensis #						X			
Lophius budegassa	474.2	474.2					X	X	
Macroramphosus scolopax	107.1	332.7	X	X	X	X	X	X	
Macrouridae indet.	363.1	925.8		X		X		X	
Merluccius merluccius	294.2	388.4		X		X		X	
Mullus surmuletus	173.0	173.0					X	X	
Muraena helena	46.4	46.4					X	X	

Mycteroperca rubra	81.8	81.8			X			X	
Myctophidae indet.	420.2	881.5		X	X	X	X	X	
Nemichthys scolopaceus	672.1	672.1					X	X	
Nemipterus randalli +	68.6	100.7	X					X	
Nettastoma melanurum	487.4	1045.3	X	X	X	X	X	X	
Nettastomatidae indet.	682.0	881.5	X	X		X		X	
Nezumia aequalis	536.6	1,005.4	X	X	X		X	X	
Nezumia sclerorhynchus	536.3	898.0	X	X		X		X	
Nezumia sp.	538.0	948.0	X	X	X		X	X	
Ophisurus serpens	192.1	192.1	X					X	
Ostorhinchus fasciatus +	65.5	89.4	X	X				X	
Pagellus bogaraveo	177.7	504.8			X	X	X	X	
Pagellus erythrinus	69.2	92.0	X	X				X	
Pagellus sp.	65.5	65.5	X					X	
Parablennius pilicornis	48.4	48.4				X		X	
Parablennius rouxi	81.0	81.8			X			X	
Peristedion cataphractum	334.1	375.2	X	X				X	
Phycis blennoides	645.1	942.7		X	X	X	X	X	
Phycis phycis	148.5	192.9	X				X	X	
Pisces indet.	63.3	979.0	X	X	X	X	X	X	
Pleuronectiformes indet.	80.1	375.2	X	X		X		X	
Pterois miles +	49.5	85.5			X		X	X	
Sargocentron rubrum +	36.0	47.0				X	X	X	
Scorpaena elongata	127.7	441.8	X	X	X	X	X	X	
Scorpaena notata	61.9	344.8	X	X		X		X	
Scorpaena porcus	49.5	119.8	X				X	X	
Scorpaena scrofa	62.4	419.0	X	X		X	X	X	
Scorpaena sp.	80.7	88.0	X	X				X	
Scorpaeniformes indet.	435.3	435.3				X		X	
Seriola dumerili	62.7	133.6		X	X		X	X	
Serranidae indet.	113.6	113.6				X		X	
Serranus cabrilla	46.1	171.5	X	X	X	X	X	X	
Serranus hepatus	61.6	178.3	X	X	X	X	X	X	
Serranus scriba	61.6	61.6		X				X	
Serranus sp.	90.0	90.0	X					X	
Siganus luridus +	36.0	49.5				X	X	X	
Sparidae indet.	198.3	198.3				X		X	
Stephanolepis diaspros +	63.6	63.6			X			X	
Stomias boa	399.3	861.4		X	X	X	X	X	
Stomiidae indet.	448.3	448.3				X		X	
Stomiiforme indet.	696.0	696.0			X			X	
Symphurus ligulatus	778.7	849.9	X	X	X			X	
Symphurus nigrescens	122.6	226.1			X			X	
Symphurus sp.	408.1	408.1	X					X	
Synchiropus phaeton	304.6	474.6	X	X	X	X	X	X	

Syngnathus acus	65.5	65.5					X	X	
Synodus saurus	69.2	69.2	X					X	
Synodus synodus	266.9	266.9	X					X	
Thorogobius ephippiatus	94.2	341.4	X	X		X	X	X	
Torquigener flavimaculatus +	63.0	110.2	X		X		X	X	
Tripterygion melanurum	70.0	70.0			X			X	
Tursiops truncatus #				X					

CHORDATA/TUNICATA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Aplidium sp.	60.5	60.5	X					X	
Aplousobranchia indet.	69.2	72.0	X				X	X	
Ascidia conchilega	157.8	157.8		X				X	
Ascidia cf. *mentula*	70.9	102.1	X				X	X	
Ascidia sp.	77.1	95.6	X					X	
Ascidiacea indet.	56.0	551.2	X	X	X			X	
Ascidiella cf. *aspersa*	69.2	119.2	X					X	
cf. Ascidiidae indet.	78.5	83.5	X					X	
cf. Botryllinae indet.	63.0	63.0	X					X	
Botrylloides sp.	38.8	39.1				X		X	
Cystodytes sp.	56.0	57.7		X				X	
Cystodytes dellechiajei	67.5	82.0	X		X		X	X	
Diazona violacea	80.1	126.3	X	X	X	X		X	
Didemnum fulgens	70.6	83.5	X	X	X			X	
Didemnum sp.	53.2	116.1	X	X	X	X	X	X	
Halocynthia papillosa	70.6	163.1	X	X	X	X	X	X	
Microcosmus cf. *vulgaris*	69.2	69.2	X					X	
Pseudodistoma cf. *cyrnusense*[38]	65.2	71.7					X	X	
Polysyncraton lacazei	71.7	71.7					X	X	
cf. *Polysyncraton* sp.	83.5	83.5		X				X	
cf. *Polyzoinae indet.*	81.8	81.8			X			X	
Pycnoclavella cf. *communis*	69.0	71.0	X			X		X	
Pycnoclavella sp.	39.1	71.4	X			X		X	
cf. *Pycnoclavella* sp.	38.8	53.2				X		X	
Pyura dura	63.0	64.1	X					X	
Pyuridae indet.	107.1	107.1	X					X	
Rhopalaea cf. *hartmeyeri*[38]	60.2	93.4	X	X			X	X	
Rhopalaea sp.	68.1	78.5	X					X	
Styela cf. *canopus*	78.0	107.0	X					X	
Styela sp.	119.2	119.2	X					X	
Styelinae indet.	56.0	84.1		X	X			X	
Tunicata indet.	66.4	66.4			X			X	

TABLE A2. LIST OF THREATENED SPECIES IDENTIFIED

Species are listed that are either included on Annex II or III of the SPA/BD Protocol of the Barcelona Convention, and/or have been assessed by IUCN as threatened (i.e., Vulnerable (VU), Endangered (EN), or Critically Endangered (CR)) or Near Threatened (NT) in the Mediterranean Sea.

Phylum	Species	Listed on Annex II (SPA/ BD Protocol)	Listed on Annex III (SPA/ BD Protocol)	IUCN Red List Threat Status in the Mediterranean	Reference
Arthropoda/Crustacea	*Scyllarus arctus*		X		43
Chordata	*Chimaera monstrosa*			NT	26
Chordata	*Dipturus oxyrhincus*			NT	26
Chordata	*Epinephelus marginatus*		X	EN	26, 43
Chordata	*Merluccius merluccius*			VU	26
Chordata	*Tursiops truncatus*	X		VU	26, 41
Cnidaria	*Dendrophyllia ramea*	X		VU	26, 53
Cnidaria	*Desmophyllum dianthus*	X		EN	26, 53
Cnidaria	*Funiculina quadrangularis*			VU	26, 53
Cnidaria	*Pennatula rubra*			VU	26, 53
Echinodermata	*Centrostephanus longispinus*	X			41
Mollusca	*Pinna rudis*	X			41
Mollusca	*Tonna galea*	X			41
Porifera	*Sarcotragus foetidus*	X			41
Porifera	*Spongia (Spongia) officinalis*		X		43

FIGURE A1. NUMBER OF IDENTIFIED TAXA, ACCORDING TO BROAD TAXONOMIC GROUP