



OFFSHORE EXPLORATION DRILLING PROGRAM

Blocks 4 & 9 - Lebanon

ENVIRONMENTAL BASELINE STUDY



Romain de la Martinière
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Sustainable development is at the heart of TotalEnergies projects and operations. That's why our Company is proud of its contribution to the United Nations Sustainable Development Goals, including those related to providing affordable and clean energy, and to the conservation of biodiversity.

The Mediterranean Sea is one of our world's biodiversity hotspots. Within its Eastern Basin, Lebanese waters host a variety of ecosystems including seagrass meadows and underwater canyons. The Environmental Baseline Survey we conducted in Blocks 4 and 9 offshore Lebanon as part of our Environmental Impact Assessment, allowed us to collect and analyze valuable biodiversity data.

Through this booklet, TotalEnergies EP Liban SAL and its partners are pleased to share these biodiversity data findings with our stakeholders, the scientific community and the general public. This is perfectly in line with TotalEnergies commitment to promote biodiversity.

Romain de la Martinière
General Manager
TotalEnergies EP Liban SAL

A handwritten signature in blue ink, consisting of a stylized 'R' followed by a series of loops and a vertical line extending downwards.

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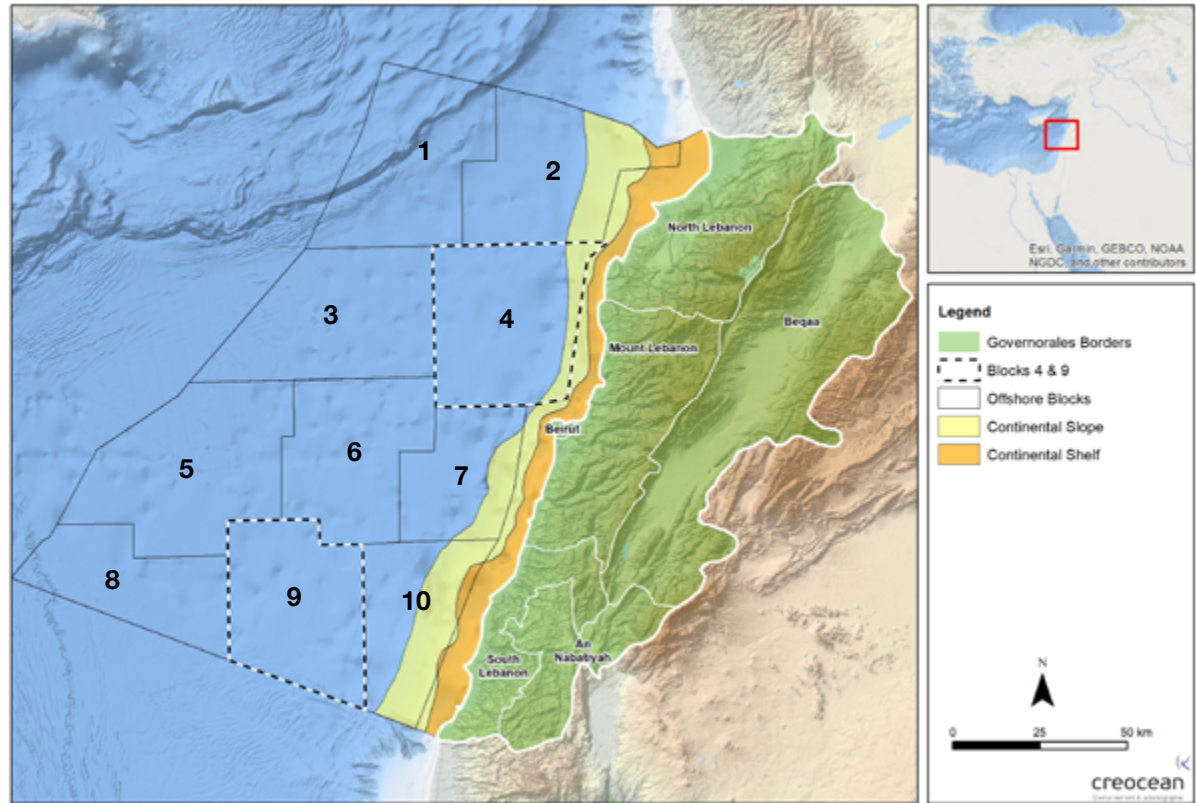
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In January 2018, the Government of the Republic of Lebanon signed an exploration and production agreement (EPA) with TotalEnergies EP Liban SAL (TEP Liban), Eni Lebanon BV and Novatek Lebanon SAL for offshore Blocks 4 and 9. TotalEnergies internal requirements (<https://totalenergies.com/group/commitment/environmental-issues-challenges/environment-protection>) and Lebanese regulations require an Environmental Baseline Survey (EBS) to be conducted prior to any planned activity. TotalEnergies EP Liban SAL therefore contracted Créocéan to conduct this EBS for each of these two blocks.

The study program consists of the following contents:

1. A bibliographic study
2. A field oceanographic campaign
3. The **EBS** report
4. This EBS is integrated in the Environmental Impact Assessment report.

Blocks location



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A project operated by
TotalEnergies EP Liban SAL (40%)



With partners
Eni Lebanon BV (40%)



And
Novatek Lebanon SAL (20%)



< 2 / The oceanographic survey >

The oceanographic campaign was performed by a team of scientists from Creocan onboard the Comex's survey vessel, the Janus II, between March 20th and April 11th, 2019. More than twenty people can be accommodated on board for long periods.

The vessel is equipped with **USBL** positioning, several winches, an APACHE ROV, and a pilot **ROV** station.

The sampling effort was focused of several biological compartments:

- Water column characteristics (stratification and quality)
- Plankton community (abundance and biodiversity)
- Sediment characteristics (nature and quality)
- Benthic endofauna (abundance, diversity and health)
- Seafloor observations by ROV (seabed relieves, fishes and other epifauna)
- Megafauna survey (mammals, birds, turtles) and marine traffic.



1. Janus II / 2. Winch / 3. ROV control room / 4. Pilot bridge © Creocan

Acquisition program of the oceanographic campaign

Compartment	Investigation type	Acquisition B9	Acquisition B4
Water column	Physico-chemical properties (3 depth)	4 stations (3 depth)	4 stations (3 depth)
	Multiparameter profiles	4 stations	4 stations
	Chlorophyll & phaeopigments	4 stations	4 stations
	Phytoplankton	4 stations	4 stations
	Zooplankton	4 stations	4 stations
Seafloor sediment	Physico-chemical properties	27 stations	29 stations
	Microbiology	27 stations	29 stations
	Macrobenthic infauna (0,1 m ²)	27 (3 replicates)	29 (3 replicates)
	Drop down video	27 stations	29 stations
	Video transect	8 transects	14 transects
Marine megafauna	Marine megafauna (mammals, birds, turtle and fish)	75,1 hours	110 hours
	Acoustic recording of marine mammals	30 deployments	33 deployments

[Video visit of the Janus](#)

< 3 / Water compartment - Data acquisition >

Water characteristics study included:

- Water samples at three different depths, using a Niskin bottle.
- Water profile measurements throughout column height using a CTD probe.
- Chlorophyll concentration measured after water filtration, for assessing water phytoplankton enrichment.
- Analysis of organic and nutrient contents, Metals (19), HAP (16), BTEX (4), Aliphatic hydrocarbons, PSBs (7), microorganism and chlorophyll concentrations.

Plankton communities' study included:

- Plankton sampling using Bongo nets (50 et 200 μm)
- Species identification and counting by the Institut de la Mer à Villefranche (France), using automatic recognition via the web-based application **ECOTAXA**.

Water and plankton sampling



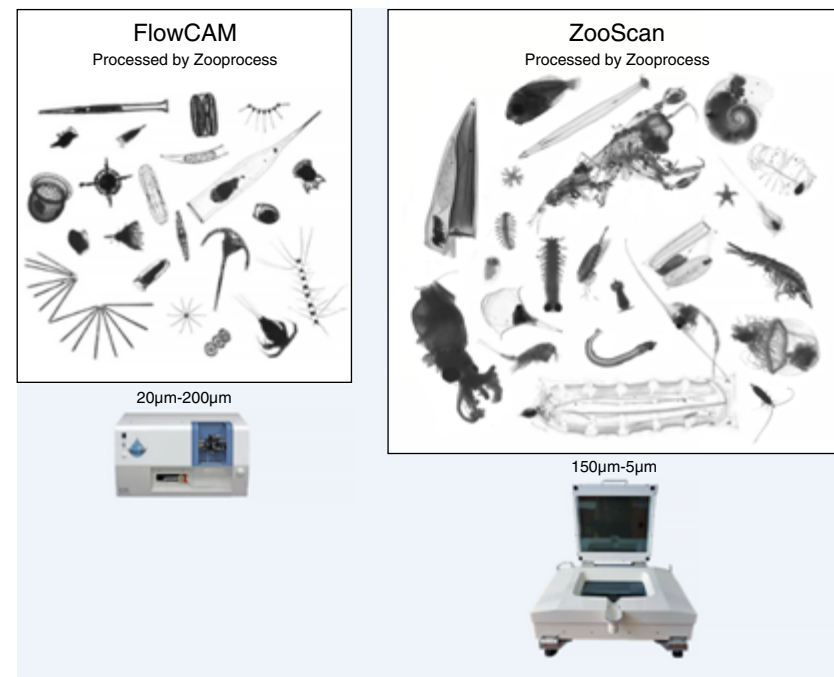
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Sampling effort



FlowCAM (Fluid imaging Inc.) is an in situ imaging instrument to measure/count and classify particles and organisms between 20 μm and 200 μm in the liquid environment. This instrument is well adapted for the study of departing or fixed nano- and micro-plankton.

The **ZooScan** (HYDROPTIC Inc., CNRS patent) is an in situ imaging instrument to measure/count and classify particles and organisms between 150 μm and 5 cm in the liquid environment. This equipment is well adapted for the study of fixed or non-motile meso- and macro-plankton.



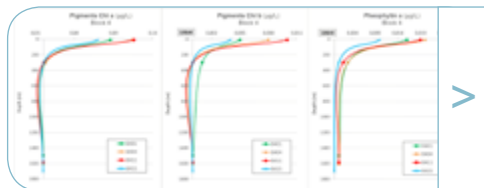
< 4 / Water compartment - Results >

A water quality assessment of the water column includes the measurement of the level of organic and nutrient enrichment, which originates from terrestrial inputs or upwelling. It can provide information on possible water contaminations by pollutants such as metals and hydrocarbons. In turn, these results reveal the quality and trophic state of water masses which may support plankton and biodiversity. However, since water masses are dynamic, the results on water quality are snapshots and have a short-term validity. And so, several sampling efforts spread out in time are necessary to characterize seasonal and interannual variations.

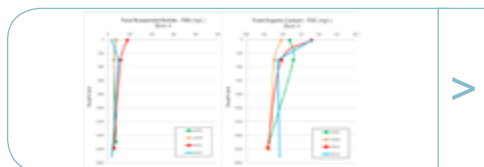
Illustration of few plankton species



Chlorophyll concentration in the water column



Organic component and nutrient concentration in the water column



Main results on water mass quality:

- **Water column was poor in organic components** (Total Suspended Solids and Total Organic Carbon), as well as **in nutrient contents (nitrogen and phosphorous)**. This is consistent with oligotrophic waters of the eastern Mediterranean Basin.
- **The water column was also poor in chlorophyll and phaeopigment contents**, with higher concentrations in subsurface levels compared to mid-depth level and seabed.
- **Metal concentrations were low**, more often below or close to the Limit of quantification by the laboratory. Only 4 metals (Chromium, Molybdenum, Lithium and Vanadium) showed detectable values on a majority of the samples, with remarkable stability between stations and depths.
- **PAHs**, **PCBs** and **BTEX** were not detected
- **TPH contents** were below or equal to the Limits of quantifications by the laboratory.

Main results on plankton:

- Between 45 and 57 taxa were identified per station in the 50 µm net and 47 to 64 taxa in 200 µm net.
- The phytoplankton was dominated by Bacillariophyceae (unicellular algae with valves), *Holodiniophyta* and *Ciliophora*.
- The zooplankton was largely dominated (in diversity and abundance) by the Arthropods
- Results indicate low diversity of plankton taxa and a low abundance of zooplankton collected in the samples which is consistent with the low enrichment in nutrients of surface waters, and with the spring season during which the oceanographic campaign took place. However, abundance of phytoplankton was very high in Block 9, far above what was found in Block 4.

Conclusions: These results indicate oligotrophic waters free of metal and hydrocarbon contamination. Plankton samples showed low diversity and abundance, which is consistent with the low enrichment of surface water.



Metal concentration in the water column

Heavy metals (µg/l)	Block 4 - Mean			Block 9 - Mean		
	Surface	Mid-depth	Bottom	Surface	Mid-depth	Bottom
Iron (Fe)	<100	<100	<100	<100	<100	<100
Aluminum (Al)	10,0	12,5	<10	12,3	12,8	10,3
Silver (Ag)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Arsenic (As)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Barium (Ba)	<10	<10	35,0	<10	33,0	35,8
Beryllium (Be)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cadmium (Cd)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium (Cr)	1,5	2,2	1,4	1,6	2,1	3,6
Cobalt (Co)	<1.0	<1.0	<1.0	<10	<10	<10
Copper (Cu)	<1.0	<1.0	<1.0	<10	<10	<10
Lithium (Li)	213	180	228	203	225	235
Manganese (Mn)	<1.0	<1.0	<1.0	<10	<10	<10
Mercury (Hg)	<0,015	<0,015	<0,015	<0,015	<0,015	<0,015
Molybdenum (Mo)	12,5	12,8	12,5	12,8	12,8	12,8
Nickel (Ni)	<1.0	<1.0	<1.0	1,1	<1,0	<1,0
Lead (Pb)	<1.0	<1.0	<1.0	<10	<10	<10
Thallium (Tl)	<1.0	<1.0	<1.0	<10	<10	<10
Vanadium (V)	2,2	2,2	2,2	2,3	2,2	2,3
Zinc (Zn)	10,3	10,8	<10	18,8	<10	<10

What are planktons?

The term **plankton** refers to all living organisms, animals and plants, drifting, floating, or weakly swimming in the water column. Plankton is composed of **phytoplankton and zooplankton**.

Phytoplankton are composed of organisms related to plants known as micro-algae. Phytoplankton contain chlorophyll and require sunlight in order to live and grow. These organisms constitute the base of the marine food web. Phytoplankton live in suspension in the water column and passively drift with currents.

Zooplankton are planktonic organisms related to animals. They include holoplankton which are species that spend their entire life cycle in the water column, and meroplankton which have part of their life cycle in or attached to the seafloor. Zooplankton include herbivorous species that eat phytoplankton and carnivorous species that feed on other zooplanktonic organisms.

Most plankton species are less than one millimeter in size. However, some species are larger, such as siphonophores, ctenophores and jellyfish. The large majority of plankton is made of micro- and mesoplankton.

< 5 / Sediment and macrofauna samples >

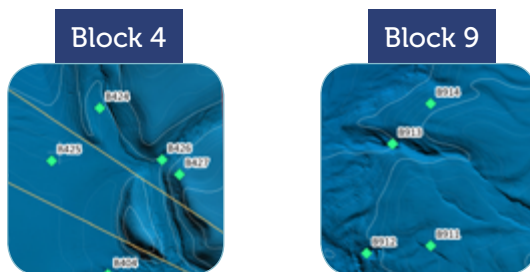
Sediment sampling and analysis:

- Deployments of a Grey O'Hara steel box core for a surface sampling of 0.25 m² up to 20 cm depth.
- Multi-parameters analysis: sediment aspects, particle size, organic and nutrients (N, P) contents, Metals, PAHs, TPC, BTEX and Bacteria concentrations.

Macrofauna sampling and analysis:

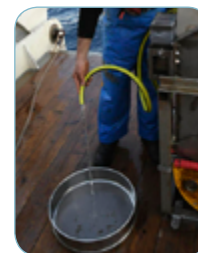
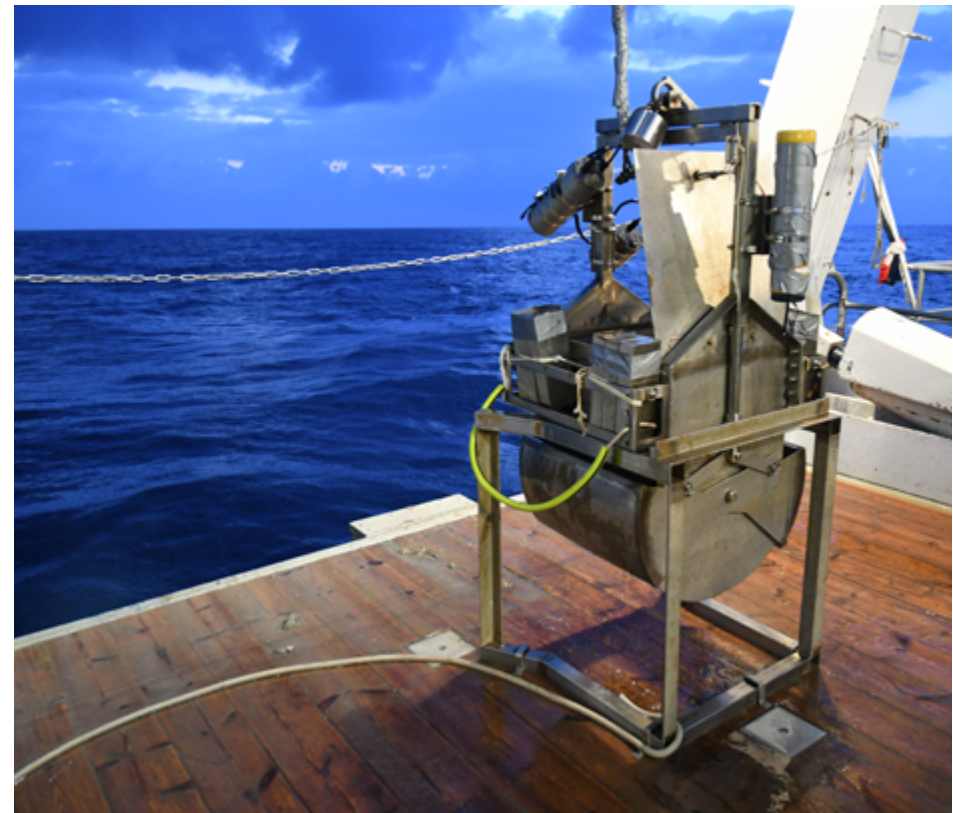
- Second deployments of the Grey O'Hara box core.
- Sieving the sediment on 1mm mesh to retrieve the benthic fauna.
- Species identification and counting by CEAB laboratory (University of Blanes, Spain)
- Calculations of biological parameters (specific richness, density, biomass)
- calculations of biological index (diversity and trophic index)
- Analysis of species composition

Sampling effort on the two blocks



 [Video on sediment box core sampling](#)

 [Video on benthic fauna box core sampling](#)



Box core
© Creocan

Sediment characteristics:

- **Sediments are brownish pure mud** (fine particles fraction (63µm) overpassed 96% at B4 80% at B9), with a typical superficial fluid silty layer overlying more compact clay sediment.
- Coarser elements (weight refuse at 2 mm) were also observed with very variable rates (B4: 2% to 73 % d.w. – B9 : 25% to 73% d.w.)
- Total Organic Matter: very variable (low to very high) – TOC: low.
- Sediments were slightly rich in nitrogen and phosphorus.
- **Concentrations in trace metal were low**, with the **exception of Nickel, Copper and Arsenic** (to a lesser extent) whose concentrations were relatively high at the whole study scale.
- In Block 9, **Station B906** presented particularly high values for Arsenic, Chromium, Nickel and Molybdenum.
- **Concentrations** in PAH were low in both blocks.
- Other hydrocarbon molecules (Aliphatics, Aromatics, BTEX and PCB) were not detected, except in one station (B902: 3 PCBs detected).

The physicochemical data of sediments characterize the environment in which benthic organisms are found. Granulometry provides essential information on the seafloor substrate upon which depend sediment oxygenation and transport of pollutants. Furthermore, sediments keep a record of pollutants present in the overlying water column. The pollutants, attached to fines particles, reach the seafloor and accumulate. Hydrocarbons allow to trace industrial pollutants and to define the origin of the pollution.

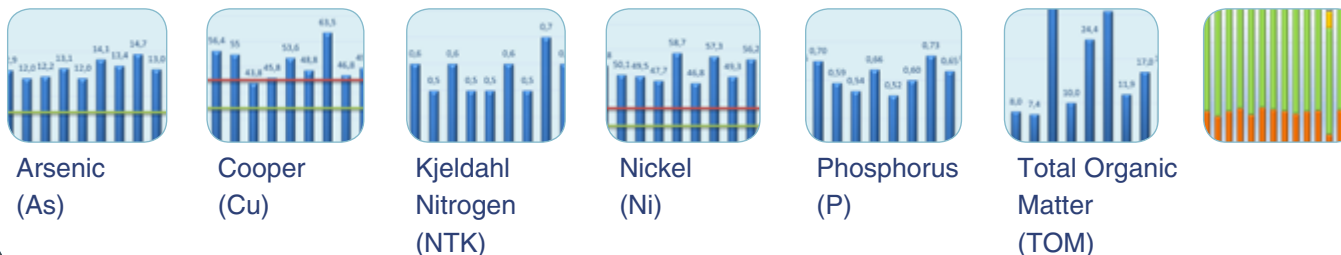


Sediment aspect in the box core
© Creocean

Conclusion:
Low TOC, nitrogen and phosphorus concentrations are consistent with the values measured in the Leviathan Field, and the highly **oligotrophic** nature of the region. These results are consistent with those obtained in the Levantine Basin and Leviathan field where no metal contamination was observed except for Arsenic, Copper, and Nickel.

Organic component and nutrient concentration in the sediments

Block 9



Benthic fauna structure and composition are suitable parameters to monitor the quality of sediments and environmental conditions. Most of endobenthic species usually have limited mobility and changes in species composition and densities can therefore easily be identified. The distribution of the fauna can be related to natural variations in environmental parameters such as depth and sediment type. The distribution can also be related to an excess of nutrient inputs or high levels of metal and hydrocarbons contents and can then serve as indicators of pollution.

Overall good conditions are characterized by high numbers of species and diversity with high general abundance but no proliferating species. Deteriorated conditions (e.g., excess of nutrient/organic inputs, low oxygenation rate, low organic matter turn over, or chemical contamination) often lead to a decrease in the species richness and diversity with the proliferation of “tolerant” species to the detriment of others unable to cope such degraded environmental conditions.

The occurrence of certain species can have great ecological significance and can be used as bioindicators of excess organic inputs, hypersedimentation processes, sediment instability, and pollutions. Conversely, other species can give information of the environment sensitivity, its natural conservation and its natural value (rare, uncommon, vulnerable, ...).

Main results on benthic endo-fauna:

All results indicate an impoverished benthic community:

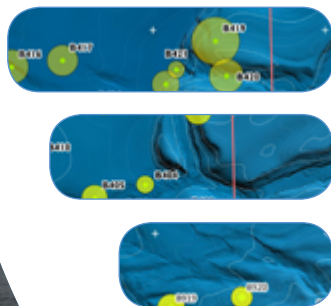
- **Low retained fauna sample** by the sieve.
- **Low specific richness** – B4: 4 to 15 species per station / B9: 0 and 8 species per station.
- **Low densities** – B4: 38 individuals/m² / B9: 27 ind./m².
- **Very low biomass produced:** < 0,15 g/m² on both blocks.
- **Low to medium diversity Shannon index** – B4: 2,9 bits / B9: 2,2 bits.
- **Low to medium trophic index** – B4: 64.3% / B9: 49%.

In terms of species composition:

- **Annelids** were dominant in terms of species and abundance.
- **Echinoderms** (Block 4) and **Sipunculids** (Block 9) dominated in terms of biomass.
- The annelid ***Notomastus sp.*** and **juveniles of bivalves** were the most abundant species on both blocks.

These results suggest that the ocean floor off the eastern coasts of the Levant Basin is an area of low biological benthic production, which corresponds to the low organic and nutrient enrichment of sediments.

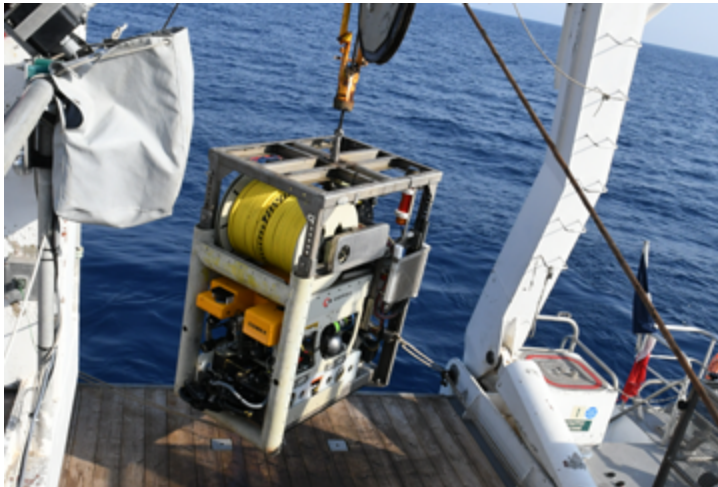
Examples of results



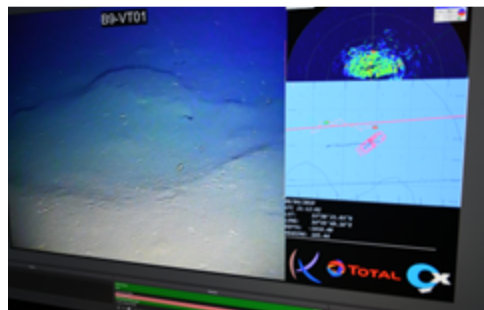
Benthos Plates



Example of low retained fauna sample in the sieve
© Creoclean



© Creoclean



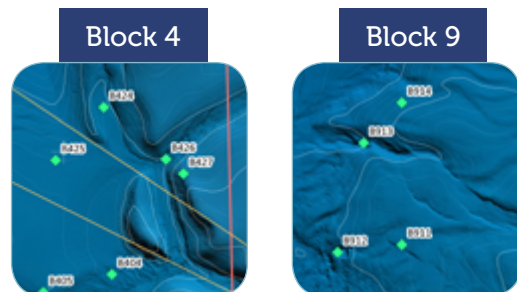
ROV deployment and equipment

The APACHE-type ROV is equipped with 4 thrusters, a wide-angle camera, an HD Camera BOWTECH, 4 projectors Deep-sea Power & Light 250 W, a depth sensor and one telemanipulation skid hydraulic HYDROLEK. The video system allows direct visual observations at about 3 to 4 meters in front of the ROV. Additionally, the ROV is also equipped with a sonar that allows object detection at a distance of about 80 meters upfront with an angle 120°.

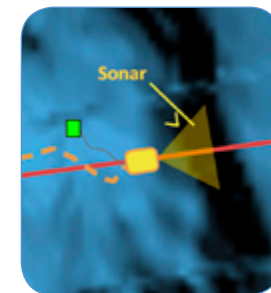
The ROV is controlled by a pilot and a copilot who provides navigation and assistance in handling the mechanical arms and triggering HD photo and video shots. It is lowered into a cage held by a 3000 m long cable, made of optical fiber wound on a winch. Once at about 20 meters above the seabed, the ROV exits its cage to which it is connected by an umbilical rolled up above the cage on a drum. It reaches the bottom and begins its progression along the theoretical line of the transect.

The length of the transects varied between 780 m and 1.3 km for a duration of exploration between 1h05 minutes and 2h05, depending on locations and the monotony of the relieves. A marine biologist recorded in an access database all the observations made from the video feedback. This concerned both the characteristics of the funds and the different living organisms encountered. Thanks to Quincy navigation software, all the observations were georeferenced.

Sampling effort on the two blocks



ROV operating and acquisition



 [Video of ROV operation](#)

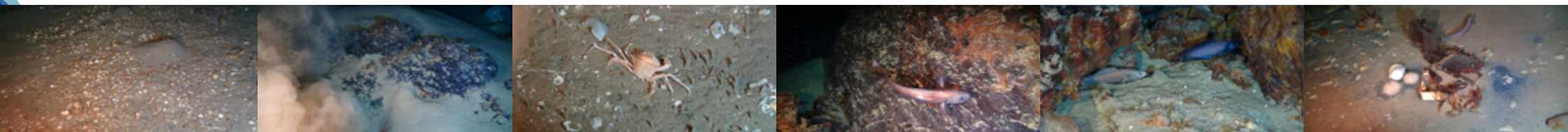
Seabed aspects and fauna on block 4

- The seabed was a flat sedimentary plain.
- Very little invertebrate biota was observed despite numerous traces of life (holes, mounds, print marks...).
- The main species were some red shrimps (included cf. *Aristeus antennatus*) and fishes, mainly tripod fishes (*Bathypterois dubius*).

- Rocky outcrops (carbonate crust) were encountered within a pre-identified **pockmark area** (B4-VT07 and B4-VT13), with dark hard reliefs one or two meters high colonized by sessile invertebrates (fairly abundant shells, white urchins, and crabs) and few fish (*Diplocanthopoma cf. brachysoma*, *Lepidion sp.*).
- The seafloor was characterized by a high abundance and frequency of anthropogenic waste, various in nature and size (average of frequency: 1 waste per 50 m, likely due to the proximity to Beirut).

Plates with sediment aspects, mains species and wastes

Plates on rocky outcrops



Shell accumulation

Rocky outcrops

Carbe living in the rocky outcrops

Fishes living in the rocky outcrops

Fishes living in the rocky outcrops

White urchins and wastes

© Comex

Soft seafloor aspect and cocolonization on block 4



Soft sediment with holes and mounds



Longnosed skate (*Galeus melastomus*)



Red shrimp (cf. *Aristeus antennatus*)



Anthropogenic waste colonized by a fish



Tripod fish (*Bathypterois dubius*)



Blackfin sorcerer fish (*Nettastoma melanurum*)



Anthropogenic waste



Acumulation of anthrpopogenic waste

© Comex

Seabed aspects and fauna on block 5

- No outcrops
- Singular reliefs:
 - Medium size (<1m side) black hard substrates apparently randomly dispersed (on B9-VT02, B9-VT03, B9-VT04 and B9-VT05).
 - Mega ripples like hydraulic dunes at several stations.
 - High slopes, successive steps and real vertical cliffs of several meters

high (corresponding to collapse profile on high slopes linked to the instability of marine bottoms due to rising fluids) where clay stratifications clearly appeared on stations from the western part of the block (on B9-VT01, B9-VT02 and B9-VT03, as well as B9-VT07).

- Local stone fields with white urchins (B9-VT02).
- The seafloor was characterized by a high abundance and frequency of anthropogenic waste, various in nature and size (average of frequency: 1 waste per 100 m).

Plates



Video on particular relieves on B9

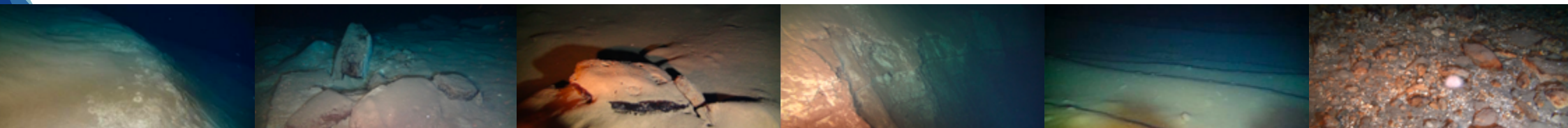


Video on fish



Video on wastes

Particular relieves on Block 9



White microbial mats

Black hard substrates

Black hard substrates covered by sediments

Vertical cliff

Ripple marks

Stone field with white urchins

© Comex

Soft seafloor aspect and cocolonization on block 9



Submarine cable



Grouped holes in patch



Red shrimps (cf. *Aristeus antennatus*)



Domes



Tripod fish (*Bathypterois dubius*)



Common Atlantic grenadier (*Nezumia aequalis*)



Anthropic waste



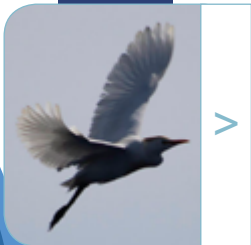
Acumulation waste

© Comex

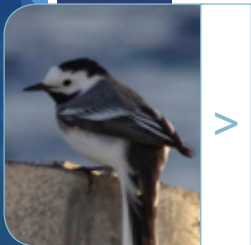
Plate species



Block 4



Block 9



Opportunistic megafauna sightings and marine traffic survey

Two trained and experienced Marine Fauna Observers (MFOs) from COHABY company conducted visual operations from an observation station on the bridge deck of the survey vessel. These visual observations were conducted during daylight hours (roughly sunrise to sunset and when weather permits) when the vessel was on station (conducting benthic surveys), underway between stations, and transiting to and from the port. The MFOs recorded opportunistic sightings of marine mammals, sea turtles, seabirds, fish, invertebrates, and vessels as well as floating wastes.

Visual efforts: 2 plates

Results on megafauna:

- Marine mammals: only two observations of bottlenose dolphins were in Block 4 and one observation of a group of unidentified delphinids in Block 9.
- No sighting of turtles.
- 94 and 53 sightings birds, respectively in Blocks 4 & 9, including 12 and 10 species, mostly Laridae.
- Fish: few rays and coryphaenid sightings.

Results on anthropogenic Activities:

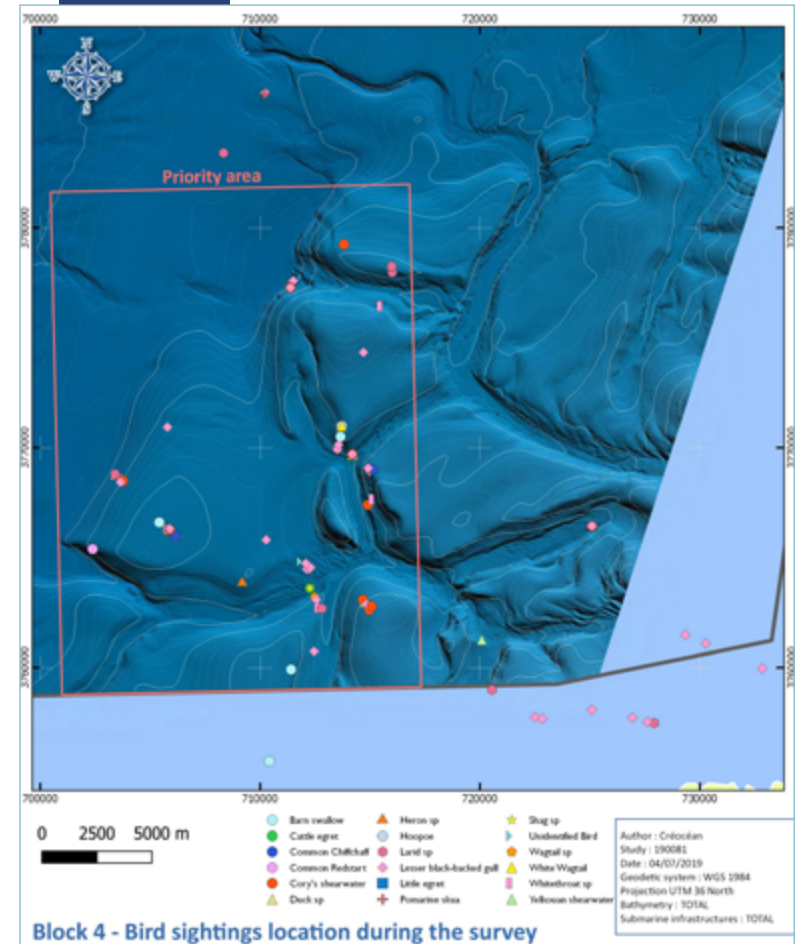
- Numerous sightings (36 and 24 in Block 4 & 9) of marine traffic: cargo ships and tankers, military vessels, ferry, and fishing boats.
- Respectively 92 and 43 sightings of wastes (plastic or other) in Blocks 4 & 9.

Conclusion:

Blocks 4 & 9 are not highly frequented by marine mammals, possibly due to human activities.

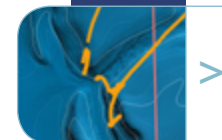
The area is more frequented by birds, mainly Laridae, which is in line with the scientific literature. Lebanon is considered a bottleneck along an important bird flyway twice a year and is located on one of the world's main migratory bird corridors (MoE/UNEP/GEF, 2016).

Block 4

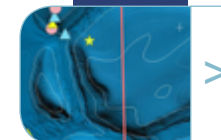


Block 4 - Bird sightings location during the survey

Block 4



Block 4



Block 9



The oceanographic campaign contributes to increase the knowledge in offshore Lebanon waters with the following main results:

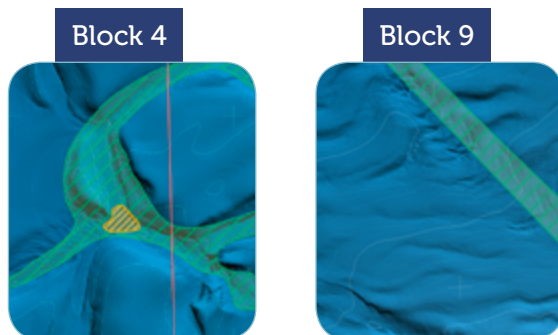
- **Offshore waters are oligotrophic**, although conditions may vary with the seasons according to the bibliographic literature.
- **Waters bodies are uncontaminated** despite substantial contamination of the Lebanese coast.
- Water mass characteristics showed **high homogeneity** in the of environmental conditions in the two blocks.
- The seabed was composed of **pure mud, with low organic and nutrient enrichment**, except for Total Organic Matter.
- **Sediments were uncontaminated** but significant concentrations of **copper, nickel and arsenic** which are detected at the scale of the Levantine Basin.
- **Benthic** infauna and epifauna communities were very impoverished.
- A particular **pockmark area in Block 4 was discovered**, with dark hard reliefs (carbonate crust, colonized by abundant shells, urchins, crabs, and few fishes).
- **Singular high reliefs were encountered in Block 9** (black rocks, mega ripple marks and high successive cliffs) but with no specific fauna colonization.
- **The study area sheltered very few spotted marine mammals** and no turtles.

- **A higher occurrence and diversity of birds was observed**, birds migrating along the Lebanon coast.
- **Vessel circulation was high** (tankers, cargo vessels, warship).
- **A high abundance and diversity of wastes was observed** on the seafloor and floating on the sea surface.
- **No archaeological findings were detected throughout the entire campaign.**

Sensitive maps were drawn on Blocks 4 and 9, highlighting the particular area with carbonate crust on Block 4. Outside of this area, no sensible recognized area was observed on both blocks. However, since a small surface of the canyons were explored during the oceanographic campaign, and due to high relieves discovered along these structures (especially on Block 9), we cannot rule out the hypothesis that canyons may locally shelter sensitive surfaces.

The baseline survey is an important step in the impact assessment process. it provides essential information in terms of environment quality, potential pre-existing contaminations, biological richness, ecological functions and sensitivity of habitats. All these informations are essential for evaluating ecological issues according to the impacts of the project.

Sensitivity map



Sensitivity criteria

Habitats	Criteria	Block 4		Block 9	
		Validated sensitivity	Potential sensitivity	Validated sensitivity	Potential sensitivity
Flat soft sediment plain	Low to very low biological richness and diversity	Very low		Very low	
Canyons	Low biological richness and diversity observed during the campaign but areas with potential according to OCEANA mission (CNRS, 2014)		Low		Low
Canyons boundary with high slopes	Low biological richness and diversity observed during the campaign but areas with potential according to OCEANA mission (CNRS, 2014)		Low		Low
Pockmark areas	Outcrops build dark hard reliefs sheltering higher biological richness and diversity. Extrapolation to other known pockmark areas	High	High		



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