# FRA Proposal: The Palmahim Disturbance Cold Water Coral Gardens and Cold Seeps

Standard Form for the Submission of Proposals for GFCM Fisheries Restricted Areas (FRAs) in the Mediterranean and the Black Sea


אוני׳ברסיטת חיפה
University of Haifa
جامعة حيفا

The Society for the Protection of Nature in Israel
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הרפורמה להצלת הים התיכון

Name of the FRA

**The Palmahim Disturbance Cold Water Coral Gardens and Cold Seeps**

Submitted by:

**The Society for the protection of Nature in Israel**

www.mafish.org.il/english

**University of Haifa, Israel**

Date of submission:
April 2021
revised, May 31 2021

The data presented in this proposal is based, mainly, on the research work of Dr. Yizhaq Makovsky, and on the PhD thesis of Adam Weissman under the supervision of Prof' Dan Chernov.

Unless specified otherwise, all photos in this document where taken during research expeditions with the participation of researchers from the University of Haifa, including:

- 2010-2011 expedition on E/V Nautilus as part of NA019 - Exploration of the Israel Continental Margin, led by – Leon H. Charney School of Marine Sciences, University of Haifa; ;Institute for Exploration, University of Rhode Islands; The Helmsley Charitable Trust; Israel Oceanographic and Limonological Research Institute
- 2017 - Charney School of Marine Sciences expedition on the Bat –Galim research vessel using the Leopard ROV, led by Dr Yizhaq Makovsky
- 2016 - expedition on R/V Aegeo as part of SemSeeps project, funded by Eurofleets and led by Dr Yizhaq Makovsky and Dr. Andres Rüggeberg.

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# Table Of Content

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# Executive Summary

Summary of the information contained in sections 2 to 8, including expected results

The Palmahim Disturbance is a unique site with fragile and vulnerable deep-sea ecosystems, such as coral gardens and cold seeps, based upon a distinct geological formation. In addition, in the pelagic domain, a spawning area for Atlantic Bluefin Tuna occurs.

The Palmahim Disturbance is a salient submarine slide deforming the continental margin off southern Israel due to gravitational slumping above the Messinian evaporates. The benthic habitats present at the Palmahim Disturbance fit the criteria for Vulnerable Marine Ecosystems (VME) (IUCN, 2019; CBD 2016; GFCM, 2018). the Pelagic area is also important as Essential Fish Habitat (EFH) for priority species like Atlantic Blue fin Tuna.
The objectives of the proposed FRA are therefore:
1. VME protection (primary objective).
2. EFH protection.

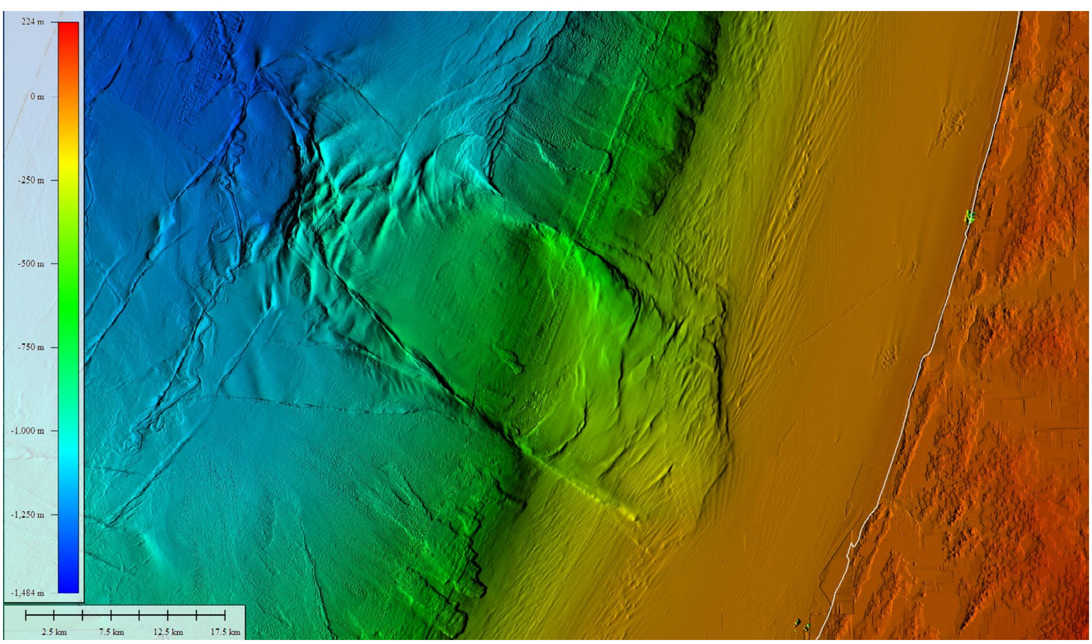
The Palmahim Disturbance represents a rare occurrence of hard substrate in the deep water of the southeastern Mediterranean, which is generally soft bottomed with low species richness. Two distinct benthic ecosystems are present in the area, forming biodiversity hotspots in the deep Levant Sea:
On the margins of the Palmahim Disturbance, exposed carbonate rocks facilitate the succession of cold-water coral (CWC) communities, which inhabit rare and endangered species in need of immediate protection, such as black corals, octocorals, sea pens, deep-sea sharks and rays and a wide variety of invertebrates.

In the deeper, western zones of the site, cold seeps fuel fragile chemosynthetic communities sustaining symbiotic and non-symbiotic organisms such as tubeworms, clams, crustaceans, echinoderms and fish, which depend on the chemosynthetic primary production. Some of these sites were found recently (2021) to function as mass reproduction sites for blackmouth catsharks, in the vicinity of recently discovered brine pools.

Although fishing activity in the area is low intensity, due to the sensitivity of the ecosystem, those activities take a heavy toll on nature. Recent scientific surveys at the locality have documented habitat destruction caused by bottom trawling: evident trawl marks and carbonate rubble demonstrate the damage caused to the benthic communities and the potential for large-scale habitat destruction of the entire site, if protective measures are not taken. Damage to CWC systems may be irreversible due to destruction of the substrate itself. Even if the substrate were to remain intact, the slow growth rates, combined with other anthropogenic stressors, may substantially inhibit the recovery of the benthic systems. Therefore, even a single event of trawling over the CWC gardens could destroy this rare community. The cold seep communities depend on the carbonate rock foundation for

settlement as well. Thus, bottom trawling, which crushes the carbonate rocks, may pose a serious threat to these unique chemosynthetic communities.
Other fishing practices, such as long lines and nets, have also left their mark on the coral communities, and were found entangled in the corals at numerous locations, obstructing their food availability and at times splitting the colonies.

The pelagic zone is a spawning ground for the endangered Atlantic Bluefin Tuna (BFT). The area may support the reproduction of a genetically distinct population.
In light of the fragile and unique benthic ecosystems found at the Palmahim Disturbance and its importance for shark reproduction and for the endangered BFT, the evident damage and future risks to the VME and endangered species at the locality, we propose closing the Palmahim Disturbance to fishing, for the conservation of biodiversity in both the benthic and pelagic habitats. This is expected to ensure the survival of the benthic VMEs, and the safe reproduction of sharks and BFT in the FRA. Both outcomes will support the replenishment of fish stocks in the eastern Mediterranean, and boost research and education activities in the deep-sea.




**general map of Palmahim disturbance.**
Map created by Yizhaq Makovsky. The basis of this map is from EmodNet, and is based on Hall, J. K., Lippman, S., Gardosh, M., Tibor, G., Sade, A. R., Sade, H., … Nissim, I. (2015). A New Bathymetric Map for the Israeli EEZ: Preliminary Results. Ministry of National Infrastructures, Energy and Water Resources and the Survey of Israel.

2

# Area Identification

## 2.1. GFCM GEOGRAPHICAL SUBAREA

Eastern Levant Sea ,GSA 27

## 2.2. NAME OF THE FRA

The Palmahim Disturbance Cold Water Coral Gardens and Cold Seeps

## 2.3. GEOGRAPHICAL LOCATION

### 2.3.1. General location

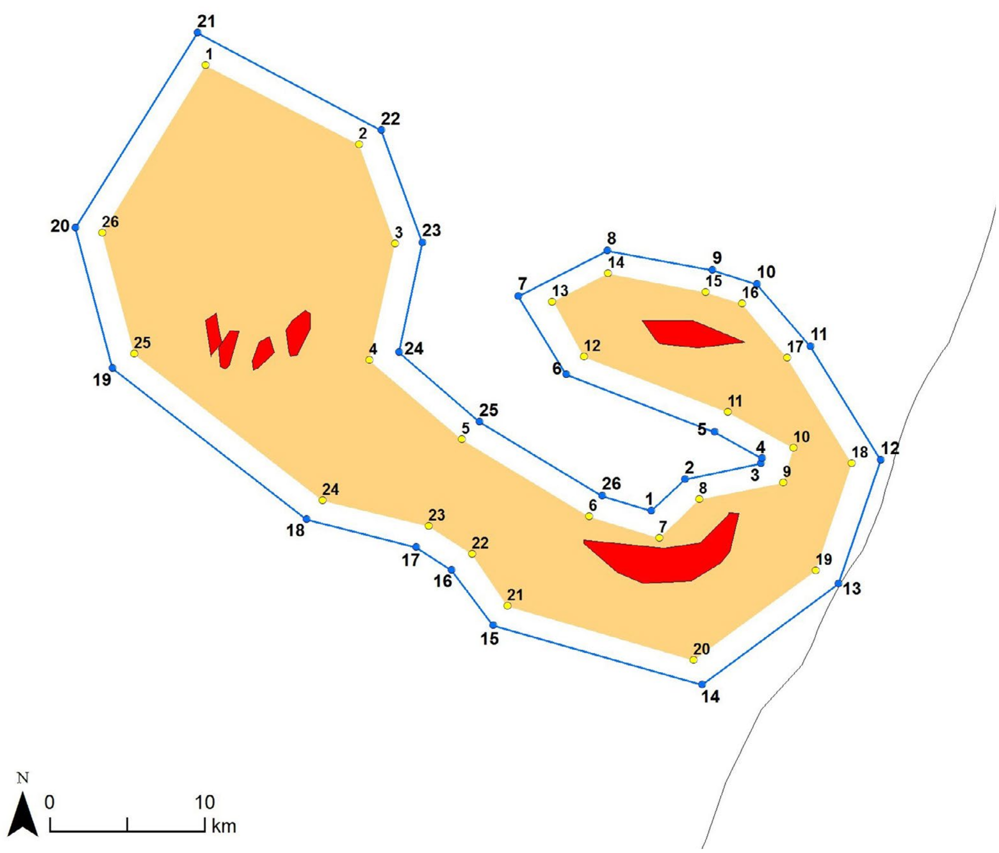
The area is located in the southeastern Levant Sea, west of the central Israeli shore.

### 2.3.2. Precise location of the proposed core area

Provide geographical coordinates (latitude and longitude in degrees, minutes and seconds) for the vertex of a polygonal area.

| Long | Lat | POINT_Y | POINT_X | ID |
|---|---|---|---|---|
| 34° 6' 45.419" E | 32° 18' 56.133" N | 32.315592 | 34.112616 | 1 |
| 34° 12' 8.331" E | 32° 16' 9.540" N | 32.269317 | 34.202314 | 2 |
| 34° 13' 23.281" E | 32° 12' 40.940" N | 32.211372 | 34.223134 | 3 |
| 34° 12' 29.779" E | 32° 8' 36.657" N | 32.143516 | 34.208272 | 4 |
| 34° 15' 43.861" E | 32° 5' 49.622" N | 32.097117 | 34.262184 | 5 |
| 34° 10' 51.665" E | 32° 3' 41.493" N | 32.061526 | 34.181018 | 24 |
| 34° 4' 16.087" E | 32° 8' 49.151" N | 32.146986 | 34.071135 | 25 |
| 34° 3' 8.493" E | 32° 13' 3.793" N | 32.21772 | 34.052359 | 26 |
| 34° 18' 52.883" E | 32° 10' 39.121" N | 32.177534 | 34.31469 | 13 |
| 34° 20' 50.252" E | 32° 11' 38.112" N | 32.19392 | 34.347292 | 14 |
| 34° 24' 15.275" E | 32° 10' 58.969" N | 32.183047 | 34.404243 | 15 |
| 34° 25' 32.569" E | 32° 10' 34.791" N | 32.176331 | 34.425714 | 16 |
| 34° 27' 6.703" E | 32° 8' 41.040" N | 32.144733 | 34.451862 | 17 |
| 34° 29' 21.877" E | 32° 4' 59.069" N | 32.083075 | 34.48941 | 18 |

| | | | | |
|---|---|---|---|---|
| 34° 28' 6.798" E | 32° 1' 14.389" N | 32.020664 | 34.468555 | 19 |
| 34° 23' 49.690" E | 31° 58' 5.745" N | 31.968263 | 34.397136 | 20 |
| 34° 17' 19.285" E | 32° 0' 0.005" N | 32.000001 | 34.28869 | 21 |
| 34° 16' 5.638" E | 32° 1' 48.492" N | 32.030137 | 34.268233 | 22 |
| 34° 14' 34.240" E | 32° 2' 47.920" N | 32.046644 | 34.242844 | 23 |
| 34° 20' 11.008" E | 32° 3' 7.944" N | 32.052207 | 34.336391 | 6 |
| 34° 22' 38.553" E | 32° 2' 22.432" N | 32.039564 | 34.377376 | 7 |
| 34° 24' 1.772" E | 32° 3' 43.935" N | 32.062204 | 34.400492 | 8 |
| 34° 26' 57.992" E | 32° 4' 18.866" N | 32.071907 | 34.449442 | 9 |
| 34° 27' 19.693" E | 32° 5' 32.443" N | 32.092345 | 34.45547 | 10 |
| 34° 25' 1.646" E | 32° 6' 47.834" N | 32.113287 | 34.417124 | 11 |
| 34° 20' 0.000" E | 32° 8' 43.439" N | 32.1454 | 34.333333 | 12 |



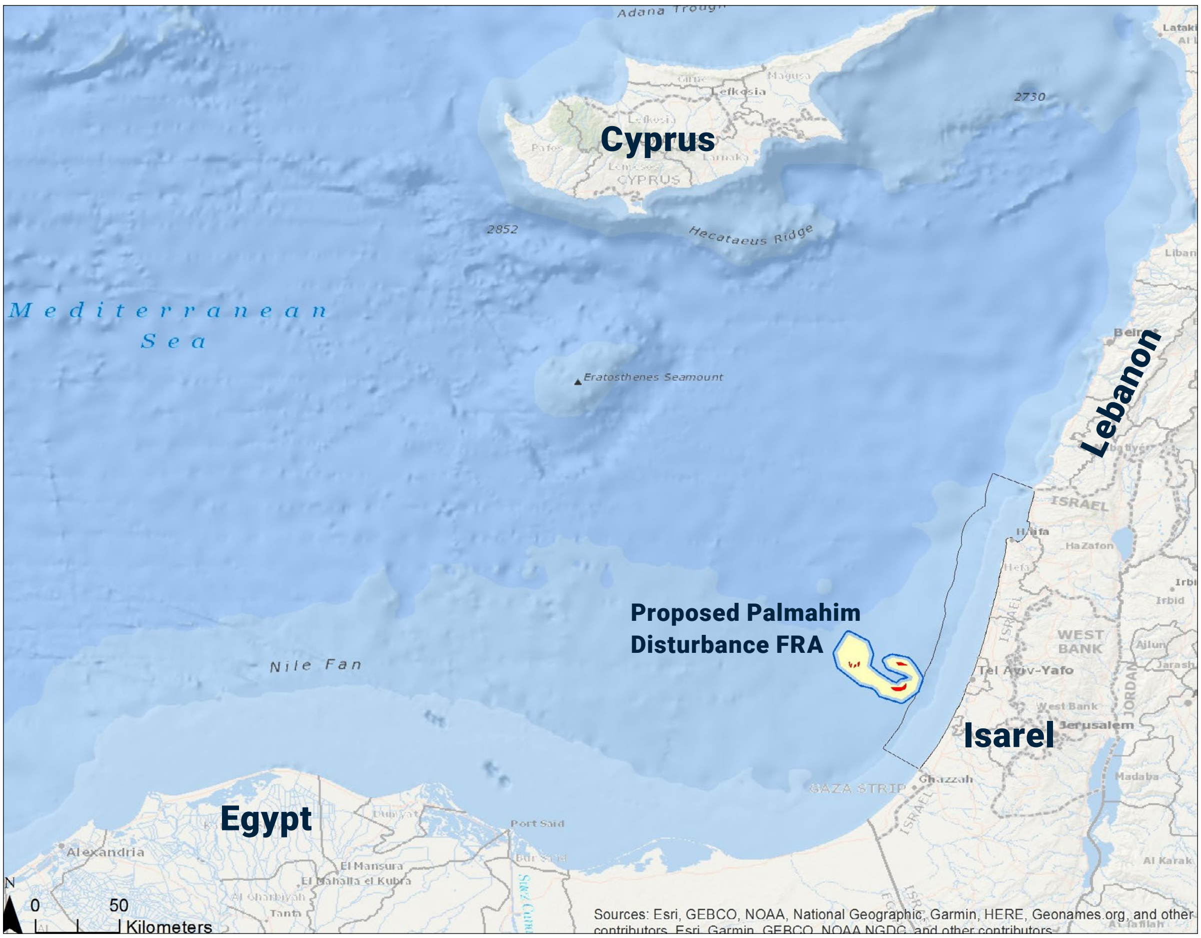
### 2.3.3. Buffer area (if applicable)

Provide geographical coordinates (latitude and longitude in degrees, minutes and seconds) for the vertex of a polygonal area.

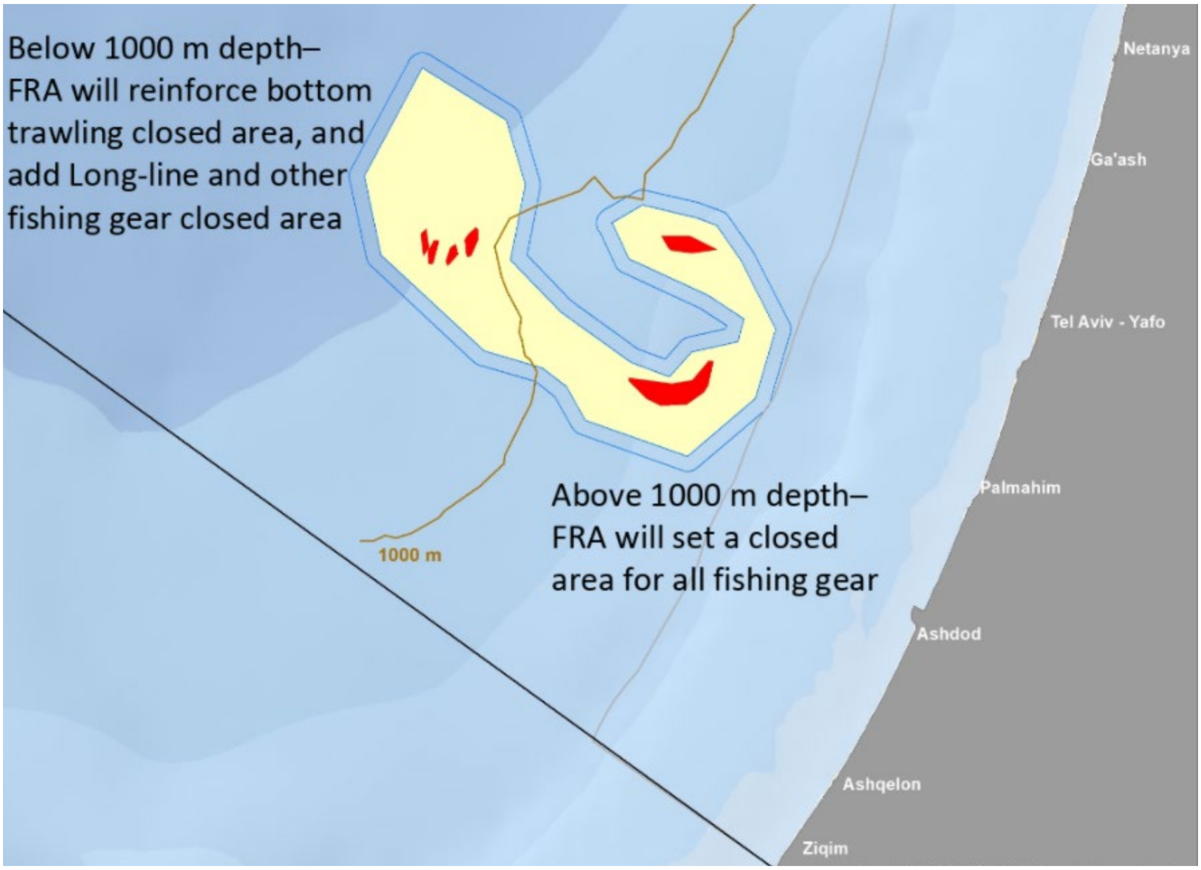
| Longitude | Latitude | ID |
|---|---|---|
| 34° 22' 21.142" E | 32° 3' 19.612" N | 1 |
| 34° 23' 32.609" E | 32° 4' 25.836" N | 2 |
| 34° 26' 11.012" E | 32° 4' 59.568" N | 3 |
| 34° 26' 14.192" E | 32° 5' 10.355" N | 4 |
| 34° 24' 34.294" E | 32° 6' 4.902" N | 5 |
| 34° 19' 22.841" E | 32° 8' 6.388" N | 6 |
| 34° 17' 42.089" E | 32° 10' 51.265" N | 7 |
| 34° 20' 48.877" E | 32° 12' 26.805" N | 8 |
| 34° 24' 30.270" E | 32° 11' 45.976" N | 9 |
| 34° 26' 3.051" E | 32° 11' 16.025" N | 10 |
| 34° 27' 56.292" E | 32° 9' 5.378" N | 11 |
| 34° 30' 23.410" E | 32° 5' 6.769" N | 12 |
| 34° 28' 54.039" E | 32° 0' 46.962" N | 13 |
| 34° 24' 7.681" E | 31° 57' 14.913" N | 14 |
| 34° 16' 48.933" E | 31° 59' 18.731" N | 15 |
| 34° 15' 21.867" E | 32° 1' 15.678" N | 16 |
| 34° 14' 8.201" E | 32° 2' 3.574" N | 17 |
| 34° 10' 17.880" E | 32° 3' 2.189" N | 18 |
| 34° 3' 30.428" E | 32° 8' 19.763" N | 19 |
| 34° 2' 12.688" E | 32° 13' 14.845" N | 20 |
| 34° 6' 28.096" E | 32° 20' 3.843" N | 21 |
| 34° 12' 54.100" E | 32° 16' 38.873" N | 22 |
| 34° 14' 20.465" E | 32° 12' 43.939" N | 23 |
| 34° 13' 31.548" E | 32° 8' 52.792" N | 24 |
| 34° 16' 21.061" E | 32° 6' 26.876" N | 25 |
| 34° 20' 37.808" E | 32° 3' 51.483" N | 26 |

### 2.3.4. Location map

Include geographical coordinates of the core and buffer areas, bathymetry and boundary of international waters. Add a global reference map of the Mediterranean with the location of the site.




The map of the site in the Levant Sea




**Close up of the suggested FRA.** The areas in **RED** are benthic VMEs observed by ROV: The two eastern polygons are CWC habitats, while the deeper, western, polygons are the Cold Seeps. The **YELLOW** polygon is an area unexplored by ROVs yet, although acoustic geophysical data indicated a high potential for hard substrate – indicating a high probability for additional benthic VMEs. The area between the yellow zone and the **BLUE** line is the suggested Buffer Zone (1.5 km). The **dashed black** line is the Israeli marine border with Gaza, the dashed gray line is the Israeli territorial water boundary, and the brown line marks the 1000 m depth which is the maximal depth where trawling is allowed according to the GFCM decision from 2005.

### 2.3.5. Depth range

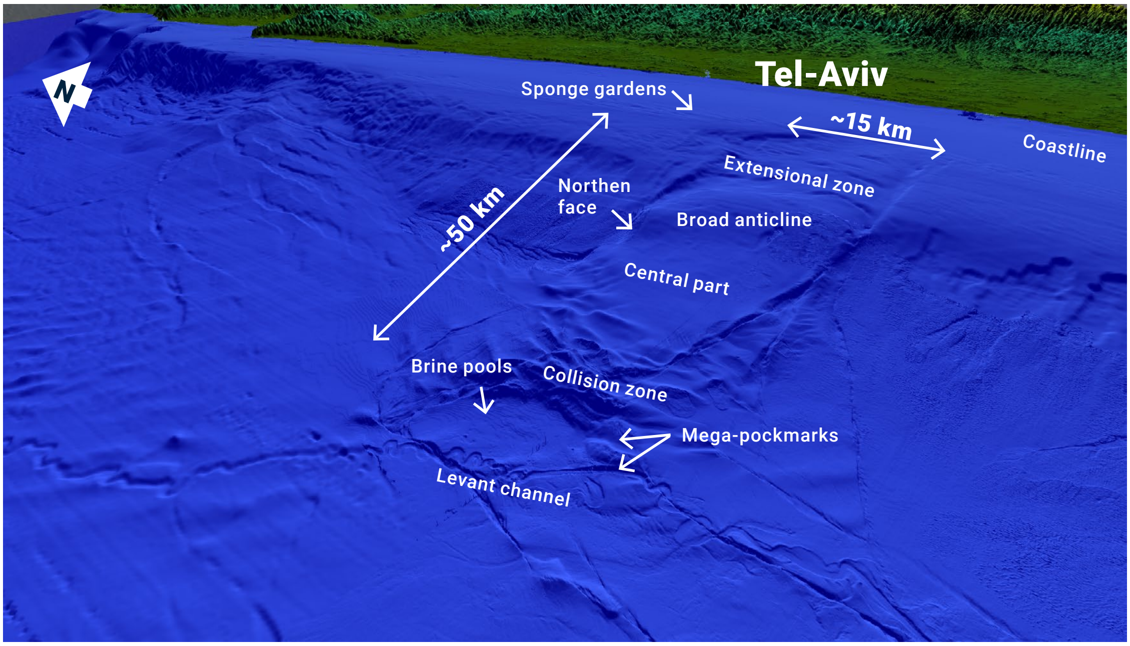
Core Zone: bottom depth 450-1200 mbsl, which includes:

- Pelagic zone – The entire water column.
- The cold-water corals grow at 450-850 mbsl.
- The cold seep communities are located at 900-1200 mbsl.

## 2.4. SURFACE AREA

In ha and km2. Specify core and buffer area, if applicable.

- The proposed core area is 590 sq. km/59000 ha.
- The buffer zone is 255 sq. km/25500 ha.




**3D simulation of the Palmahim disturbance, view from south west.**

Map created by Yizhaq Makovsky. The basis of this map is from EmodNet, and is based on Hall, J. K., Lippman, S., Gardosh, M., Tibor, G., Sade, A. R., Sade, H., … Nissim, I. (2015). A New Bathymetric Map for the Israeli EEZ: Preliminary Results. Ministry of National Infrastructures, Energy and Water Resources and the Survey of Israel.

3

# Site Description

## 3.1. MAIN PHYSICAL FEATURES

### 3.1.1. Geology/Geomorphology

Briefly describe geological aspects, sedimentation and erosion processes observable in the area and other geomorphologic features or geological risks. Indicate bibliographical sources.

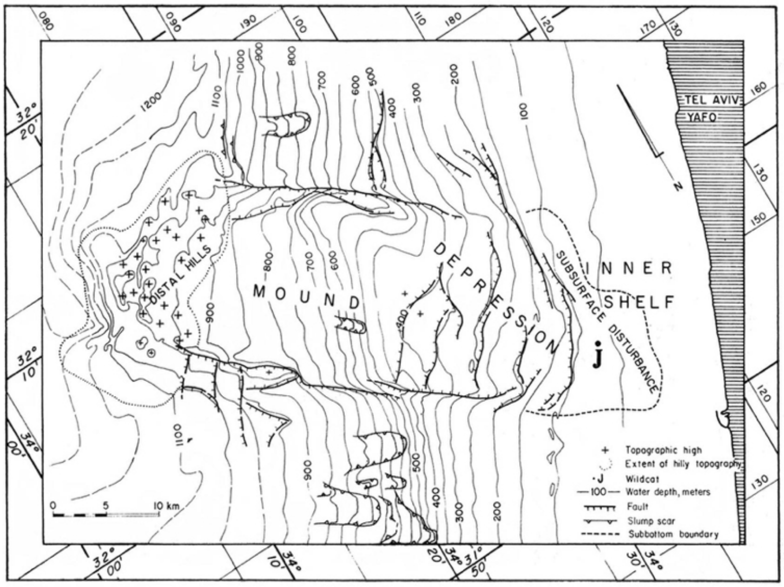
The Palmahim Disturbance is a large-scale 15x50 km rotational slide, stretching between water depths of ~100 m and ~1200 m on the continental slope offshore Israel (Almagor and Garfunkel, 1979). This continental slope, bounding the ultra-oligotrophic southeastern Mediterranean Sea (e.g. Krom et al. 2004), is composed predominantly of fine grain clayey clastic sediments supplied by the Nile river to the south (e.g. Almogi-Labin et al. 2009). The Disturbance has a general box shape, delimited on the northeast and southwest by a series of faults and a head scarp in the southeast at ~100 mbsl and a series of folds in the compressional zone at the base of the slide to the northwest at ~1100 mbsl (Garfunkel et al. 1979). However, extensive presence of authigenic carbonates, the product of the biogenic degradation of naturally seeping hydrocarbons, along the perimeters of the Palmahim Disturbance (Coleman et al. 2011; Makovsky et al. 2016; Rubin-Blum et al. 2014) **provide a unique concentration of hard substrates in the otherwise soft-bottomed deep southeastern Mediterranean basin**.

### 3.1.2. Other relevant physical or chemical features

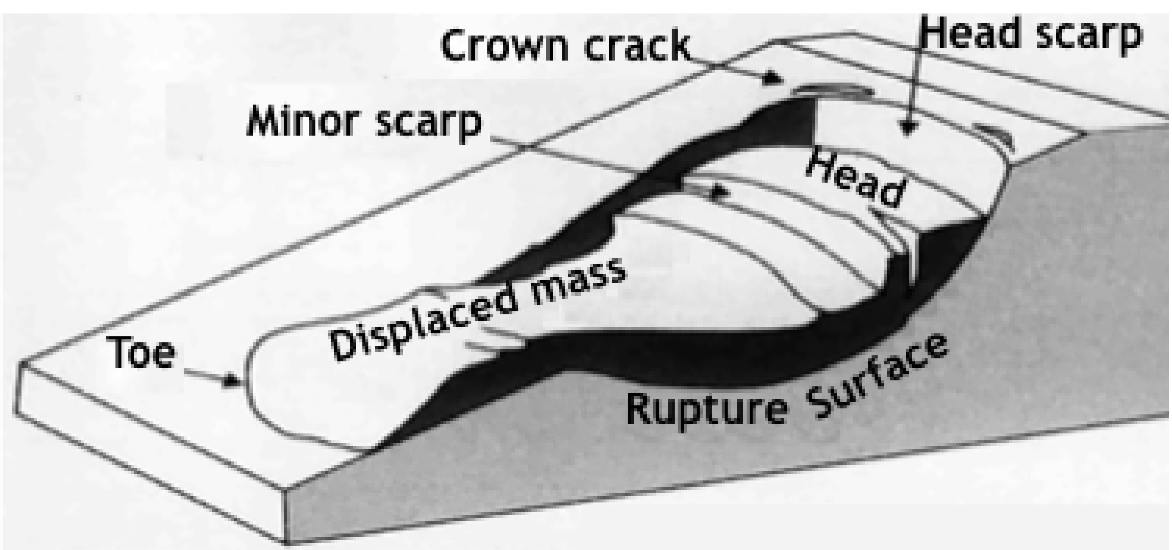
E.g. hydrodynamics, frontal areas, upwelling, etc.

The area surrounding the cold seeps (900-1200 Meters Below Sea Level - mbsl) appears to be highly bioturbated, indicating intense biological activity, uncommon at these depths in the surrounding area. The bioturbation is assumed to be fuelled by widespread subsurface chemosynthetic production. The only living macro-fauna found in the sediments was the ghost shrimp *Calliax lobate*, though large accumulations of dead chemosymbiotic bivalves were found aggregated on the sediments, indicating chemosynthetic trophic sourcing. Various deep-sea fishes have been documented roaming the area (Basso et al, 2020; Makovsky et al, 2017, Makovsky et al. 2020).

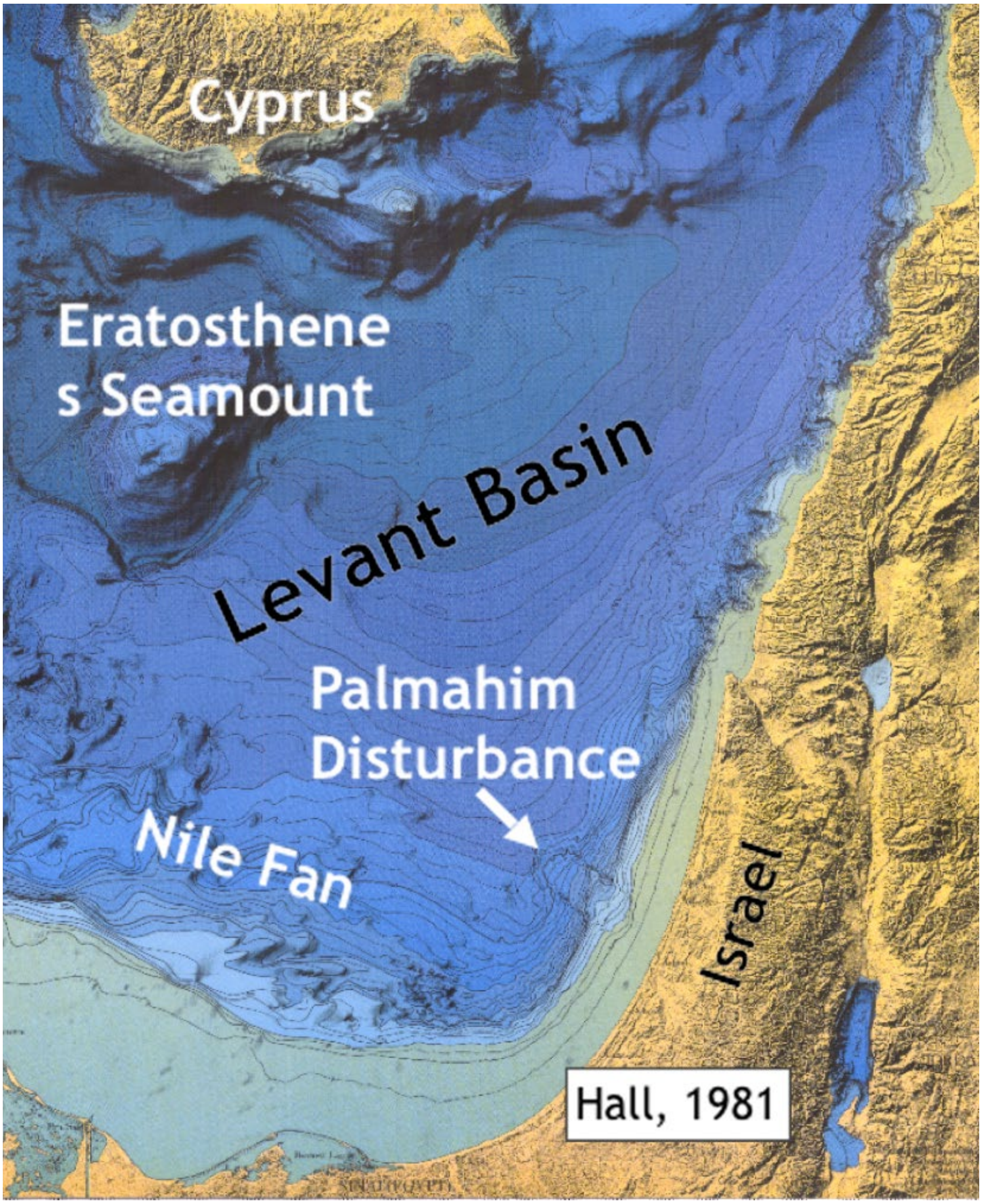
## PALMAHIM DISTURBANCE – A MAJOR ANOMALY ON THE SOUTHEASTERN MARGIN OF THE LEVANT




**Garfunkel et al., 1979**




**schematic description of submarine landslide features. Hampton et al.,1996**


Cyprus
Eratosthenes Seamount
Levant Basin
Palmahim Disturbance
Nile Fan
Israel
Hall, 1981

**Hall, 1981**

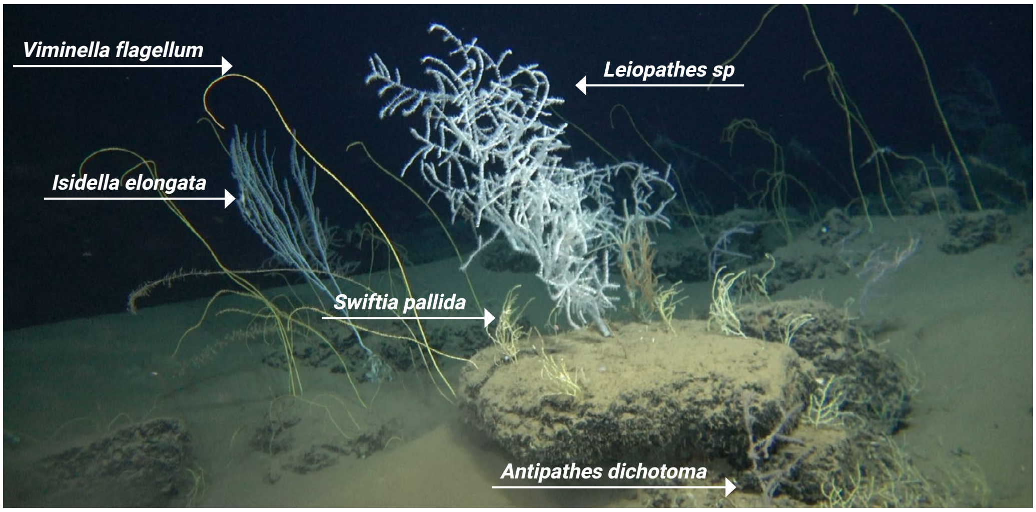
## 3.2. BIOLOGICAL FEATURES

### 3.2.1. Habitats

Briefly describe the dominant marine habitats, including pelagic habitats, if applicable.

Recent exploration has uncovered unique deep-sea communities on the Israeli shelf at the Palmahim Disturbance (Coleman et al. 2012). Vast coral gardens are distributed along the margins of the Palmahim disturbance, CWC (Cold Water Coral) meadows grow in the compact sediments around the coral gardens and cold seep communities thrive in the deeper western zones of the site. Recently, Brine seepage and brine pools where documented in the north - west part of the proposed FRA, with dense chemosynthetic tube-worm cover, and their vicinity appears to function as a blackmouth catshark reproduction hotspot, with numerous eggs laid on the benthos (Makovsky et al. 2021).

These benthic habitats form important deep-sea ecosystems, which are extremely rare in the eastern Mediterranean. These discoveries were documented by Remotely Operated Vehicle (ROV). Yet, habitat distribution model based on biophysical and ecological analysis conducted in the area, suggests that coral gardens and cold seeps are present in other areas on the site which were not yet visualized, and therefore estimates that VME's are present in almost all of the area proposed as FRA (Makovsky et al. 2020, attached as annex 1 to this proposal). This model is currently being validated by additional AUV and ROV explorations and the preliminary results from January and April 2021 indicated good predictive ability of the model (Makovsky and Rubin-Blum, 2021; Makovsky et al. 2021).




**Diverse CWC community on the northern margins of the Palmahim Disturbance, including black corals, whip corals, bamboo corals and additional octocorals.**

**The Critically Endangered *Isidella elongata* on compact mud sediments**

## Cold Water Coral Gardens

Diverse communities of endangered corals and associated deep-sea species, many of which are protected under several international agreements, were found to flourish at the site. This is the easternmost CWC community in the Mediterranean, and the only one found in the southeastern Levant Sea to date. Overall, more than 7400 colonies have been documented to date, including *Leiopathes, Antipathes Dichotoma, Callogorgia verticilata, Viminella flagellum and Parantipathes larix* (Makovsky et al, 2020).

## Octocoral Beds on Compact Mud

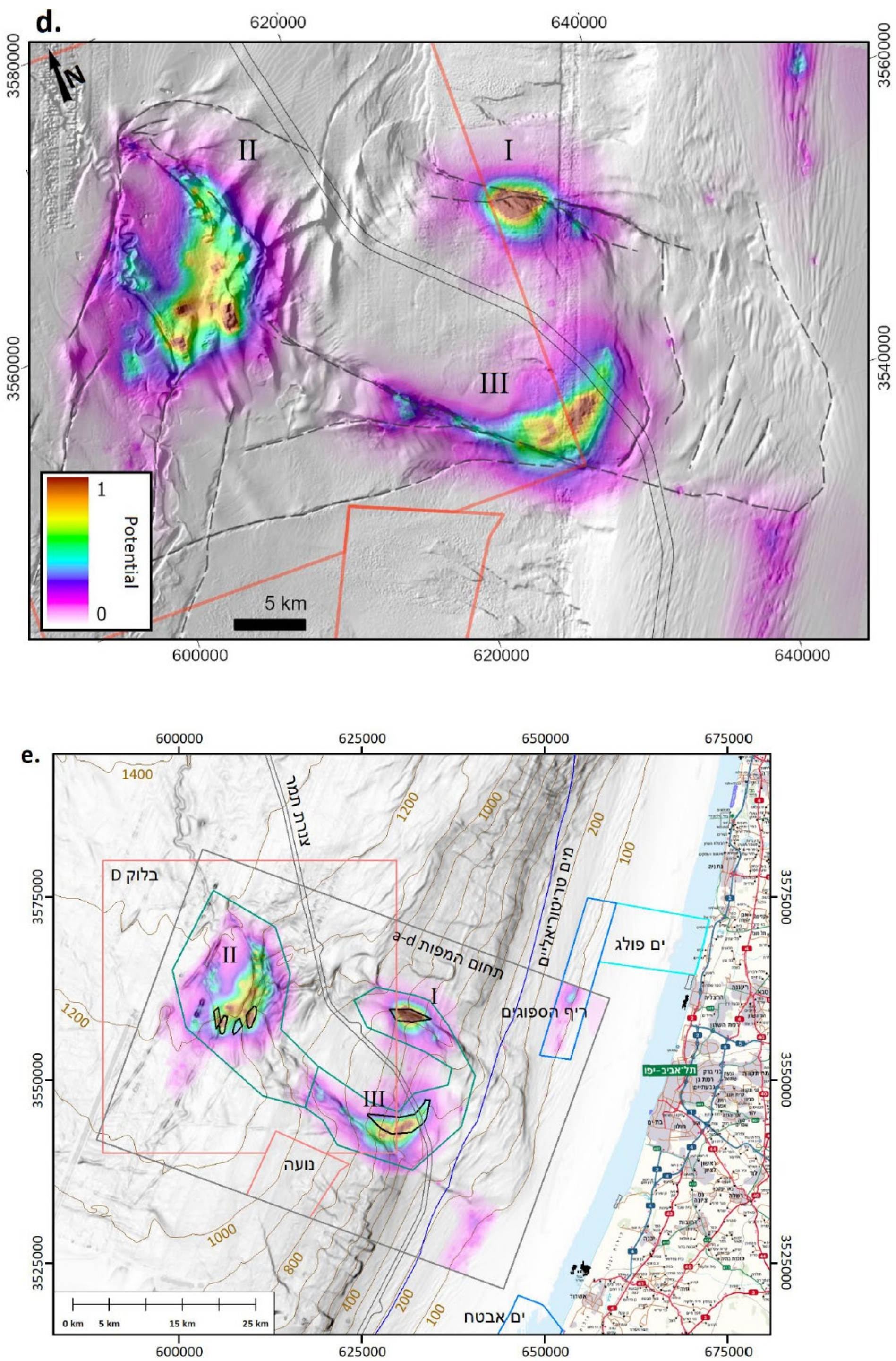
Numerous octocorals inhabit the surface of the compact mud in the area between the CWC gardens growing upon the rock facies. Both the critically endangered bamboo coral, *Isidella elongata*, and the sea pen *Funiculina quadrangularis* (VU) (Otero et al. 2017), are found in large numbers (Hundreds of colonies) at the locality (Weissman et al. unpublished data) The occurrence of either of these species is a criterion for essential Marine Habitats (EMH) relevant for the management of priority species (GFCM 11th session, 2008).

## Cold Seep Chemosynthetic Communities

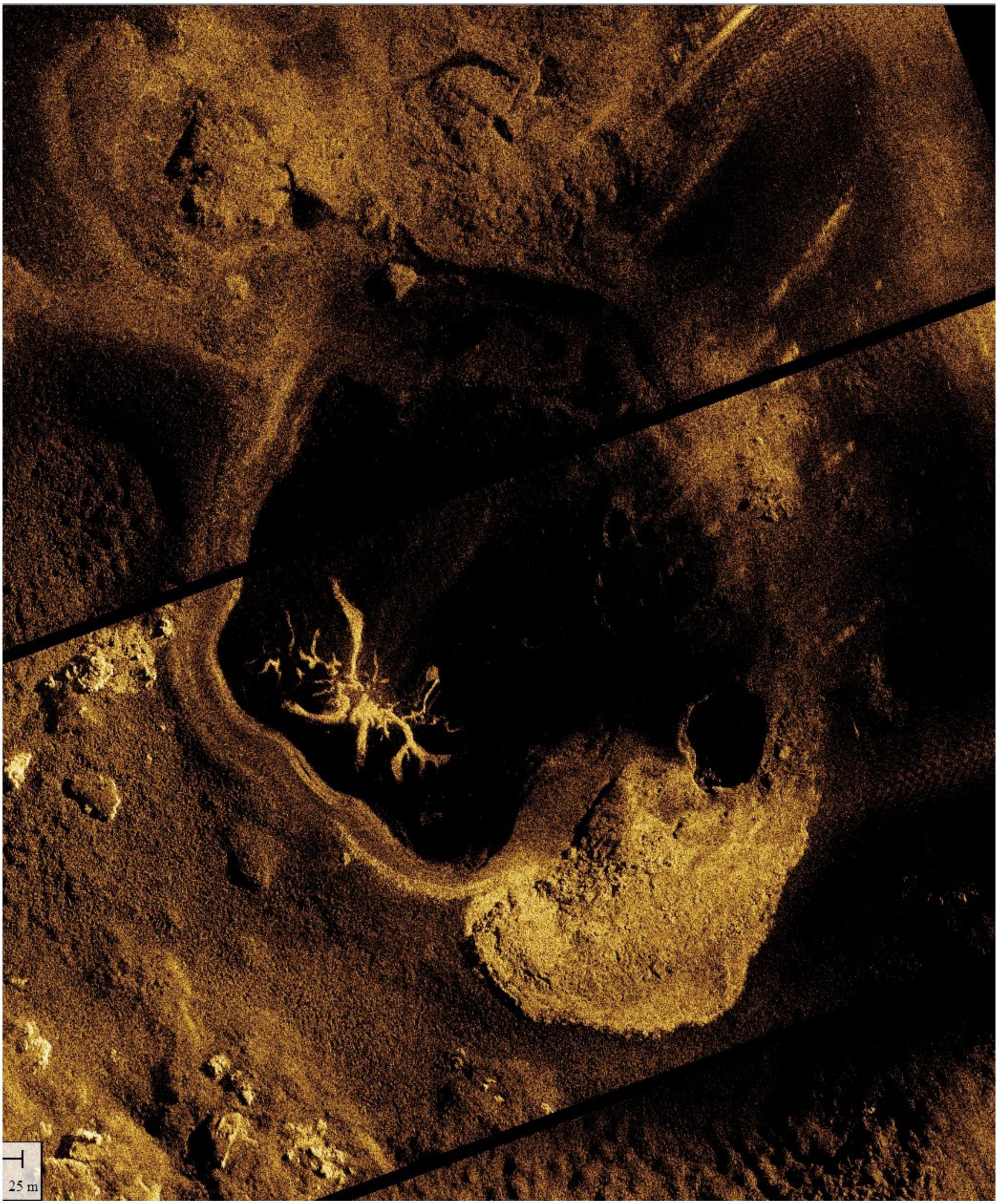
In seeps, microbial consortia oxidizing methane and their end-product (e.g., sulphide) sustain abundant microbial populations exhibiting diverse metabolic pathways. Differences in seep intensity and temperatures create distinct habitats, dominated by unique microbial communities, sustaining symbiotic and non-symbiotic organisms such as tubeworms, clams, crustaceans, echinoderms and fish, which depend on the chemosynthetic primary production. Cold seeps are biodiversity hotspots in the deep sea, featuring unique species compositions with high variability between different seep systems. The high variability of seep conditions in the oceans, contributes to highly adapted faunal communities with a high potential for endemic species. Even though species richness is low in each individual site (Levin, 2005), their unique species composition contributes substantially to the beta diversity in the deep sea (Cordes et al. 2010).

Chemosynthetic communities, inhabited by thriving populations of vestimentiferan tubeworms *(Lamellibrachia anaximandri)*, chemosymbiotic bivalves and echinoderms feeding on the biofilm formed on the carbonate rocks in the seeps, were described around hydrocarbon seeps at the deep outskirts of the Palmahim Disturbance (Rubin-Blum et al. 2014[a-d]). Although no endemism was documented among the species found at the seeps to date, it should be noted that no extensive biological survey has been conducted yet on the seeps of Palmahim Disturbance, and much remains to be discovered.

**A seep community at 1150 mbsl, exhibiting typical seep fauna living off chemosynthetic production – grazing urchins and crabs, and symbiotic *Lamellibrachia anaximandri* tubeworms.**



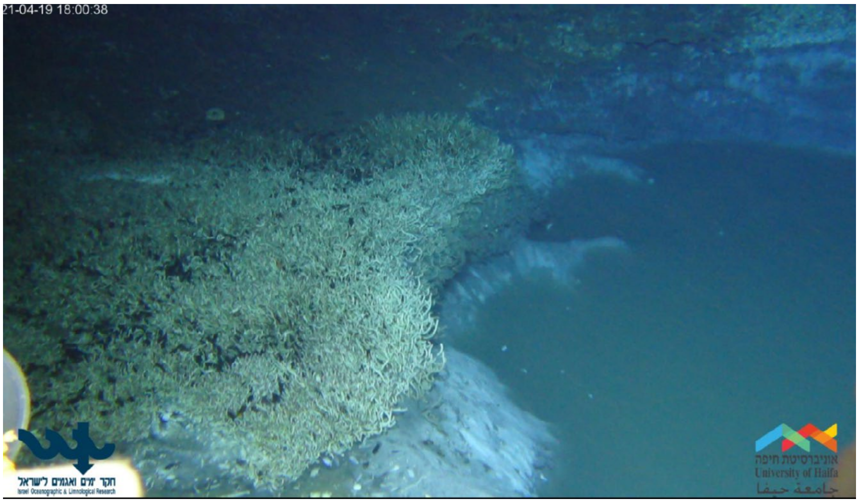

**The potential for VME occurrence in the Palmahim disturbance, according to a predictive model based on analysis of existing ROV sightings, Bathymetry, and substrate complexity. From Makovsky et al, 2020.**



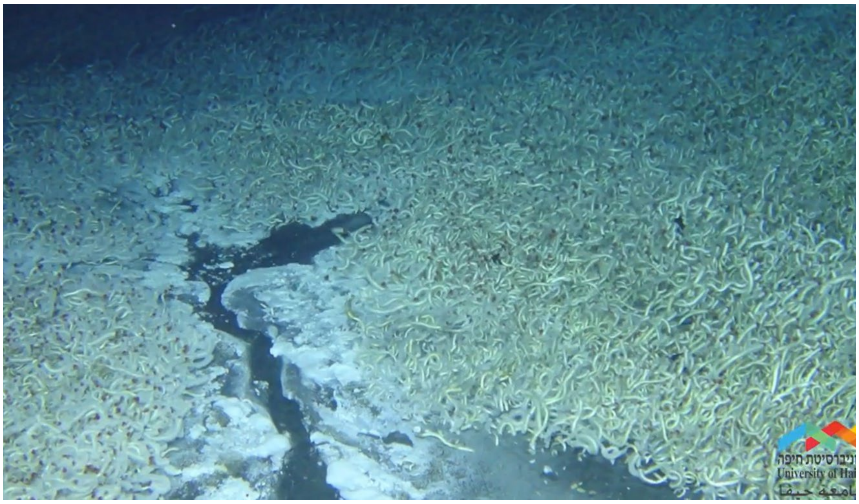

**SAS simulation of a site that was predicted by the model to contain pockmarks and seeps. Validation of the biophysical model indicate good predictive ability of the model (Makovsky and Rubin-Blum 2021).**

## Brine seeps and Brine pools

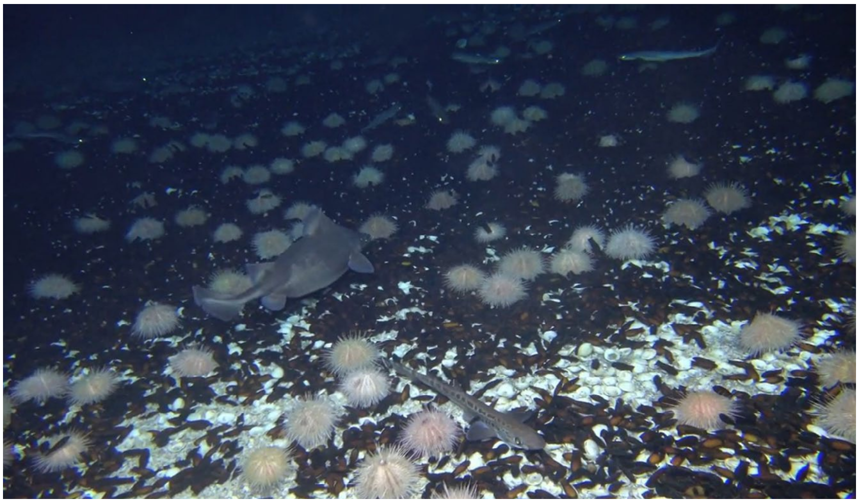
Newly discovered brine pools and brine seeps where recently documented to function as a hotspot for shark reproduction (Makovsky et al. 2021).



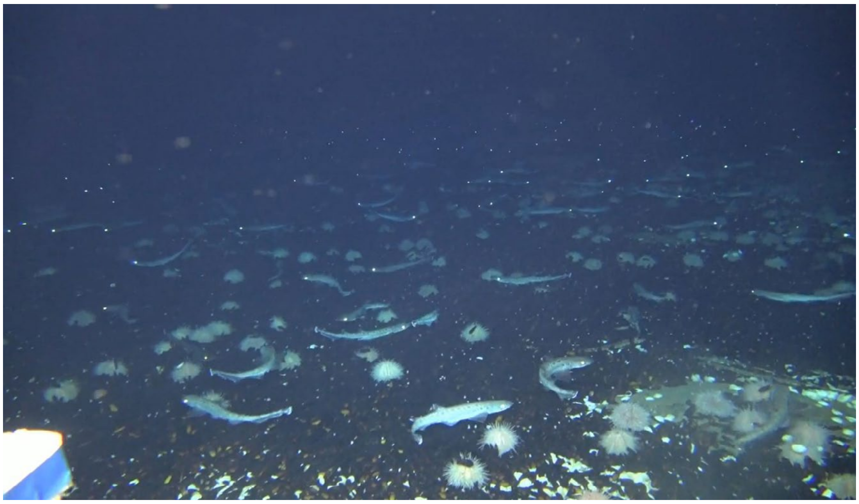

**A brine pool and numerus *Lamellibrachia anaximandri* Tubeworms in the western part of the proposed FRA. Photo: Makovsky Y, University of Haifa;**
**Rubin-Blum M, IOLR; Antler G, Ben Gurion University & IUI (Makovsky et al. 2021).**



**Brine seeps and numerus *Lamellibrachia anaximandri* Tubeworms in the western part of the proposed FRA. Photo: Makovsky Y, University of Haifa;**
**Rubin-Blum M, IOLR; Antler G, Ben Gurion University & IUI (Makovsky et al. 2021).**



Blackmouth Catshark nesting ground & Angular Roughshark in the western part of the proposed FRA. Photo: Makovsky Y, University of Haifa;
Rubin-Blum M, IOLR; Antler G, Ben Gurion University & IUI (Makovsky et al. 2021).



Blackmouth Catshark nesting ground in the western part of the proposed FRA. Photo: Makovsky Y, University of Haifa;
Rubin-Blum M, IOLR; Antler G, Ben Gurion University & IUI (Makovsky et al. 2021).

**Pelagic spawning area for Atlantic Bluefin Tuna**

In the pelagic zone, the Palmahim disturbance is part of a spawning ground for the Bluefin Tuna (BFT) *(Thunnus thynnus)*. Druon et al. (2016) highlighted the Palmahim disturbance as a part of the potential habitat for spawning in the southeastern Mediterranean during early summer (May-July). Genetic differences were documented between populations breeding in different areas in the Mediterranean (Riccioni et al, 2010), suggesting that the southeastern levant area may support a distinct population of BFT.

Elmaliach (2018) reported the area as a spawning ground, but also reported high percentage of juvenile BFT in catches in Israel, highlighting the potential importance of the area as a nursery as well. She has also reported some demersal fish found in BFT stomachs caught in the area, implying potential importance of benthic habitats for BFT feeding.

### 3.2.2 List of species of regional importance

List the marine species protected under international agreements (specify which agreements) and/or included in the GFCM priority list. If applicable, indicate the IUCN category. Any other species may be listed if they are clearly considered of regional importance given their high representation in the area.

For each species indicate: 1) relative abundance (common [C], uncommon [U] or occasional [O]); 2) regional status (rare [r], endemic [e] and/or threatened [t]); and 3) local status as an important resident population (R), or important for breeding (B), feeding (F), wintering (W) or migratory passage (M).

Reference for cnidarian species in IUCN categories and international agreements may be found in Otero et al. 2017.

| Species | 1 - Relative abundance (C) (U) )O) | 2 - Regional status (r) (e) (t) | 3 - Local status (R) (B) (F) (W) (M) | 4- IUCN category | International Agreements | Mediterranean VME indicator taxa (GFCM) |
|---|---|---|---|---|---|---|
| *Leiopathes glaberrima/ Leiopathes sp.* | C | R, E*, T *If the new species is valid, manuscript in review. | R, B | EN | CITES Annex II, Protocol SPA/BD Annex II, EU Regulation Trade wild fauna and flora Species (B), Bern Convention (III) | + |
| *Antipathes dichotoma* | C | R, E, T | R, B | NT | CITES Annex II, Protocol SPA/BD Annex II, Bern Convention (III) | + |
| *Swiftia pallida* | C | R, E | R | DD | | + |
| *Viminella flagellum* | C | R, E | R | NT | | + |
| *Parantipathes larix* | R | R, E, T | R | NT | CITES Annex II, Protocol SPA/BD Annex II | + |
| *Isidella elongata* | C | R, Nearly Endemic, T | R | CR | Protocol SPA/BD Annex II | + |
| *Callogorgia verticilata* | R | R | R | NT | Protocol SPA/BD Annex II | + |
| *Funiculina Quadrangularis* | C | R | R, B | VU | | + |
| *Desmophyllum dianthus* | R | R, E | R | EN | CITES Annex II, EU Regulation Trade wild fauna and flora species (B) | + |
| *Chimera monstrosa* | U | | | NT | | |
| *Oxynotus centrina* | U | R | | CR | SPA/BD Annex II | |
| *Dipturus batis* | U | R | | CR | SPA/BD Annex II | |
| *Thunnus thynnus* | U | T | B, F | EN | SPA/BD Annex III | |

### 3.2.3 Occurrence of biological and ecological processes relevant to fish resources

E.g. essential fish habitats.

**Deep-sea coral gardens as essential habitats**

Deep-sea coral gardens are an important habitat, both as a nursery and a feeding ground for deep demersal fish species: The Coral gardens at the Palmahim Disturbance CWC gardens were found in association with abundant shrimp *(Plesionika spp)*, Blackmouth Catsharks, Atlantic Wreckfish and Blackbelly Rosefish (Makovsky et al, 2017). These same fish were found in high numbers in CWC sites in Italian waters as well (D'Onghia et al. 2012), highlighting the association between them and Mediterranean CWC grounds.

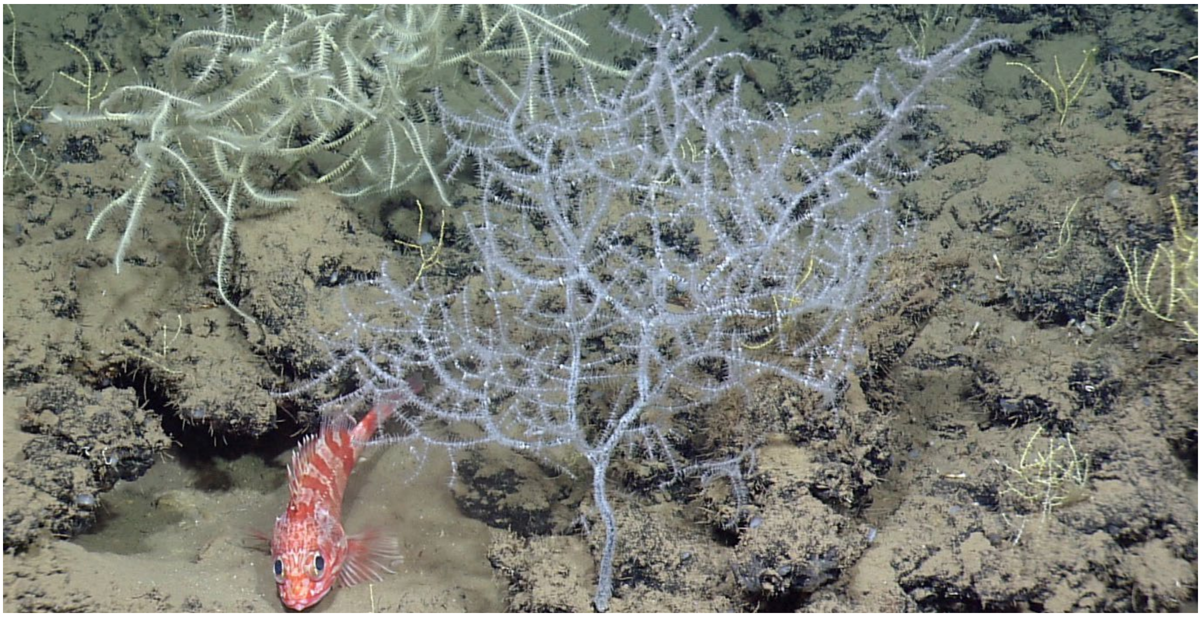
Catsharks were documented using CWC as a nursery in the Gulf of Mexico (Etnoyer, 2007), and as a spawning ground in Scottish waters (Henry et al. 2013). A large population of Blackmouth Catshark lives among the corals at the Palmahim Disturbance, although there is no direct evidence for spawning at the locality, yet.

Cold-water coral habitats provide an important habitat for the Blackbelly Rosefish *(Helicolenus dactylopterus)*. In the Santa Maria di Lucia (SML) coral banks in the northern Ionian, the biomass and individual size of this species was found to be higher when compared to surrounding waters, thus demonstrating a spillover effect. Furthermore, an abundance of young individuals was found among the corals in the SML coral banks, suggesting the coral grounds act as a spawning ground and nursery for this species (D'Onghia et al. 2010).

Deep-sea coral gardens have been found to be a suitable habitat for Atlantic Wreckfish *(Polyprion americanus)*, and it is abundant in deep-sea coral habitats in the Mediterranean and the Atlantic (Ross et al. 2004, D'Onghia et al. 2012). Large specimens of this fish, over 1 m long, have settled among the corals in Palmahim Disturbance, evidence of long-lived individuals finding refuge at the site.

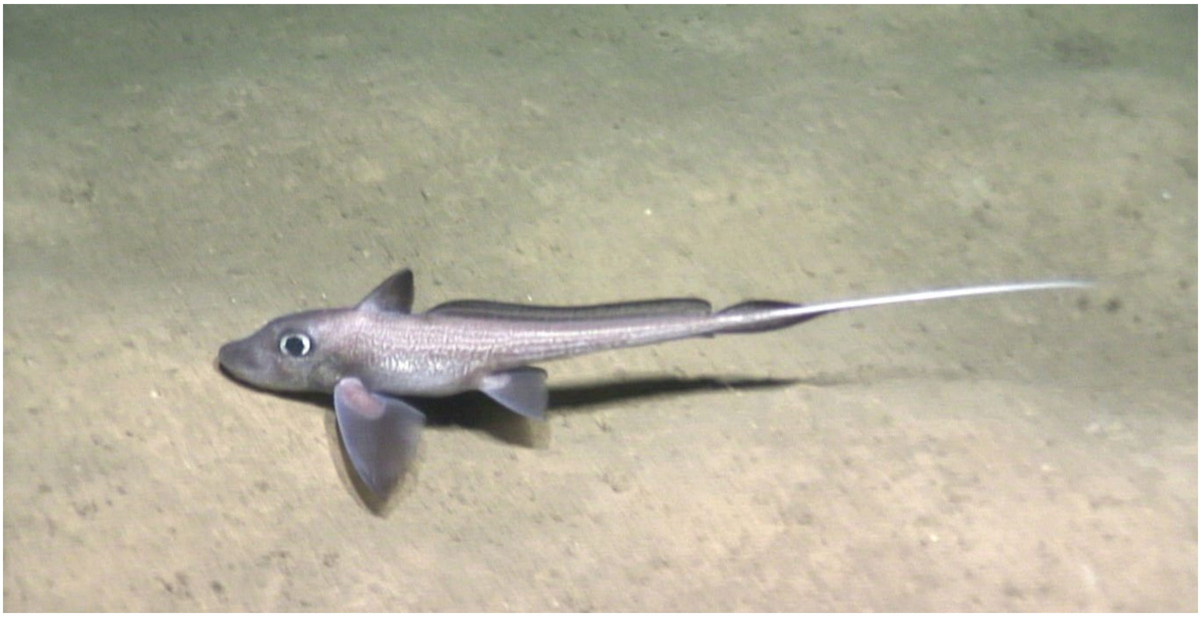
**cold methane seeps and brine seeps as essential shark habitats**

blackmouth sharks were recently documented in large numbers to reproduce and lay eggs in the proposed FRA area. Angular roughsharks were also documented roaming in the same area (Makovsky et al. 2021)..



**A Blackbelly Rosefish *(Helicolenus dactylopterus)* residing among Antipatharians.**

**The Critically Endangered Common Skate *(Dipturus batis)* found at 600 mbsl in the vicinity of the coral gardens.**



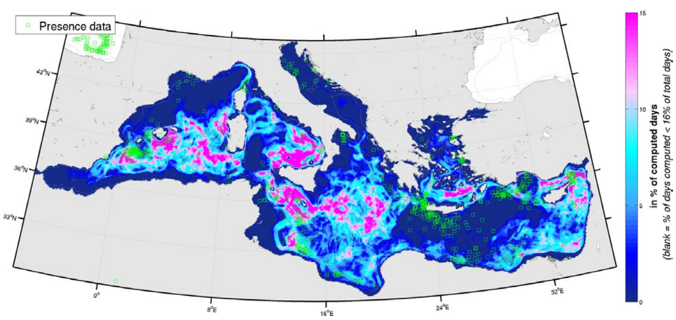
**The elusive *Chimera monstrosa* in the deeper regions of the Palmahim Disturbance; several encounters have been documented at varying depths.**

**Blackmouth catsharks *(Galeus melastomus)* were commonly sighted roaming in the vicinity of the Palmahim Disturbance, and were recently documented in large numbers to reproduce and lay eggs in the proposed FRA area (Makovsky et al. 2021).**

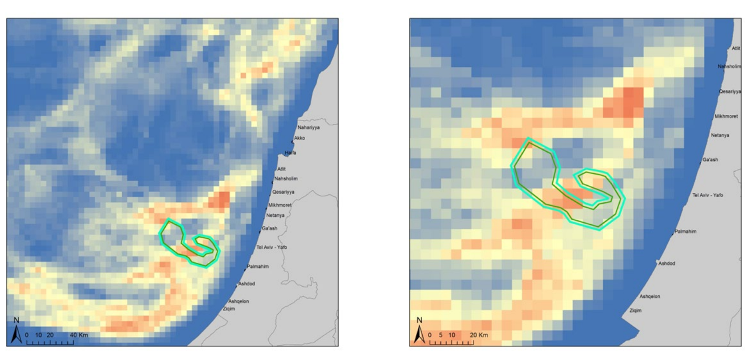
**Pelagic spawning area for Atlantic Bluefin Tuna**

In the pelagic zone, the Palmahim disturbance is part of a spawning ground for the Bluefin Tuna (BFT) *(Thunnus thynnus)*. Druon et al. (2016) highlighted the Palmahim disturbance as a potential habitat for spawning in the southeastern Mediterranean during early summer (May-July). Genetic differences were documented between populations breeding in different areas in the Mediterranean (Riccioni et al, 2010), suggesting that the south eastern levant area may support a distinct population of BFT.

Elmaliach (2018) reported the area as a spawning area, but also reported high percentage of juvenile BFT in catches in Israel, highlighting a potential importance of the area as a nursery as well. She has also reported some demersal fish found in BFT stomachs caught in the area, implying potential importance of benthic habitats for BFT feeding.




**Spawning sites of Atlantic Bluefin Tuna. From Druon et al, 2016.**



**Areas identified as suitable spawning grounds for Bluefin Tuna were represented by Druon et al. 2016 based on CHL (Chlorophyll a), SST range and monthly increase of SST (DSST30) and updated in 2018 by Druon to match CHL records measures by NASA and used in MODIS-Aqua. The maps represent overlay of mean occurrence of potential spawning habitats along the Israeli coast for May-July 2003-2018. Color scale represent percentage of computed days (blank= % of days computed<16% of total days) as in Druon et al. 2016. Green polygon is the proposed FRA.**

## 3.3 USE OF NATURAL RESOURCES

### 3.3.1 Current human use and development of fisheries

The proposed FRA is not a significant fishing ground for Israeli or non - Israeli vessels, and the sporadic fishing activity in the area is negligible at the local, national and regional levels. AIS data clearly indicates that only (a few) Israeli fishing vessels fish in the area, and **no foreign vessels were recorded to fish in the area.**
**no artisanal fishing is practiced in the area due to its distance from the shore.**
**only a few Israeli vessels (and no foreign fishing vessels) were recorded to fish in the proposed FRA area, and they comprise of negligable portion of the effort and catch in the Israeli Mediterranean.**
The Palmahim Disturbance area is part of a fishing ground for few (less than 5) commercial pelagic longline vessels departing from Ashdod or Jafa ports.
Israeli Bottom trawlers do not fish in the area regularly, due to its long distance from the shore, and the low economic value of the catch. In addition, the western area of the proposed FRA lays beyond 1000 m depth where trawling is prohibited following the GFCM decision from 2005. Occasionally, bottom trawlers cross the eastern outskirts of the area, during the summer. This is not bottom trawl fishery; nevertheless, an occasional trawling event might destroy the fragile habitats in the area.
The estimated contribution of fishing catch from the area of the proposed FRA is less than 1% of the Israeli fishing fleet catch in the Mediterranean. This is demonstrated also in the low traffic of fishing vessels in the area of the proposed FRA. This together with the following AIS data analysis demonstrates the minor fishing activity in the area of the proposed FRA and the negligible contribution it has to the total catch of the Israeli fishing fleet.

- Number of vessels by fishery operating in the area:
  Between the years 2017-2020[1], 8849 daily trips of commercial fishing vessels (specific fishing method is unknown) were recorded in AIS terrestrial receptors off the central and southern coast of the Israeli Mediterranean, to a distance of 90 km from the coast. **Only 1.8% (160 trips) crossed the area of the proposed FRA, and only 1.3% (117 trips) were sailing at a speed of 2.5-4.5 knots when within the FRA area**, which is assumed to be the sailing speed during fishing activity. Less than 10 trips were

(1) The new Israeli fishing regulations came into force in March 2017, therefore, fishing activity prior to this date is assumed to be affected by the old regulations and was not included in the analysis.

recorded in the western half of the proposed FRA in 4 years (2017-2020). **The average annual number of fishing trips that crossed the proposed FRA area while sailing in fishing speed was 29**. In total, the 117 trips that passed in the proposed FRA area in 4 years, were performed by **only 7 vessels**, all sailing under Israeli flag and embarking the ports of Ashdod and Yafo.

Fishing method is not always known from the AIS data, however, Elmaliach (2018) estimated that there are less than five longline vessels operating along the Israeli Mediterranean coast.

- Total annual catches by species for each fishery in the area:

  The catches in the area are negligible. According to the analyzed AIS data, the average number of trawling hours per year is 5 hours. The average catch of one hour trawl along the Israeli Mediterranean coast is 39 kg per hour (Fisheries Department 2018, 2019,2020,2021). Therefore, the annual catch from the area of the proposed FRA is only about 226 kg, which are less than 0.001% of the annual bottom trawl catch in Israel. Pelagic longline fisheries contribute about 0.4% of the annual catch of the Israeli fleet (Fisheries Department 2018, 2019,2020,2021). Since the proposed FRA only stretches over 12% of the commercial pelagic fishing area, it is assumed that the annual catch of pelagic longline in the area of the FRA, does not exceed 0.04% of the total annual catch of the Israeli fleet.
- Percentage of total catches fished in the area in relation to the total value of catches fished in the area:

  Trawl and longline catches in the area are less than 0.1% of the total catch of the Israeli fishing fleet.
- Percentage of the value of catches in the area in relation to the total value.

  As described above, it is negligible.
- Bycatch rates of vulnerable species in the area:

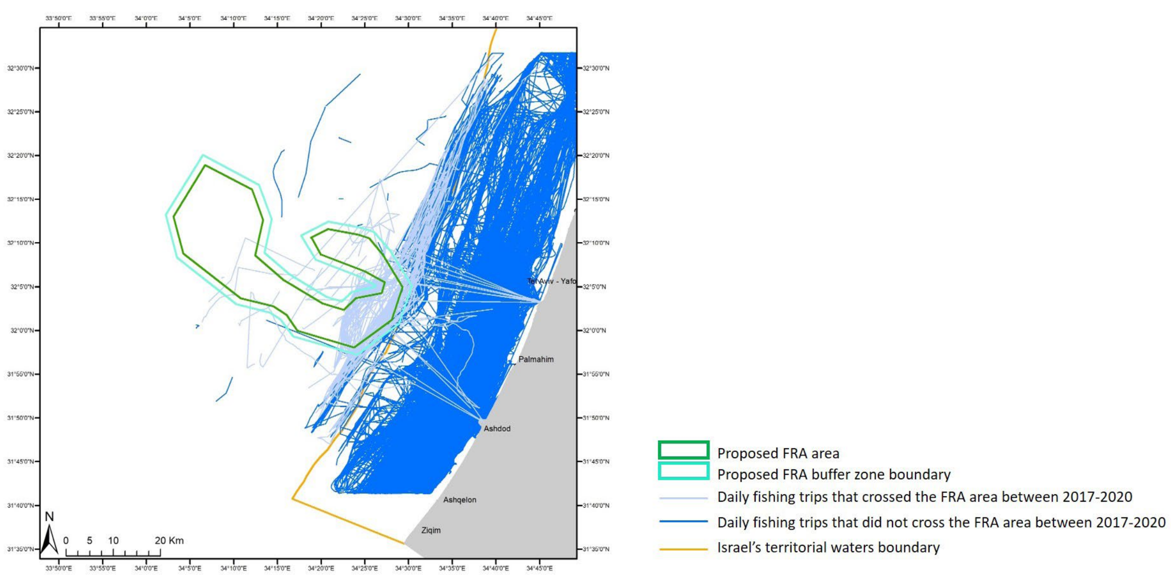
  No quantitative data is available, but Edelist at el (2013) reported bycatch of sensitive pelagic sharks during longline fishing, and Elmaliach (2018) reported bycatch of bigeye thresher sharks *(Alopias superciliosus)*, shortfin mako shark *(Isurus oxyrinchus)* a pelagic stingray *(Pteroplatytrygon violacea)* and a sunfish *(Mola mola)*.
- Number of fishers involved in the fisheries operating in the area:

  Each of the four longline vessels employs about 3-4 persons, operating less than two months each year. Bottom trawling vessels in Israel have 3 crew members for each vessel, but as noted before trawling activity in the proposed FRA is negligible.
- Name(s) of base port(s) :

  Ashdod and Jaffa.

| | | |
|---|---|---|
| Daily commercial fishing trips off the central and southern coast of the Israeli Mediterranean, in 2017-2020 | | 8849 |
| Daily commercial fishing trips that crossed the FRA area | crossed the proposed FRA | 160 |
| | crossed the proposed FRA + buffer zone | 210 |
| Daily commercial fishing trips that crossed the FRA area at a speed of 2.5-4.5 knots | crossed the proposed FRA | 117 |
| | crossed the proposed FRA + buffer zone | 159 |

**Summary of daily commercial fishing trips off the central and southern Israeli Mediterranean coast in 2017-2020**




**All daily fishing trips recorded in AIS terrestrial receptors off the central and southern Israeli Mediterranean coast between 2017-2020. Only 1.3% of the fishing trips are assumed to include active fishing in the area of the proposed FRA. AIS data was provided by MarineTraffic.com**

### 3.3.2 Current human use and development other than fisheries

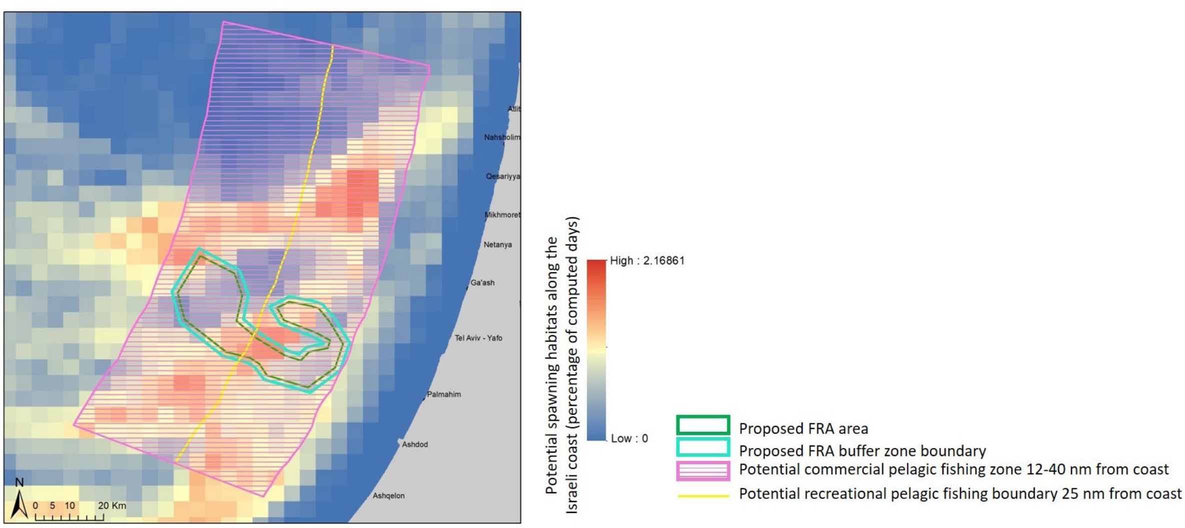
a) Briefly describe how the area is currently used by other economic sectors. To the best of our knowledge, no use is currently being made of the resources at the site.

| ACTIVITY AND CATEGORY | ASSESS THE IMPORTANCE OF | | ESTIMATED NUMBER OF USERS | SEASONALITY |
|---|---|---|---|---|
| **Fishing** | SOCIO-ECONOMIC IMPACTS | CONSERVATION IMPACTS | | |
| Artisanal | 0 | 0 | 0 (deep water, not accessible by artisanal vessels) | 0 |
| Industrial: bottom trawling | 0<br>Only occasional vessels rarely fish on the eastern outskirts of the area, but the potential of a single fishing event is destructive. | 1<br>FRA is expected to replenish demersal fish populations, creating a spill- over effect that may benefit bottom trawlers fishing to the east, in shallow waters. | 0 | Summer – a few Israeli bottom trawlers travel outside territorial waters only to avoid the summer recruitment moratorium. |
| Long line | **1**<br>**Less than 5 commercial vessels, 4 pelagic long line, and 1 occasional bottom long line vessel fishing rarely in the eastern part of the proposed FRA.** | **3**<br>**FRA may boost BFT population in the area, through the protection of the spawning and nursery of the specific population in the site. It will also protect the unique and vulnerable benthic habitats on the site which are sensitive to the unintentional damage caused by long line fisheries.** | **1**<br>**Less than 5 commercial vessels.** | **May-June, during the BFT spawning season.** |
| Other | | | | |
| Aquaculture | 0 | 0 | 0 | --- |

| Year | Number of vessels actively fishing in the area | | | Number of fishing trips | | | Flag of boats | | | Number of fishing days | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FRA** | **FRA+ buffer** | Reference area | **FRA** | **FRA+ buffer** | Reference area | **FRA** | **FRA+ buffer** | Reference area | **FRA** | **FRA+ buffer** | Reference area |
| 2017 | **4** | **5** | 20 | **39** | **49** | 1399 | **Israel** | **Israel** | Isarel | **37** | **44** | 305 |
| 2018 | **5** | **6** | 21 | **33** | **39** | 1355 | **Israel** | **Israel** | Isarel | **29** | **34** | 318 |
| 2019 | **3** | **4** | 14 | **36** | **57** | 1207 | **Israel** | **Israel** | Isarel | **35** | **53** | 328 |
| 2020 | **2** | **2** | 15 | **9** | **14** | 784 | **Israel** | **Israel** | Isarel | **9** | **14** | 305 |

**Number and flag of fishing vessels[2] sailing (2017-2020) in fishing speed in the proposed FRA area and the reference area[3] by year.**

Most of the fishing activity off the Israeli coast is distributed within the Israeli territorial waters. 45% (3998 trips) of the recorded commercial fishing trips, stayed in the territorial water. Another 52% of the trips exited the territorial waters but did not cross the area of the proposed FRA.




**Pelagic longline fishing zone and potential habitats for Bluefin Tuna adopted from Druon et al. (2016) off the Israeli Mediterranean coast.**

(2) Vessels that are listed as fishing vessel in the database of Marine Traffic.com
(3) Similar sized area in the territorial waters east to the proposed FRA

**Potential pelagic longline fishing zone (targeting highly migratory species like Bluefin Tuna)** stretches between 12 and 25 nm for recreational fishing and 12-40 nm for commercial fishing (Elmaliach 2018). The spatial distribution of this zone is derived from the seasonal presence of Bluefin Tuna (Druon et al. 2016) and operation costs. The proposed FRA and its buffer zone constitute only 12% of the potential commercial pelagic fishing zone and only 13% of the potential recreational pelagic fishing (842 km2 of 6750 km2 and 419 km2 of 3197 km2, respectively). According to Druon et al. (2016), suitable habitats for Bluefin Tuna spawning are distributed along the Israeli Mediterranean coast. **Out of the total area of relatively high potential for Bluefin Tuna spawning, only 6% are within the area of the proposed FRA. It is worth noting that Israel is not an ICCAT member and does not hold an official quota for BFT fishing.**

b) Provide the number of users depending on these resources, seasonality, assessment of the social and economic importance of their use and of the perceived impact on the conservation of the area, using a score of 0-1-2-3 (0: null, 1: low, 2: medium, 3: high).

The area is included in "Block D" that was recently allocated by the Israeli ministry of Energy for gas exploration. The proposed FRA is only 30% of block D's area, and exploration activities have not begun yet, and there is no data if or when they are going to take plave. This potential use is not dependent on the living resources in the area, thus is not expected to be impacted by the FRA.

The area is a minor transportation route, some vessels cross it (attached is a map from 2017 showing traffic volume of non-fishing vessels, according to marintraffic.com). The FRA will not limit transportation so is not expected to have any socio-economic impacts on these sectors.

| ACTIVITY AND CATEGORY | ASSESS THE IMPORTANCE OF | | ESTIMATED NUMBER OF USERS | SEASONALITY |
|---|---|---|---|---|
| **Other activities** | SOCIO-ECONOMIC IMPACTS | CONSERVATION IMPACTS | | |
| Tourism | 0 | | 1 | |
| Transport | 0 | | 1 | |
| Mining | 0 | | 0 | |

4

# Regional Importance Of The Site

This section aims at stressing the importance of the site for conservation at a regional scale.

## 4.1. PRESENCE OF ECOSYSTEMS/HABITATS OF PARTICULAR IMPORTANCE FOR THE MEDITERRANEAN

The Palmahim disturbance is home to several unique deep-sea biodiversity hotspots. Both the CWC gardens and the cold seep communities are recognized as important and vulnerable habitats by the international community (OSPAR 2008; FAO 2009; CBD, 2016; GFCM 2018; IUCN, 2019). These habitats are biodiversity hotspots in need of protection, inhabited by many organisms which are considered VME indicators, or protected under international treaties (CITES Annex II, Barcelona convention – Protocol SPA/BD Annex II, EU Regulation Trade wild fauna and flora Species (B), Bern Convention (III)).

The findings in the proposed FRA fit many of the GFCM VME indicator list, including features like steep slopes and trenches, Cold seeps (pockmarks, anoxic pools, methanogenetic hard bottoms), indicator habitats like Hard-bottom coral garden, Soft-bottom coral gardens and Seep communities, and indicator taxa like Hexacorallia (Antipatharia, Scleractinia), Octocorallia (Alcyonacea, Pennatulacea), Ceriantharia and *Lamellibrachia anaximandri*.

In the Levant Sea context, the Palmahim disturbance is the only location apart from the Eratosthenes Seamount that is known to harbour cold-water coral gardens, with thriving communities living on the hard surface provided by the carbonate rocks, essentially a deep-sea hotspot in the otherwise vast spaces of soft sediment in the eastern Mediterranean.

In 2006, the Nile Delta Fan was declared an FRA in order to protect its chemosynthetic communities. Although both the Nile Delta system and the Palmahim Disturbance system are in the same geo-region, the Palmahim gas system fuelling the community is separate from the Nile Delta gas reservoirs, thus we expect that the microbial and faunal communities may differ between the sites. Since cold seeps are a highly diverse habitat, with high beta diversity between sites (Cordes et al. 2010), it would be valuable to protect the cold seep systems in order to conserve the unique biodiversity at the Palmahim Disturbance seeps.

## 4.2. PRESENCE OF HABITATS THAT ARE CRITICAL TO ENDANGERED, THREATENED OR ENDEMIC SPECIES

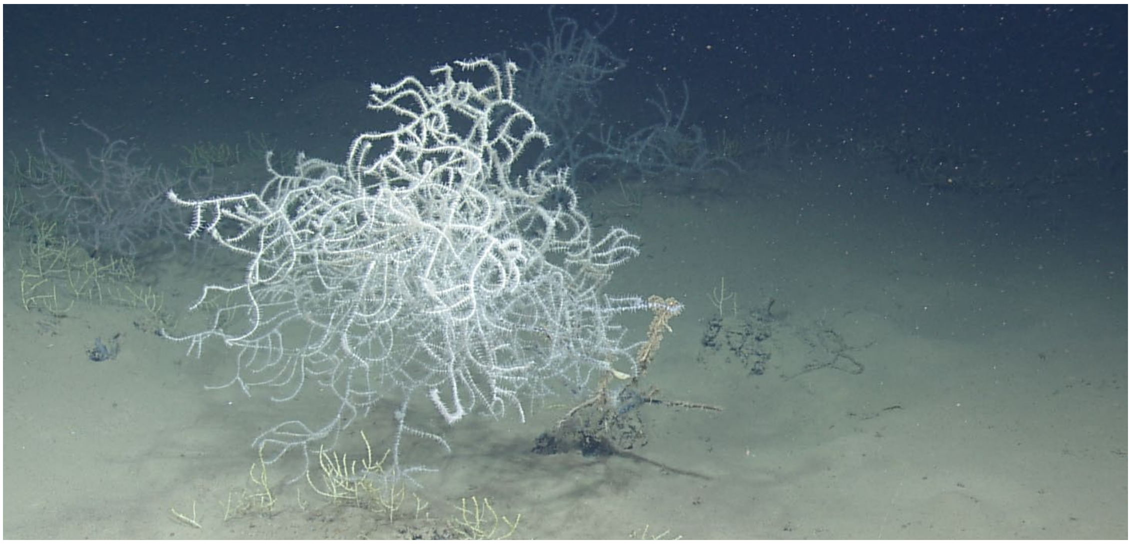
Indicate the habitat types and the species linked to them and provide information about their status (IUCN classification, etc.).

**Cold Water Coral Gardens**

The cold-water coral gardens are home to several deep-sea corals growing on the carbonate crusts found on the outskirts of the Palmahim Disturbance, most of which are considered endangered and/or protected, including the following species:

***Leiopathes sp./Leiopathes glaberrima* –** A potential new species of black coral that differs from the well-known *Leiopathes glaberrima* (Weissman, A. et al. manuscript in review), was discovered at the site. If it is indeed a new species, it is most likely endemic to the site. Over 1000 colonies have been viewed in the ROV surveys to date, with some of the colonies 1.5 meters tall, corresponding to an age estimate of over 1500 years (Etnoyer et al. 2018) indicative of long term occupation of the site. All antipatharians (black corals) are in the CITES annex II. *Leiopathes glaberrima* is classified as **Endangered** in the IUCN red list.

***Antipathes dichotoma* –** Another species of black coral with hundreds of colonies found at the site. Classified as **Near Threatened** in the IUCN red list, and included in the CITES Annex II.



**A suspected new species of black coral, *Leiopathes sp.* found at the coral gardens.**

***Parantipathes larix* –** A rare black coral; several colonies were sighted at the location. Classified as **Nearly Threated** in the IUCN red list and protected under CITES Annex II and Protocol SPA/BD Annex II of the Barcelona convention.

***Swiftia pallida* –** A small octocoral growing near the carbonate crusts; thousands of colonies were sighted at the coral gardens. Classified as **Data Deficient** in the IUCN red list.

**^**
***Parantipathes larix* colony between small *Leiopathes* colonies living on the carbonate crusts.**

***Viminella flagellum* –** The yellow whip coral; hundreds of colonies were sighted upon the ridges on the outskirts of the Palmahim Disturbance. It is the only population documented to date of this species in the eastern Mediterranean. Classified as **Nearly Threated** in the IUCN red list.

***Callogrogia verticilata* –** A large white branching octocoral; several colonies were sighted growing on the carbonate rocks. This species is included in the Protocol SPA/BD Annex II and is classified as **Nearly Threated** in the IUCN red list.

***Desmophyllum dianthus* –** A solitary stony coral; living polyps were documented at the site. It is classified as **Endangered** in the IUCN red list and is protected under CITES Annex II and the EU Regulation Trade wild fauna and flora species (B).

**Cold-water coral meadows growing on sediments**

Long stretches of compact mud extending between the carbonate rocks, are inhabited by large populations of two species, which are both included in the IUCN red list:

***Isidella elongata* –** A species of bamboo coral; hundreds of colonies were found living on compact mud between the carbonate rocks, forming large meadows. It is protected under the Protocol SPA/BD Annex II and classified as **Critically Endangered** in the IUCN red list.

***Funiculina quadrangularis* –** The tall sea pen; hundreds of colonies were sighted on the soft sediments in all areas of the Palmahim Disturbance at depths between 434-827 meters. Polyps photographed in the lab have indicated advanced reproductive stages in the colonies with several eggs found in the polyps, highlighting the importance of protecting a reproductive population of a rare species. It is classified as **Vulnerable** in the Mediterranean IUCN red list (Otero et al, 2017), and classified as **Critically Endangered** in other parts of the Mediterranean (IUCN Italy).

**Additional species found at the Palmahim Disturbance**

***Chimera monstrosa* –** The rabbitfish has been documented several times near the bottom, at depths between 800-1100 meters; it is classified as **Near Threated** in the IUCN red list.

***Oxynotus centrina* –** The Angular Rough Shark has been documented near the coral gardens at a depth of 700 meters, and near the cold seeps at 1150 meters. it is classified as **Critically Endangered** in the IUCN red list.

***Dipturus batis* –** The Common Skate, has been documented near the coral gardens at a depth of 660 meters; it is classified a **Critically Endangered** in the IUCN red list.

***Thunnus thynnus* –** The pelagic zone is an essential habitat for Atlantic Bluefin Tuna, classified as **Endangered** in the IUCN red list, and listed on annex 3 in SPA/BD Protocol of the Barcelona convention.

## 4.3. OTHER RELEVANT FEATURES

### 4.3.1 Educational interest

E.g. particular value of the site for environmental education or awareness activities.

The Palmahim Disturbance is the flagship site of deep-sea conservation awareness in Israel, as well as an important educational tool. Recently a booklet was published (www.mafish.org.il/wp-content/uploads/2018/10/yam-amok-v7-single-pages-heavy-2.pdf) on the ecology of the site by The Society for the Protection of Nature in Israel (SPNI) and Haifa University.
A short video was also produced in order to make the marvels of the Palmahim Disturbance accessible to the general public (www.youtube.com/watch?v=4eeNgKgXK6g&t=2s)

### 4.3.2 Scientific interest

Particular value of the site for research.

The Palmahim Disturbance is the focus of broad multidisciplinary research. Comprehensive work has been done by scientists from around the world in various scientific fields, with manuscripts published in their respective fields, investigating biological, geological and oceanographic features of this unique area.

**List of publications:**

Almagor, G. & Garfunkel, Z. (1979) Submarine slumping in continental margin of Israel and northern Sinai.
*American Association of Petroleum Geologists Bulletin,* 63(3), 324-340.

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Eruteya, O. E., Reshef, M., Ben-Avraham, Z., & Waldmann, N. (2018). Gas escape along the Palmahim disturbance in the Levant Basin, offshore Israel. *Marine and Petroleum Geology,* 92, 868-879.

Makovsky, Y., Rüggeberg, A., Bialik, O., Foubert, A., Almogi-Labin, A., Alter, Y., Bampas, V., Basso, D., Feenstra, E., Fentimen, R., Friedheim, O., Hall, E., Hazan, O., Herut, B., Kallergis, E, Arageorgis, A., Antonios, Kolountzakis, Manousakis, L., Nikolaidis, M., Fotios, Pantazoglou, Eyal Rahav, Panagiotis Renieris, N.S., Sisma-Ventura, G., Stasnios, V., Weissman, A., Participants, E.S. (2016). R/V AEGAEO Cruise EUROFLEETS2 SEMSEEP 20.09. – 01.10.2016, Piraeus (Greece) – Piraeus (Greece).

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Rubin-Blum, M., Antler, G., Turchyn, A. V., Tsadok, R., Goodman-Tchernov, B. N., Shemesh, E., ... & Tchernov, D. (2014c). Hydrocarbon-related microbial processes in the deep sediments of the Eastern Mediterranean Levantine Basin. *FEMS microbiology ecology,* 87(3), 780-796.

Rubin-Blum, M., Shemesh, E., Goodman-Tchernov, B., Coleman, D. F., Ben-Avraham, Z., & Tchernov, D. (2014d). Cold seep biogenic carbonate crust in the Levantine basin is inhabited by burrowing Phascolosoma aff. turnerae, a sipunculan worm hosting a distinctive microbiota. *Deep Sea Research Part I: Oceanographic Research Papers,* 90, 17-26.

Waldmann, N., Austin Jr, J., Ben-Avraham, Z., Ballard, R., Coleman, D., Hall, J., ... & Sade, R. Evidence for sediment slumping in relation to possible past active seepage in the Eastern Mediterranean.

**Unpublished Manuscripts/In Review:**

Beccari, V., Basso, D., Spezzaferri, S., Rüggeberg, A. and Makovsky, Y. (2019) Preliminary video-spatial analysis of cold seeps bivalve beds along the continental slope of Israel (Palmahim Disturbance).

Weissman, A., Bialik, M. O., Makovsky, Y., Tchernov, D. (2019) Description of a new species of Leiopathes (Antipatharia: Leiopathidae) from the Palmahim Disturbance in the Levantine Sea (Mediterranean).

5

# Impacts And Activities Affecting The Area

## 5.1. IMPACTS AND ACTIVITIES WITHIN THE SITE

### 5.1.1 Exploitation of natural resources

Assess if current exploitation rates of natural resources within the site (e.g. fishing, sand and mineral exploitation) are deemed unsustainable in quality or quantity, and possibly quantify these threats (e.g. percentage of the site area under threat, or any known increase in extraction rates).

No legislation has been established yet for the Palmahim Disturbance area.

Israeli bottom trawlers do not fish in the area on a regular basis, due to its long distance from the shore, and the low economic value of the catch. Occasionally, a bottom trawler may fish in the eastern outskirts of the area, during the summer time recruitment moratorium in effect in Israeli territorial waters. This is not bottom trawl fishery; nevertheless, an occasional one-time trawling event might destroy the fragile habitats in the area.
The Palmahim Disturbance area is a fishing ground for few (less than 5) commercial long line vessels. Lost longline fishing gear might also harm benthic habitats.

### 5.1.2 Threats to habitats and species

Indicate any serious threat to habitats (e.g. modification, disturbance, pollution) or to species (e.g. disturbance, poaching, introduction of alien species, etc.) in the area.

**Bottom trawling** is the most serious threat to cold seep and deep-sea coral communities (Althaus et al, 2009). Trawling activity may result in total destruction of these habitats. Trawl marks on the soft sediments, as well as crushed carbonate rocks, that form the foundation of the deep-sea communities, have already been documented at the site, indicating sporadic trawling activity at the location. Trawling activity near the coral gardens is also a threat, due to sediment suspension that harms suspension feeders such as corals (Hall-Spencer et al, 2002).
bottom trawling activity was found to cause damage to benthic complexity, sediment suspension (18m high, >120 m wide) and habitat cover, and also to cause disturbance to nutrient and chemical flow between the sediment and water and contaminant suspension (Puig et al. 2012; Bradshaw et al. 2012). thus, a 1.5 km buffer zone is proposed around the FRA core area, in order to prevent risk of trawlers suspending the benthos near the sensitive habitats.

**Longline fishing** also threatens corals, which are often caught as bycatch by bottom longline fishing (Sampaio et al. 2012). Corals may be physically damaged by long-line fishing as observed in multiple fishing areas around the Mediterranean (Angiolillo and Canese 2018). Most of the direct damage is caused by bottom longline fisheries. In the eastern Mediterranean, 72% of the lines were hauled with deep water corals that were accidently caught (Mytilineou et al. 2014). In the western Mediterranean, corals bycatch was reported in 15% of fishing operations (Sampaio et al. 2012). Moreover, these studies and others, report on corals that are severely damaged by fishing lines remnants, including of pelagic longlines (Orejas et al. 2009; Mytilineou et al. 2014; Angiolillo and Canese 2018). It is estimated that 20% of longline fishing gear is lost or abandoned (Richardson et al. 2019), and was scored relatively high risk for biodiversity (Gilman et al. 2021), thus posing a real threat to the sensitive benthic VME's in the proposed FRA. Indeed, Corals entangled in fishing lines were observed in Palmahim Disturbance were pelagic longline fisheries occur occasionally. **Pelagic** fishing was found to be **incompatible** with **benthic** communities conservation goals, under a few qriteria, including the following criteria that are rellevant in the proposed FRA: topographically Complex habitats (e.g coral reef & rocky reef), Major topographic and oceanographic features, continental shelf break and spawning areas (Grober-Dunsmore et al. 2008).

Beyond the physical damage to benthic habitats, longline fisheries are non-selective and characterized by frequent high rates of bycatch that includes sharks, rays, and marine mammals (Ferretti et al. 2008; Gillet 2011; López et al. 2012; Zydelis et al. 2014) that are protected by law in Israel. For example, bycatch of 27 artisanal longlines was 3 times the number of the target species and included 75 sharks, 1198 rays, and 4 sea turtles (Camiñas et al. 2009). Pelagic longline bycatch of sharks and rays was documented in Israel as well (Elmaliach 2018).

Bentho-pelagic coupling (BPC) is known to occur even at depths of 650 m', and Apex predators in Western Mediterranean continental slope were found to be closely affiliated with benthic groups (Valls et al. 2014).

Therefore, in order to protect benthic VME's from active or derelict long line gear (both benthic and pelagic gear), and in order to maintain ecosystem integrity and bentho-pelagic coupling and reduce bycatch, the FRA (core and buffer zones) are both proposed as a no fishing zones, both for benthic and for pelagic fishing.

**Corals entangled in fishing gear, 500 mbsl.**

**Plastic debris:** trash was documented both near the coral gardens, as well as in the deeper portion of the site where large amounts of trash have accumulated on the seabed and around the seep sites.

In the last decades, **oil and gas exploration** and production have been expanding in the southeastern Levant Sea. Exploration and production of oil and gas could have a severe effect on coral habitats. Physical damage due to placement of structure and gear (rigs, cables pipes), chemical pollution originating from activities such as drilling fluids, rock cuttings or discharges from the wells (Freiwald et al. 2004, Cordes et al, 2016). The area is included in "Block D" that was recently allocated by the Israeli Ministry of Energy for gas exploration. The SPNI is negotiating with the Ministry of Energy to ensure the sustainability of offshore operations in this sensitive area.

**A plastic bag entangled in a *Leiopathes sp.* colony at 650 mbsl.**

## 5.2. IMPACTS AND ACTIVITIES AROUND THE SITE

### 5.2.1 Pollution

Sources and description of pollution.

No nearby pollution source is known.
Despite the distance from shore, when surveyed with ROVs, a large proportion of the deep-sea corals were found entangled in plastic bags, plastic sheets, and fishing gear. Plastic litter was found in the seep sites as far down as 1100 mbsl. The nearby shipping route to the south of the proposed FRA might be a potential source of pollution and debris, as well as fishing vessels roaming in the area.

### 5.2.2 Other external, natural and/or anthropogenic threats

Briefly describe any other external threat to the ecological, biological, aesthetic or cultural values of the area (such as unregulated exploitation of natural resources, serious threats to habitats or species, pollution issues, etc.) that are likely to affect the area.

The area is included in "Block D" that was recently allocated by the Israeli ministry of Energy for gas exploration. The SPNI is negotiating with the Ministry of Energy, to ensure the sustainability of offshore operations in this sensitive area.

Climate change is a dominant threat in the eastern Mediterranean (Turley et al, 2007, Fox et al, 2016), and is anticipated to challenge deep-water habitats in the Palmahim Disturbance. Securing the area from local pressures is expected to improve its resilience to global pressures.

### 5.2.3 Sustainable development measures

Indicate if the area is covered by a management plan or is bordering with another zone subject to a management plan.

Not covered.

6

# Expected Development And Trends[1]

These aspects are not always easy to assess.
Therefore, filling out this section is not compulsory.

[1] Expected development and trends mean the development which is most likely to occur in the absence of any deliberate intervention to protect and manage the site.

## 6.1. EXPECTED DEVELOPMENT AND TRENDS RELATED TO THE THREATS TO AND PRESSURES UPON THE AREA

Briefly describe the development of economic and other activities in the area.

The Strategic Environmental Survey by the Israeli Ministry of Energy has recognized the CWC and the cold seep sites at the Palmahim disturbance as an extremely sensitive area.
No commercial development has been implemented in the area to date, but the area is included in "Block D" that was recently allocated by the Israeli ministry of Energy for gas exploration. The SPNI is negotiating with the Ministry of Energy to ensure the sustainability of offshore operations in this sensitive area. In addition to direct communication with the Ministry of Energy, SPNI have been active in raising publics and authorities' awareness and interest in this areas. Specifically, an online workshop was held in January 2021 where the unique habitats were presented along with their posed threats and proposed mitigation measures. This specific FRA proposal was also presented following the GFCM presentation on available measures to protect vulnerable marine habitats. The workshop was free and available to all and the 200 attendees were from various government authorities, academy, and general public. lectures where later posted in our website: https://mafish.org.il/protecting/internet-workshop/

***Helicolenus dactylopterus*, also known by its popular name Blackbelly rosefish, rests beneath a black coral at a depth of 750 meters in the coral gardens of the Palmahim disturbance. This is a demersal fish, about 25 cm long.**

# 7

# Management And Protection Regime

## 7.1. LEGAL STATUS

If applicable.

There is no legal framework to exert protective measures at this point. However, two planning processes have identified the sensitivity of the Palmahim Disturbance:
1) The Strategic Environmental Survey by the Israeli Ministry of Energy has recognized the CWC and the cold seep sites as an extremely sensitive area.
2) The Palmahim disturbance was identified as a potential marine protected area under the Israeli marine spatial plan (2019).

### Historical background related to management in the area

### 7.1.2 Regulatory measures currently governing management on the site

Indicate if the area, or part of it, has been designated under an international conservation category and, if the case, when.

The parts below 1000 m at the site are considered a "no bottom trawling zone" by the GFCM.

### 7.1.3 Objectives

Indicate the objectives of the area (by order of importance) as stated in its legal declaration.

## 7.2. LEGAL BACKGROUND

Indicate if the area, or part of it, is subject to any legal claim, or to any pending legal case in this connection within the framework of an international body.

There is no legal framework to exert protective measures at this point. However, two planning processes have identified the sensitivity of the Palmahim Disturbance:

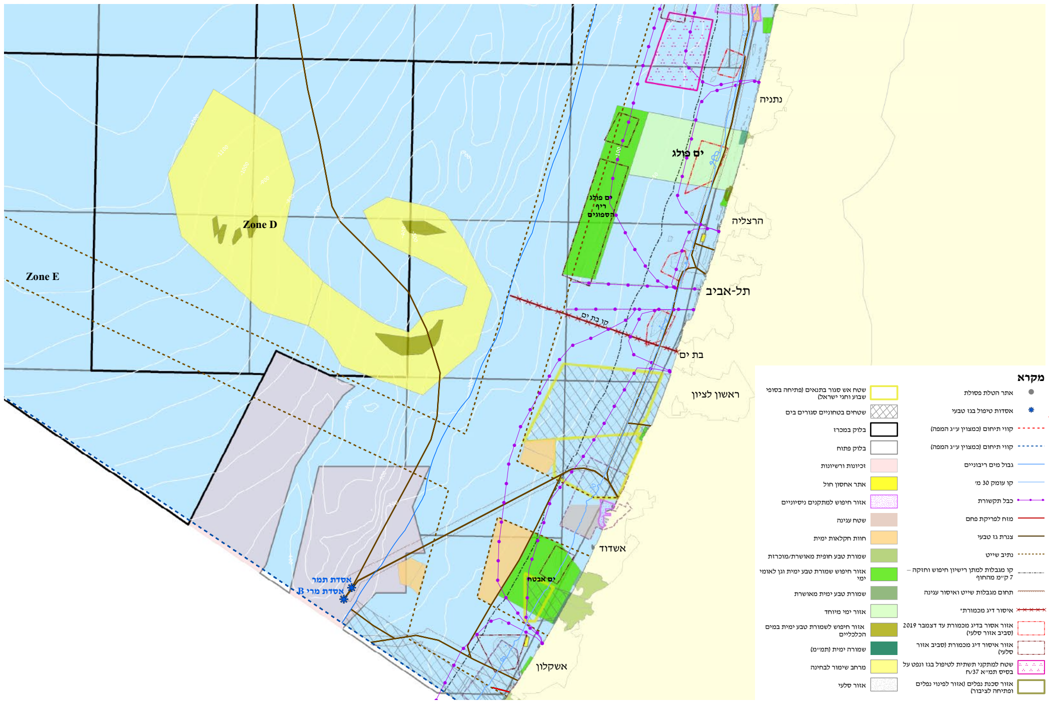
1) The Strategic Environmental Survey by the Israeli Ministry of Energy has recognized the CWC and the cold seep sites as an extremely sensitive area.
2) The Palmahim disturbance was identified as a potential marine protected area under the Israeli marine spatial plan (2019).

## 7.3. LEGAL PROVISIONS FOR MANAGEMENT

### 7.3.1 Zoning in the area

Briefly indicate if the legal texts protecting the area provide for different zones to allocate different management objectives in the area (e.g. core and scientific zones, fishing zones, etc.) and, if applicable, indicate the surface area of such zones. Provide a map in annex.

The Palmahim disturbance was identified as a potential marine protected area under the Israeli Marine Spatial Plan (2019). This initial planning designated a core area proposed as a marine reserve, and a "Potential Reserve Area" in which a detailed survey should be conducted to identify sensitive habitats for conservation.




**The Palmahim disturbance MPA in the Israeli Marine Spatial Plan, 2019.**
**known VME's are marked as brown polygons, and are designated as proposed nature reserve. potential area for sensitive VME's is marked in yellow, and is designated as "potential nature reserve".**

### 7.3.2. Legal competence

Legal competence and responsibility with regard to administration and implementation measures.

**Not relevant**

### 7.3.3 Other legal provisions

Describe any other relevant legal provisions, such as those requiring a management plan or any other significant measure concerning the protection and management of the area.

**Not relevant**

8

# Objectives Of The FRA And Proposed Management Measures

## 8.1. OBJECTIVES OF THE FRA

Indicate the rationale that justifies the designation of a FRA.

The objective of the FRA is to safeguard the cold-water corals and cold seeps VMEs in the Palmahim Disturbance from physical damage, and to protect the deep-sea fauna from fishing, including recently discovered function as a hotspot for shark reproduction.
The FRA would also serve as a Essential Fish Habitat (EFH) for BFT spawning, in order to support the rehabilitation efforts of this species.

**Benthic VMEs**

Internationally, deep-sea coral gardens and chemosynthetic based seep communities are recognized as needing protection. The United Nations Environment Program (UNEP – The Coordinating Unit for the Mediterranean Action Plan, Secretariat to the Barcelona Convention and its Protocols) has recognized coral aggregations and chemosynthetic based communities as special ecological features in need of protection (CBD, 2007).
The FAO considers coral aggregations as sensitive habitats, forming vulnerable marine habitats, and recommends fishing closures where such habitats are known or are likely to be found (FAO, 2009).
Many of the species occurring at the Palmahim Disturbance, like other Mediterranean deep-sea coral grounds, are included in the CITES annex II protocols, and/or are included in the IUCN red list, highlighting the importance of protecting these species and their habitat. Fishing pressures are already present in this site: Many of the corals viewed on the ROV surveys at the locality were entangled in fishing gear, and evidence of trawling. Trawl marks were documented on the sediments, as well as crushed carbonate rocks with an extremely depleted coral cover in the area.

**Prevention is better than cure:**

**Bottom trawling:** Destruction to deep-sea corals by bottom trawling has been documented worldwide, and the presence of coral rubble has increased in the last decades (OSPAR, 2008; IUCN and WWF, 2004). Cold water corals and octocoral beds are extremely slow growing, and damage by trawling will take decades to recover, if they recover at all (Huvenne et al. 2016).
Bottom trawling in deep-sea coral grounds may be compared to clearcutting a forest, though the recovery rates of the former ecosystems is much slower. Rehabilitation of

the sites following trawling impacts, may be irreversible, thus efficient protection prior to trawling is immensely important (Althaus et al., 2009; Clark et al. 2019; Hall-Spencer et al, 2002; D'Onghia et al, 2017).
The effectiveness of establishing protection prior to fishing destruction was demonstrated in the Darwin Mounds in the NE Atlantic. The mounds were discovered in 1998, and were closed to all bottom fishing in 2003. A survey in 2011 to evaluate the effectiveness of the fishing closure, showed that the amount of corals in the western area of the mounds that had not been previously fished, was found to be similar to the initial amount, as expected in a functioning MPA. On the other hand, the eastern part, that was heavily fished prior to the closure, showed no signs of recovery or recolonization by corals – 10 years after the MPA came into effect (Huvenne et al., 2016).
Not much research has been done to assess the effects of bottom trawling on chemosynthetic communities. Baco et al. (2010) described heavy impact due to trawling, which destroyed the foundations of the habitat in seamounts off New Zealand. If contacted by bottom trawling gear, the carbonate foundation, which form the base for chemosynthetic communities at seep sites, is crushed to rubble.
In order to prevent sediment suspension and habitat cover, a 1.5 km buffer zone is proposed around the FRA core area.

**Long-line fishing:** Longline fishing gear is highly destructive to deep-sea corals and may physically damage the corrals *in situ*, if it gets entangled in them; moreover, deep -sea corals are not uncommonly landed as bycatch (Aguilia & Marín., 2013; Sampaio et al. 2012). The benthic VME's at the site, including the cold seeps and brine pools, function as a reproduction hotspot for sharks, and are thus even more sensitive to fishing gear phisical damage and bycatch. thus, the proposed fishing enclosure will prevent ghost fishing and unintentional damage to the VME's at the site. The proposed 1.5 km buffer zone is also a no-take zone, in order to minimize the risk of derelict gear that will harm benthic VME's and pelagic fauna in the FRA.

**Atlantic Bluefin Tuna spawning site**

The proposed FRA is expected to protect an essential marine habitat of the Bluefin Tuna, preserving part of an area that is proposed as an important breeding ground for the eastern Mediterranean population, and is expected to support its recovery.

We expect the FRA to boost scientific research and activity in this unique area, and to support new discoveries in pharmacology, engineering and medicine and even in the growing submersible eco-tourism industry, in the future.

## 8.2. PROPOSED PROTECTION MEASURES FOR THE FRA

### 8.2.1 Management measures

Suggest management measures to be implemented in the FRA.

We propose a total fishing closure in the area, particularly bottom trawl fishing and longline fishing. Both of these practices have had devastating effects on these unique benthic communities in other regions of the Mediterranean.
We consider the entire FRA a unique complex of benthic and pelagic habitats, that their inter-connections are just starting to be discovered. Thus, the core area in proposed as a no-take area, and the 1.5 km buffer zone is also suggested as a no-take area in order to prevent adverse risks like sediment suspension, derelict fishing gear and bycatch.

### 8.2.2 Monitoring, control and surveillance measures

Suggest measures to effectively enforce the FRA.

Due to the distance of the FRA from the Israeli coast, it is suggested to use VMS as a key monitoring tool. The SPNI is promoting a bill to make VMS a mandatory measure for fishing vessels in Israel, in compliance with resolutions 33/2009/7 and GFCM/38/2014/1.

The Israeli Nature and Parks Authority has been operating a marine unit since 2018. It is now in the process of purchasing a long-distance vessel, which can help enforcement steps in the FRA.

### 8.2.3 Socio-economic impact(s) of the FRA

Indicate the potential socio-economic impact(s) of the proposed measures.

The estimated contribution of fishing catch from the area of the proposed FRA is less than 1% of the Israeli fishing fleet catch in the Mediterranean. This is demonstrated also in the low traffic of fishing vessel in the area of the proposed FRA. In addition, **no artisanal fishing nor foreign vessels were recorded in the area of the proposed FRA**. All the above demonstrate the minor fishing activity in the area of the proposed FRA and the negligible contribution it has to the total catch of the Israeli fishing fleet.

Thus, a fishing closure is not expected to have negative socio-economic impacts. On the other hand, the FRA would support the recovery of eastern ABFT population, and would boost demersal fish populations, creating a spillover effect for the benefit of nearby regions.

### 8.2.4 Economic assessment of ecosystems services

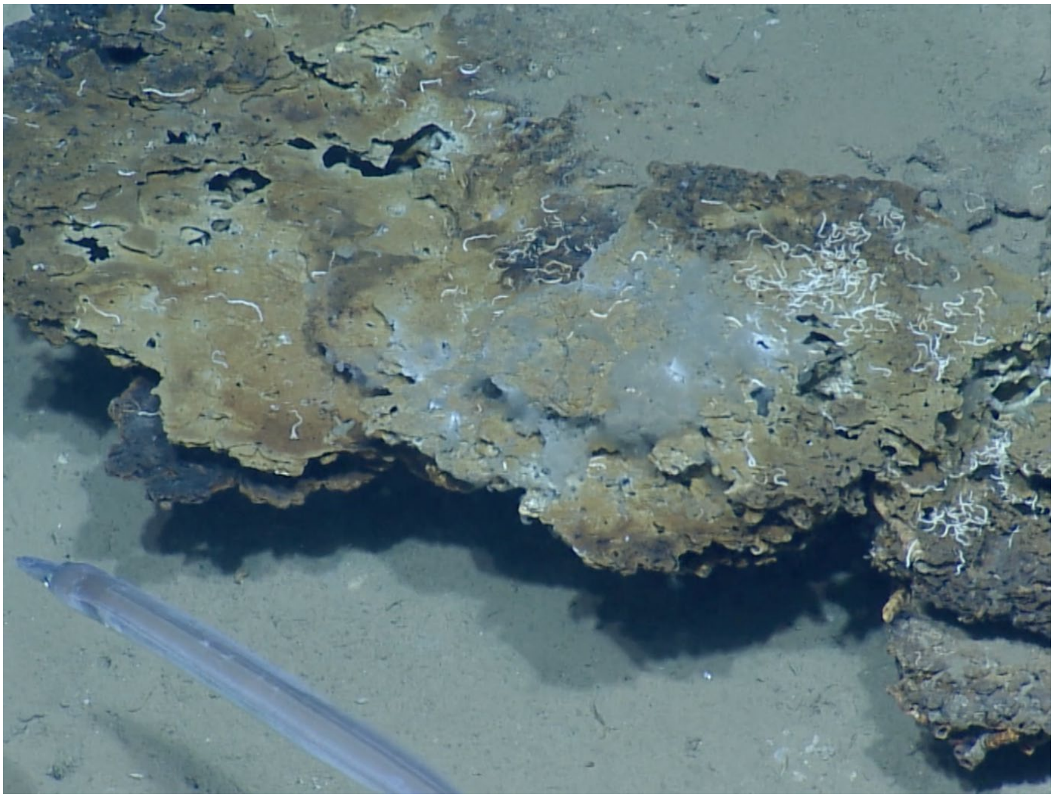
The research regarding ecosystem services provided by deep-sea habitats is in its infancy and there is not much supporting data regarding the services provided by the sites located in the Palmahim Disturbance. Therefore, the information we present refers to ecosystem services provided by similar habitats. The conservation of both the coral gardens and the seep communities have important economic implications (Jobstvogt et al., 2014; Foley et al., 2010), in the fields of science, medicine, pharmaceuticals, general ecosystem health, fisheries, and in the developing field of deep-sea ecotourism via submersibles.

#### Cold water corals

Deep-sea coral gardens act as a habitat for many species, including commercially valuable fish species. The complexity of habitat and food availability support nursery grounds for an array of taxa, including fish, shrimps and other invertebrates. New discoveries from CWC are utilized in medical, pharmacological, engineering and food research. There is a huge potential for discovering new pharmacological compounds, and already black coral extracts have been found to have a positive effect on acute lung inflammation caused by cigarette smoke (Bai et al. 2011), and the skeleton of ***Isidella*** corals is used for bone grafting. Synthetic analogues of the coral skeleton have been developed based on the structure of the *Isidella* skeleton (Ehrlich, 2019), reducing the future harvest of these endangered corals. The long-lived deep-sea corals, act as climate archives and a proxy for climate change, by using stable isotope data found in their skeleton to detect trends in ocean chemistry (Williams et al., 2006,2007 ; Robinson et al., 2014).

#### Cold Seeps

Many open questions remain regarding the functioning, distribution and diversity of cold seep environments, consequently the assessment of ecosystem function remains limited. Yet, chemosynthetic environments are some of the most diverse chemical and physical ecosystems on earth, with a high potential for discovering new eukaryotes and prokaryotes (Takai & Nakamura, 2011). The tolerance to a wide range of temperatures, pH, and pressure make Archaea found in such environments attractive to industrial sectors (UNU-IAS, 2005). Chemosynthetic communities offer an amazing opportunity to search for new metabolic pathways and compounds, inhabiting a unique and diverse genomic bank. The Seep fauna constitutes a unique pool of potential for the supply of new biomaterials, pharmaceuticals and genetic resources that have already been the basis for a number of patents (Gjerde, 2006; Arrieta et al., 2010).



**Cold gas (Methane) seeps, and the carbonate rocks formed near them, carbonate rocks formed near them, 1156 meters deep, in the Palmahim disturbance.**

# 9

# Relevant Contacts

Stakeholders (if applicable), name(s), position(s) and contact address(es) of the person(s) who compiled the form and/or can provide further information.

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**Protocol SPA/BD Annex II -**
http://rac-spa.org/sites/default/files/annex/annex_2_en_2013.pdf

**IUCN Red list of Mediterranean Corals –**
https://www.iucn.org/sites/dev/files/import/downloads/anzothoa_fact_sheet_final_baja.pdf

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# annex 1

# RARE HABITATS AT THE SEAFLOOR OF PALMAHIM DISTURBANCE – MAPPING AND CHARACTERIZATION FOR THE PURPOSE OF CONSERVATION

A Report Submitted to the Israel Nature and Parks Authority

by

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## Summary

This report aims to examine the existing data on rare habitats at the seafloor Palmahim Disturbance, and their implications for the establishment of marine protected areas in the Disturbance and its vicinity.

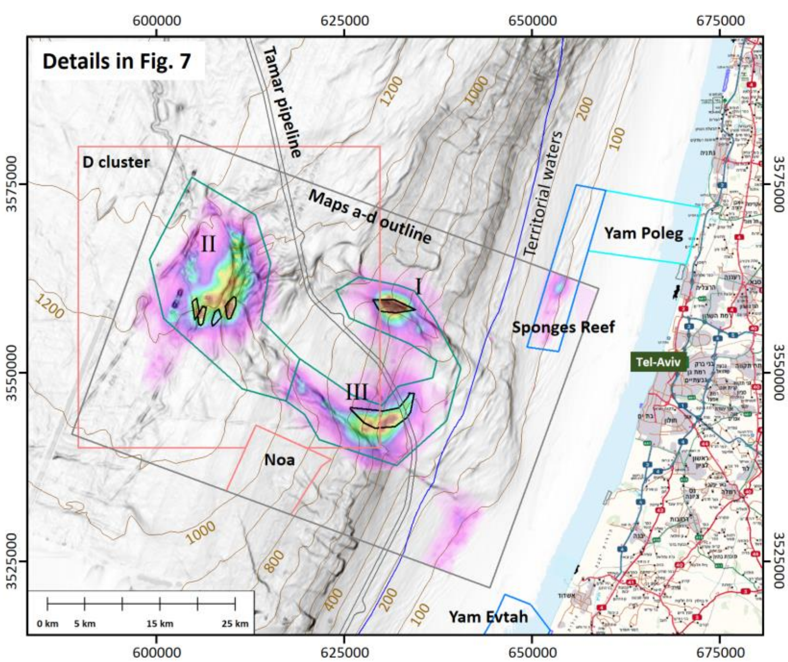
Palmahim Disturbance is a large and unusual geological structure and exceptional on the continental margin of Israel, stretching over 15 x 50 km and water depths between 100 to 1,200 m. Its complex morphology lays a foundation for a unique concentration of a distinct variety of rare seafloor habitats.

The rare habitats found on Palmahim Disturbance and its vicinity include deep-sea coral gardens, seafloor gas seepage-based communities and mesophotic sponge gardens. These habitats host a variety of rare and often endangered species, some potentially endemic, which constitute critically important conservation values at the national and global levels.

This report is based on a comprehensive database, and a designated analysis, of geophysical and bathymetric mapping, and video surveys and seafloor sampling by subsea robotic vehicles. Yet, only a small part of the Palmahim Disturbance was surveyed in sufficient detail and an understanding of the functionality and sustainability of these habitats is still missing.

Comprehensive mapping of the potential for the existence of additional rare habitats, and the potential for damage of the already known habitats, is based on:

a. A combination of all existing observations to a unified database, and their quantitative classification.
b. Two simplistic assumptions: (1) that the potentials decrease with the distance from existing observations; (2) that these potentials increase with the kilometers-scale bathymetric complexity.




The resulting mapping highlights three main areas of rare and sensitive habitats on Palmahim Disturbance: (I) an area of about 9 x 15 km that bounds the rich coral gardens along the northern slope of the central part of the Disturbance; (II) an area of about 16 x 17 km, encompassing the western part of the disturbance and the nearby Levant channel, which hosts an exceptional wealth and variety of seafloor gas seeps and their associated habitats; (III) an area of about 22 x 10 km along the southern boundary of the Disturbance, which hosts coral gardens and seafloor pockmarks. In addition, the map highlights a yet unfamiliar area on the southeastern boundary of the Disturbance, where an exceptionally rich concentration of mesophotic sponge gardens may exist. We pledge for the urgent surveying of this area. A comparison of the mapped potential and existing observations suggests that even areas with a relatively low potential (~0.2) should be regarded as areas with rare habitats.

This map provides a conservative estimation of the potential for direct impact on rare habitats from antropogenic seafloor activity, and does not reflect the potential effects of currents or adverse impacts from the sea surface.

In light of the concentration and unique richness, at the national and global levels, of rare habitats and endangered species, we proclaim utmost importance in a regulatory indemnification of the conservation of the areas identified here. In addition, we recommend undertaking a broad and thorough study to elucidate the distribution and and sensitivity of rare habitats on Palmahim Disturbance.

## Limitations

This report was prepared with due scientific care and diligence, based on the available data and the authors' expertise. As such, the report includes interpretations and assumptions that are based on the authors' professional opinions, and these limit the liability of the authors towards the conclusion of this report and any actions that may be based upon it.



## Contents

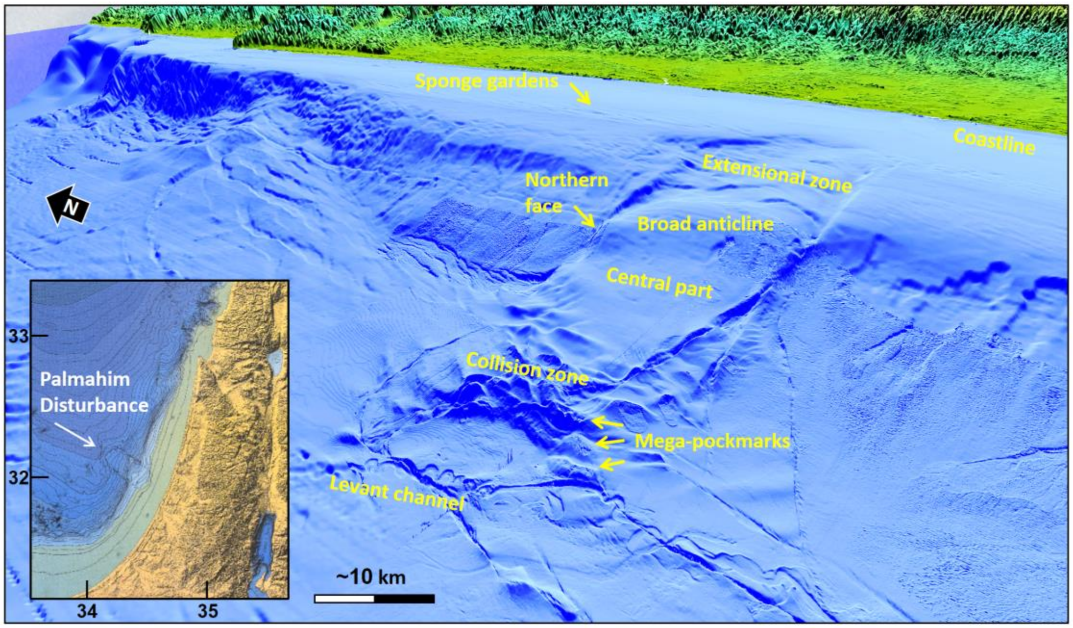



**Figure 1.** A 3D shaded relief depiction of the bathymetry and topography of the continental margin of Israel as viewed from the southwest, showing the morphology of Palmahim Disturbance, its parts and associated landforms. This report focuses on an overall mapping of rare habitats on the Disturbance. (Bathymetry after [(1)].)

## 1. Palmahim Disturbance – morphology and formation

Palmahim Disturbance is an exceptional landform, extending from the continental margin of Israel, which formed through the detachment of a segment of this margin and its gradual slumping westwards over several millions of years [(2)] (Fig. 1). Its alongshore width is 15 km, and it stretches across 50 km between water depths of 100 to 1,250 m. Along its length, it comprises four main parts: (1) **An extensional area** that is characterized as a 15 km long and ~100 m deep depression in the continental margin. This depression represents a disintegration and spreading zone, encompassing a system of extensional faults that form a set of significant bathymetric steps. (2) **A central part** is a broad ramp-like area that rises up to 200 m above its northern and southern surrounding. It is composed of a 20 km long continuous slab that translates westwards, with its upward eastern part folded to form a north-trending broad 10 km wide anticline ridge. (3) **A collision zone** at the western end of the down sliding slab, which is characterized by a series of generally north-trending narrow (~1 km wide) and ~50 m tall steep ridges. (4) **Levant channel** [(1)], which is a ~500 m wide submarine river-like landform that undulates in a general northwards direction along the western bound of Palmahim Disturbance, and is bounded by tens-of-meters tall bathymetric faces. The Levant channel forms the eastern edge of the deep-sea fan of the Nile river, which intersects with the continental margin of Israel in the Palmahim Disturbance region. The Levant channel does not appear to conduct sediments at present, but to date, no published work examined this issue. The northern and southern lateral boundaries of the Disturbance are delimited by strike-slip fault systems, which form sharp faces and ridges in the extensional and central parts and splay westwards to branching systems of deep sharp fractures in the collision and Levant channel areas. There are multiple lines of evidence that these fault systems and the Palmahim Disturbance deformed in the recent tens of thousands of years at average rates of meters per thousand years, and it is reasonable to assume that this activity is still ongoing.

## 2. Rare habitats found in Palmahim Disturbance and its surrounding

The combined effect of the geological complexity of Palmahim Disturbance and several water masses engulfing it forms a variety of marine environments, in which we discovered in recent years a large number of exceptional and rare habitats. These habitats are impressively picturesque, standing out over the poor surrounding environment of the southeastern Mediterranean Sea. Sustaining the austere conditions of the oligotrophic (nutrients poor) and exceptionally warm (~14°C) water of the Southeastern Mediterranean Sea [3], these habitats are unique at the global and local level (the Israeli offshore). As detailed below, we developed a preliminary understanding of the geological and oceanographic contexts of the different habitats and their characteristics, which allowed us to map the potential for the presence of rare habitats.

Three primary types of rare habitats, which are classified as vulnerable marine ecosystems (VMEs) by the Food and Agriculture Organization (FAO) of the United Nations and other international organizations [4], were found so far on the Palmahim Disturbance and its surrounding:

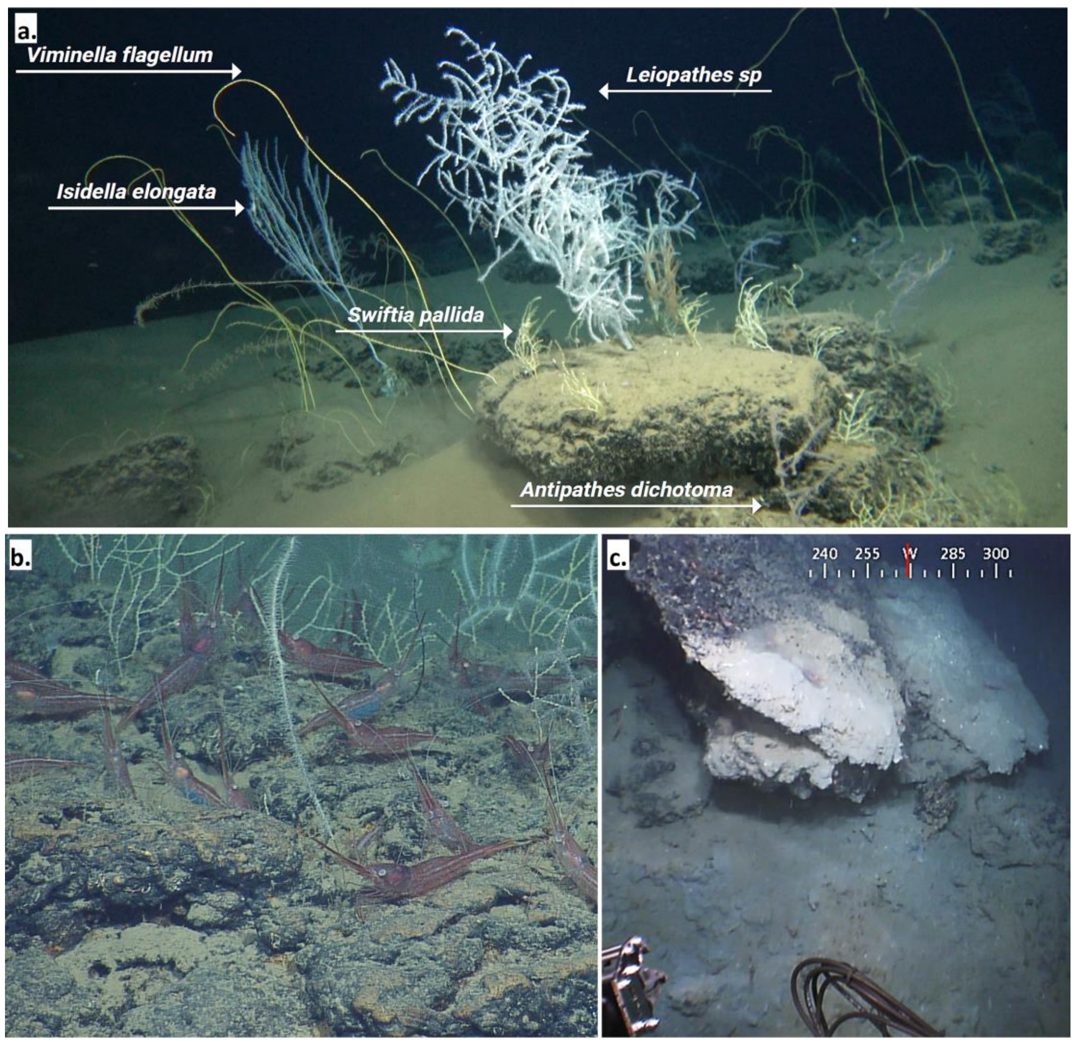



**Figure 2.** Deep-sea corals gardens on Palmahim Disturbance. **a.** A variety of coral species on the northern face of Palmahim Disturbance (~650 m water depth). **b.** A wealth of shrimps in a relatively shallow (~600 m

water depth) deep-sea corals garden. **c.** A rocky buildup overlaid with a corals garden that was shattered by trawl fishing on the southern part of Palmahim Disturbance (~450 m water depth).

**2.1. Deep-sea corals gardens** were found on the east of the central part of Palmahim Disturbance (Fig. 1), at water depths between 400 to 800 m [(5,6)]. These gardens comprise thousands of deep-sea corals colonies (a total of 7459 colonies were counted) of several different species, growing on and around rocky formations and focusing the growth of a variety of additional organisms (Fig. 2a,b). These colonies appear as delicate branching bushes, often reaching heights of up to ~1.5 m. Notably, estimated growth rates of such coral species are particularly slow (7), and it may have taken hundreds and even thousands of years for the coral colonies observed on Palmahim Disturbance to reach their sizes. Analysis of samples collected by us suggests that the most common corals on Palmahim Disturbance are *Leiopathes* species, which may be a new phylotype or phenotype first observed here. *Leiopathes* are considered as 'endangered' by the International Union for Conservation of Nature (IUCN) red list. Other deep-sea coral species growing on Palmahim Disturbance include *Antipathes Dichotoma* (black corals), *Callogorgia verticilata* (fan corals), *Viminella flagellum* (whip corals) and *Parantipathes larix* (all four defined on IUCN list as 'nearly threatened'), *Isidella Elongata* ('critically endangered'), *Funiculina quadrangularis* ('vulnerable') and *Desmophylum dianthus*. All these coral species are protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In addition, the coral gardens host a variety of fish, most prominently the blackbelly rosefish (*Helicolenus dactylopterus*), the wreckfish (*Polyprion americanus*) and other species that habituate these water depths, shrimps and crabs, anemones and other cnidarians, sea stars, worms and more. An unusual wealth of shrimps was observed in the relatively shallower water depths (between 400 to 600 m) coral gardens (Fig. 2b) and may constitute a target for trawl fishing, which we found to bulldoze coral gardens on the Disturbance (6) (Fig. 2b). In addition, harvesting of deep sea corals, and particularly black corals, for the jewelry and decorations industry, have been resulting with the global twiddling of their communities.

In the lack of light penetration into the Palmahim Disturbance coral gardens water depths, no photosynthesis-driven primary production occurs at the deep-sea corals and surrounding habitats. These habitats depend therefore on 'marine snow' (organic remnants and other particles) that descend from the upper water layers, as indicated by our isotopic analysis of amino acids from coral samples collected on the Disturbance. Benthic stationary organisms in this habitat, in particular, deep-sea corals, have a distinct capability for capturing and concentrating the food from the water, promoting the development of the rich habitat around them. As such, most of these organisms require a rocky substrate, on which they can settle. The rocky outcrops that serve as a settling substrate for the Palmahim Disturbance coral gardens are an unusual phenomenon on the Southeastern Mediterranean Sea seafloor, where the majority of the seafloor is a muddy mixture of clays outpoured by the Nile river and planktonic shells. Widespread rocky outcrop patches stretch within an area of 4 x 1.5 km, on a relatively steep face that cut the northern side of the broad anticlinal ridge in the central part of the Disturbance. These outcrops are covered with the richest and most diverse deep-sea coral gardens found (Fig. 3a,b). Additional rocks were found on the southern side of the same anticlinal ridge. There several broad knolls were surveyed and found to be associated with rocky buildup outcrops that are covered with deep-sea coral gardens. The bathymetric and geophysical data testify that multiple such knolls, associated with rocky buildups, are distributed over ~8 x 3 km in this area, and these may constitute the substrate for additional coral gardens. Geochemical analysis of rock samples collected indicates that the rocks are primarily (authigenic) carbonates that formed in association with past natural seafloor gas seepage. When seepage ceased, substrate attached organisms settled on the rocky substrate formed. We suggest that the formation of rocks in the area is associated with past tunneling of gas seepage to the sides of the anticline, which allowed the development of coral gardens over wide regions on the two sides of the Palmahim Disturbance. Detailed mapping of the distribution of the different coral species shows that most of them are found on locally protruding parts of the seafloor (Fig. 3). This observation presumably testifies that these species prefer to be exposed to nutrients and oxygen-enriched water currents. Dune-like bed-forms, which in places burry modern garbage, and the concentration of garbage in seafloor notches, provide pieces of evidence to the activity of significant bottom water currents that mobilize sediments in a generally northern direction and turbidity currents that flow down the slope. It is possible that the morphology of Palmahim Disturbance focuses the water currents and sediment flows, enhancing the supply of nutrients to the coral gardens. However, this dependence on focused food supply from the water body also results in sensitivity of the coral gardens to the release of harmful substances at relatively large distances, and particularly to waste and contaminants that arrive from the surface on the south of the Disturbance. Yet, to date, no organized study was carried on the ranges of influence of such threats.

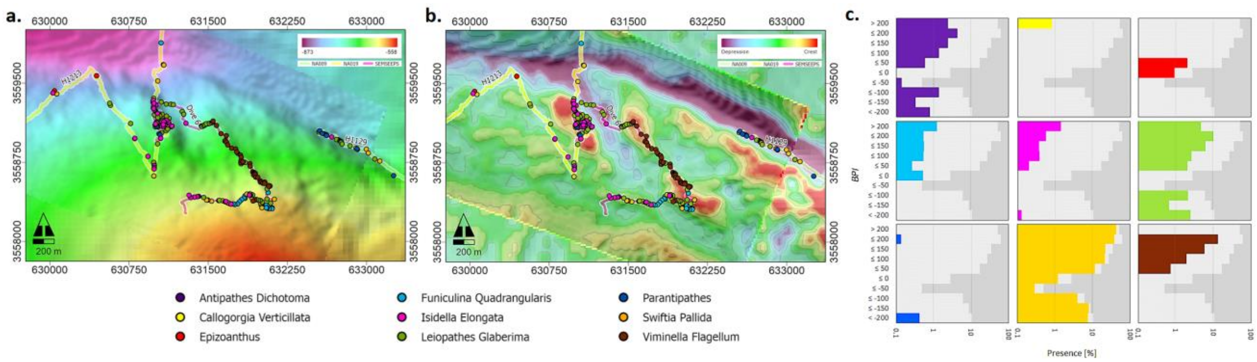



**Figure 3.** A detailed analysis of the distribution of the deep-sea coral species (color-coded as in the index) on the northern slope of Palmahim Disturbance, in relation to the bathymetric depth (**a**) and bathymetric position index (BPI – a measure of protruding with respect to the surrounding) at a ~500 m lateral scale (**b**). Histograms of the normalized distribution of corals with respect to the substrate BPI (**c**) shows differences in the preferences of the different species, presumably associated with the affinity to water currents.

**2.2. Natural seafloor gas seepages and associated habitats** were found so far primarily in the collision and Levant channel areas in the western part of Palmahim Disturbance (Fig. 1), between water depths of 1,000 to 1,250 m. Albeit, there is evidence for their possible presence in other areas of the Disturbance (as detailed below). Our analyses revealed that the gas seeping on Palmahim Disturbance is primarily methane [(8)]. It appears to be emitted mostly in dissolved form, but in some places also gas bubbles are discharged. The gas seepage and associated processes form a variety of pockmarks (seafloor depressions) with different sizes and morphologies. Where seepage lasted for a long enough time (thousands of years) astounding carbonate rock buildups evolved and are exposed at the surface, towering up to ~2 m tall and resembling abstract statues and/or chimneys of various sizes (Fig. 4a). The gas seeps are hotspots of life for bacteria. These exploit the energy stored in the seeping fossil fuel for chemosynthetic primary production, and serve as a ‘biological shield’ that prevents the emission of the greenhouse potent methane to the atmosphere. The chemosynthetic bacteria form, via symbiotic relations or consumption, a base for a unique and rich ecological system on the seafloor, with a community structure succession with the distance from the seepage edifices. In Palmahim Disturbance the sulfide-rich seepage edifices appear as dark patches or are hidden beneath the rock formations (Fig. 4b). Above and around the dark patches appear bacterial mats, various Polychaetea worms and other invertebrates. Among these are the chemosynthetic tubeworms *Lamellibrachia anaximandri*, which may live to ages of hundreds of years. In the course of evolution, these worms lost their digestive system, and instead have a trophosome that hosts sulfide-oxidizing bacteria [9] that provide the worm with nutrition. Another species found in Palmahim Disturbance is the *Idas* bivalve, which can store in its gills ~7 different lineages of intracellular symbionts, including sulfur- and methane-oxidizing bacteria. In and around the rocks reside burrowing worms and bivalves, sea urchins, *Bathynectes maravigna* crabs etc. A cryptic species of sipunculid worm, *Phascolosoma* aff. *turnerae*, was found burrowing within authigenic carbonates [10]. Concentrations of bivalve shells are found on the nearby sediments, and particularly the chemosynthetic bivalve *Lucinoma kazani* [11,12].

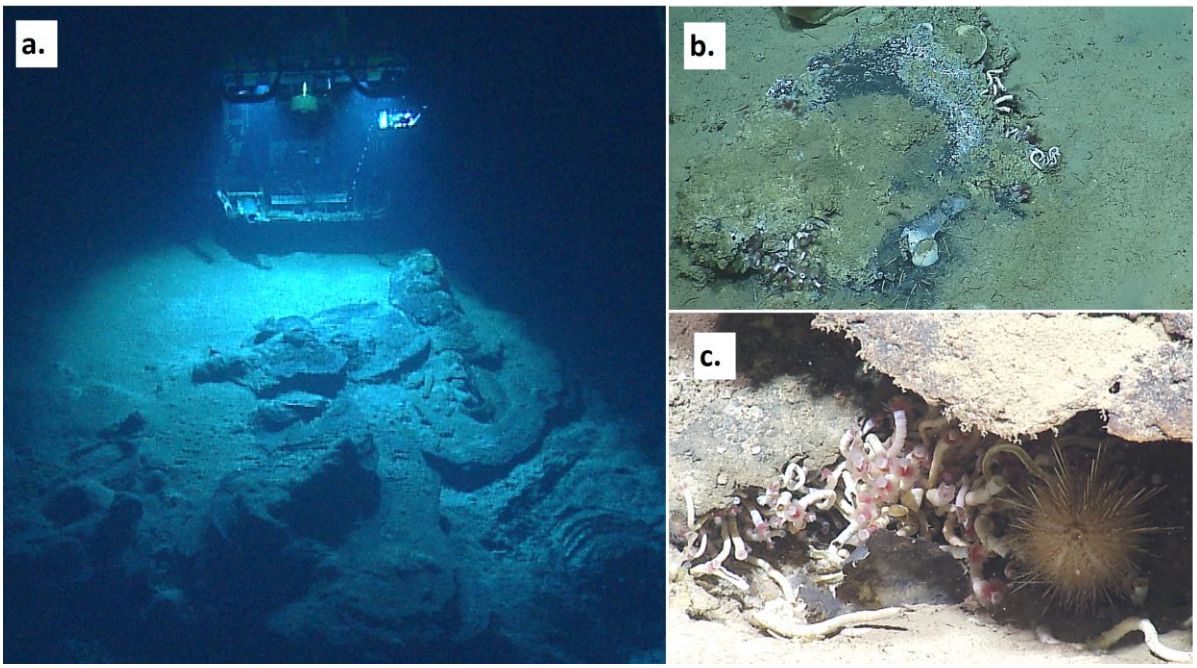



**Figure 4.** The gas seepage habitats on Palmahim Disturbance. **a.** Seepage related carbonate rock formations, as photographed in an underwater remotely operated vehicle (ROV) survey, with fine bubble stream discharged in front of the ROV (arrow). **b.** A gas seepage edifice characterized as a dark patch, partly overlaid by white bacterial mats, and a small carbonate rock outcrop, teeming with different tubeworm species and bivalve shells. **c.** A carbonate crust, underlain by chemosynthetic *Lamellibrachia anaximandri* tubeworms and a sea urchin and visibly teeming with smaller tubeworms. The presence of these organisms indicates active gas seepage, presumably in dissolved form, although no bubbles are observed.

The soft sediment seafloor around the seepage edifices and carbonates are pervasively textured with centimeters to decimeters scale soil piles, the burrowing products of intense networks of burrows to depths of ~0.5 m in the sediment (Fig. 5a,b). These burrows are created primarily by a blind shrimp of the species *Calliax lobata* (Fig. 5c) [11]. This lineage was identified only recently. However, following the finding of several living specimens and a multitude of claw remains in sediment samples, which we collected in Palmahim Disturbance seepage habitats, we established that this lineage plays an important role in the seafloor ecology and is a major component of the 'biological shield' that may limit methane emissions to the hydrosphere. It appears that in burrowing through the sediment this shrimp siphons seawater into the sediment, promoting the growth of specific microbial communities and deposition of authigenic carbonates. Isotopic analysis of *Calliax lobata* amino acids revealed that its nutrition originates from a mixture of chemosynthetic and other sources. We conclude that the activity of these shrimps increases the usage of nutrients from the water body, resulting in a sensitivity of the seepage burrows habitat to environmental treats. However, this sensitivity was not examined to date. The burrowed areas, constituting rare habitats, stretch to distances of tens and even hundreds of meters from the seepage edifices [13].

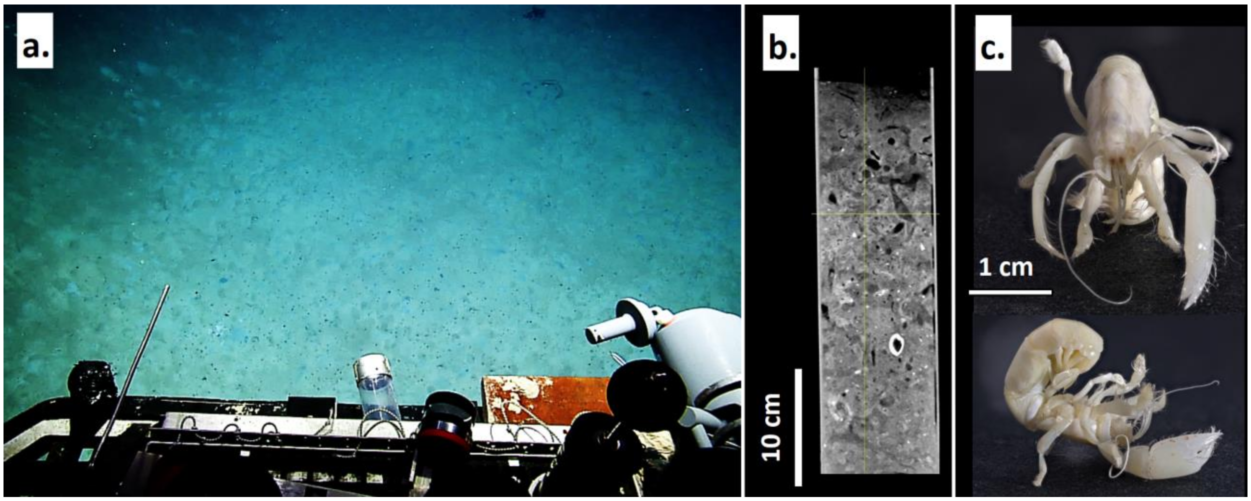



**Figure 5.** Seepage-associated seafloor burrows, as observed on Palmahim Disturbance at the seafloor (**a**) and in a CT image of a sediment core sample (**b**), and the blind *Calliax lobate* shrimp (**c**) that appears to be the primary creator of the seafloor burrows on Palmahim Disturbance.

Three types of active gas seeps, and their associated habitats, were found so far on Palmahim Disturbance, which defers in their characteristics and geological contexts. 1. The most developed and prominent seepage sites were found inside wide seafloor mega-pockmarks (with hundreds of meters lateral extents and up to tens of meters deep), which extend along the crests of three of the narrow ridges in the collision zone on the west of the Disturbance. Multiple seepage edifices and extensive carbonate rock formations, which have complex morphologies and chemical compositions, are distributed within these mega-pockmarks along with subsurface fractures and are surrounded by broad and intensive burrowed regions. These features and the complex structures of the mega-pockmarks suggest that they formed over a relatively long time of thousands of years, and possibly more. Accordingly, the habitats found within these mega-pockmarks are particularly rich and variable in comparison to the variety of seafloor gas seeps that were found so far in the Israeli offshore. Analysis of the geological structure at the base of these mega-pockmarks indicates that the seepage and pockmarks formation is supported by focusing on subsurface gas seepage from a broad region onto the crests of the ridges. 2. Elongate (>1 km long) narrow (<100 m) seepage areas were found within the Levant channel, along its banks, with several seepage edifices, unique carbonate chimneys and a variety of organisms. A broad-scale geophysical study shows that the Levant channel seepage is associated with paleo-channel lobe systems of the deep-sea fan of the Nile, which are presently buried to tens of meters below the seafloor and are probably charged with natural gas. The incision of this buried system by the Levant channel allows the seepage of gas through the seafloor along the sides of the channel. 3. Minor, up to tens of meters in diameter and meter-scale depth, seafloor pockmarks are distributed on Palmahim Disturbance. Several such pockmarks were visited by us in preliminary ROV surveying in the vicinity of the Levant channel and the extension area in the western part of Palmahim Disturbance. These were found to portray areas of enhances burrowing, but no clear seepage edifice or carbonate formations were observed and they appear to be associated with relatively modest biodiversity. However, this type of pockmarks was not studied in an organized manner to date. Another type of seafloor seeps, which was not found to date on Palmahim Disturbance, is characterized by clusters of small (a few meters across and <1 m depth) pockmarks with areas of enhanced burrowing and seldom active seepage edifice and related organisms. A multitude of these clusters was observed by commercial and academic autonomous underwater vehicles (AUV) surveying along the base of the Israeli continental slope to the north of Palmahim Disturbance. Geophysical investigation of these seeps reveals that they are associated with the formation of a set of depositional mini-basins in association of the retreat of an undelaying salt layer along the base of the continental slope.

**Figure 6.** A portion of the mesophotic sponge gardens at the edge of the continental shelf at a water depth of 90 m offshore Herzlyia, as an example for the intensity and richness characterizing these habitats [13]. (Photographed through ROV surveying as part of the Ph.D. research of Tal Idan, Prof. Micha Ilan's Laboratory, School of Zoology, Tel-Aviv University; and brought here under their generous custody.)

**2.3. Mesophotic sponge gardens** were found on rocky knolls at the edge of the continental shelf at water depths of 95 to 125 m, and particularly offshore Herzlyia ~15 km to the north of Palmahim Disturbance (Fig. 1). These were investigated in detail by the group of Prof. Micha Ilan of Tel-Aviv University, and are described as rich with a variety of sponges and other organisms [14] (Fig. 6). The intense sponge coverage, and their variable morphologies, form a 3D framework that attracts other fauna. It appears that a particular importance of this habitat is in providing a refuge for species that were pushed out of the shallower water regions by anthropogenic pressure, invading species and climatic changes. The rocky knolls, which provide the substrate for the mesophotic sponge gardens, are parts of an extensive geological rock formation that is buried beneath sediments along much of the edge of the continental shelf and parts of it are exposed to the surface by the activity of intense bottom water currents. Bathymetric mapping around the eastern top of Palmahim Disturbance (Fig. 1) reveals a belt of multiple additional seafloor knolls that are exposed to the surface at water depths between 85 to 300 m, and along the upper morphological steps that were formed by the extensional faults and crown the top of the Disturbance. We assess that at least some of these bathymetric knolls have rocky outcrops and support mesophotic sponge gardens or similar habitats, but focused surveying is required for mapping these habitats.

## 3. History of the Palmahim Disturbance research

This report is based on a pervasive database. The geological structure of Palmahim Disturbance and its surrounding was investigated through several seismic surveys since the fifties (15), and Hana-1 exploration well was drilled at the center of the Disturbance but not developed. Since the beginning of the current millennium several 3D seismic surveys were acquired around the Disturbance, covering considerable parts of its area. Data of these surveys were granted for academic research by the Oil Commissioner's office, Ministry of Energy, and by some of the exploration companies, and served us for some of the analysis presented in this report. A decade ago the seafloor bathymetry was mapped through multibeam surveying at a good horizontal resolution (~25 m), but only a reasonable quality [(16)]. However, combining high-quality maps of the seafloor that were obtained from the 3D seismic data [(1,17)], and follow-up multibeam surveying results, the bathymetry is now well mapped over most of the Disturbance, and its morphology is reasonably well known. Four ROV-based seafloor surveys were carried by us on Palmahim Disturbance, including: one deeply-towed sidescan sonar and five ROV dives in the course of EV Nautilus 2010 and 2011 cruises [(5)]; five ROV dives in the course of SEMSEEP project 2016 cruise onboard RV Aegaeo [(6)]; and three ROV dives in the course of a collaborative University of Haifa and IOLR cruise onboard RV Bat-Galim in 2017. These, several- to 20-hours long, dives acquired video surveys of the seafloor and collected samples of organisms, rocks and sediments. In addition, in the course of 2016 SEMSEEPS cruise and three 2017 and 2020 cruises onboard RV Bat-Galim, we sampled on Palmahim Disturbance a total of ~20 box-core and two piston-cores samples of the seafloor- and bottom-dwelling organisms, as well as water-column measurement profiles and water samples. Analysis of the data and samples collected is carried in the framework of a broad collaboration, primarily between the universitis of Haifa (Israel), Ben Gurion (Israel), Friborg (Switzerland) and Milano-Bicocca (Italy), and the IOLR. Analysis combined so far the research projects of about ten M.Sc. and Ph.D. students, three post-doctoral trainees and substantial additional scientific and technical stuff, utilizing advanced marine research methodologies. Particularly, samples of chemosynthetic organisms that were collected on Palmahim Disturbance serve as a base for genetic and physiological studies, which deal in the evolution of symbiosis between bacteria and other animals and characterize methods for the disposal of greenhouse gasses ($CO_2$ and methane). Part of the results of these works were published so far in scientific journals, thesis works and sciemtific conferences; while some of the results described here have not been published as of yet. Based on the insights that accumulated we developed a method for predicting the presence of seafloor seepage sites based on 3D geophysical data, where no a-priory seafloor surveying is available. This methodology was successfully verified by a number of discoveries of new seepage sites in subsequent ROV surveying. In addition, detailed analyses of the video surveys, positions of the different classified observations and samples and the geophysical data and analyses results where all combined to a uniform GIS database, and serve us for overall mapping of the potential presence of rare habitats over the area of the Disturbance.

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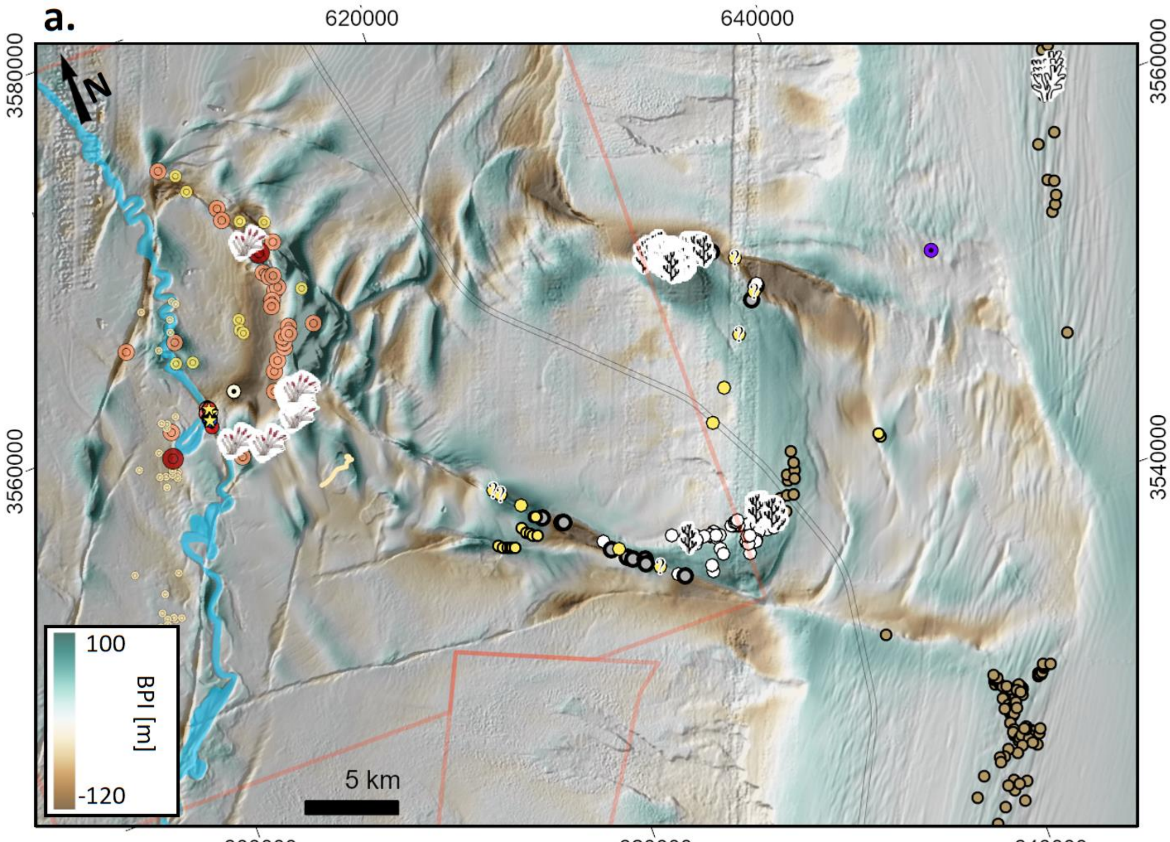

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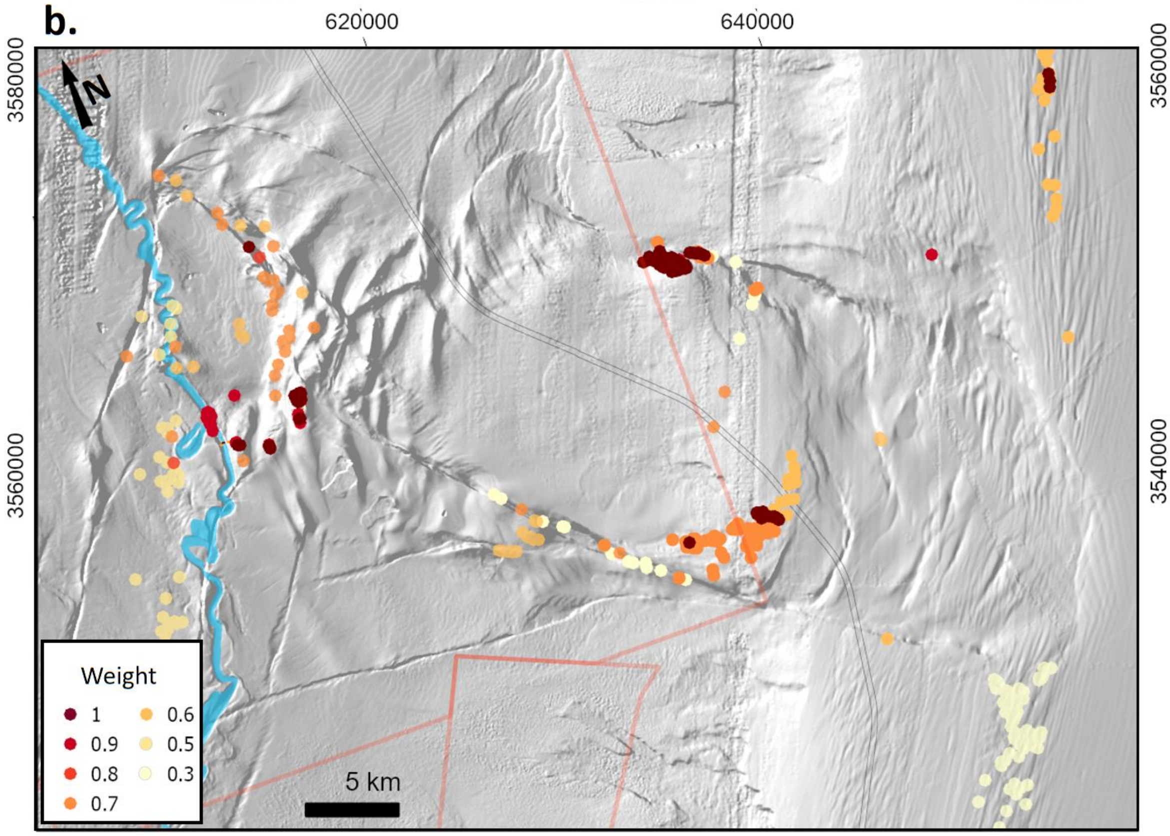

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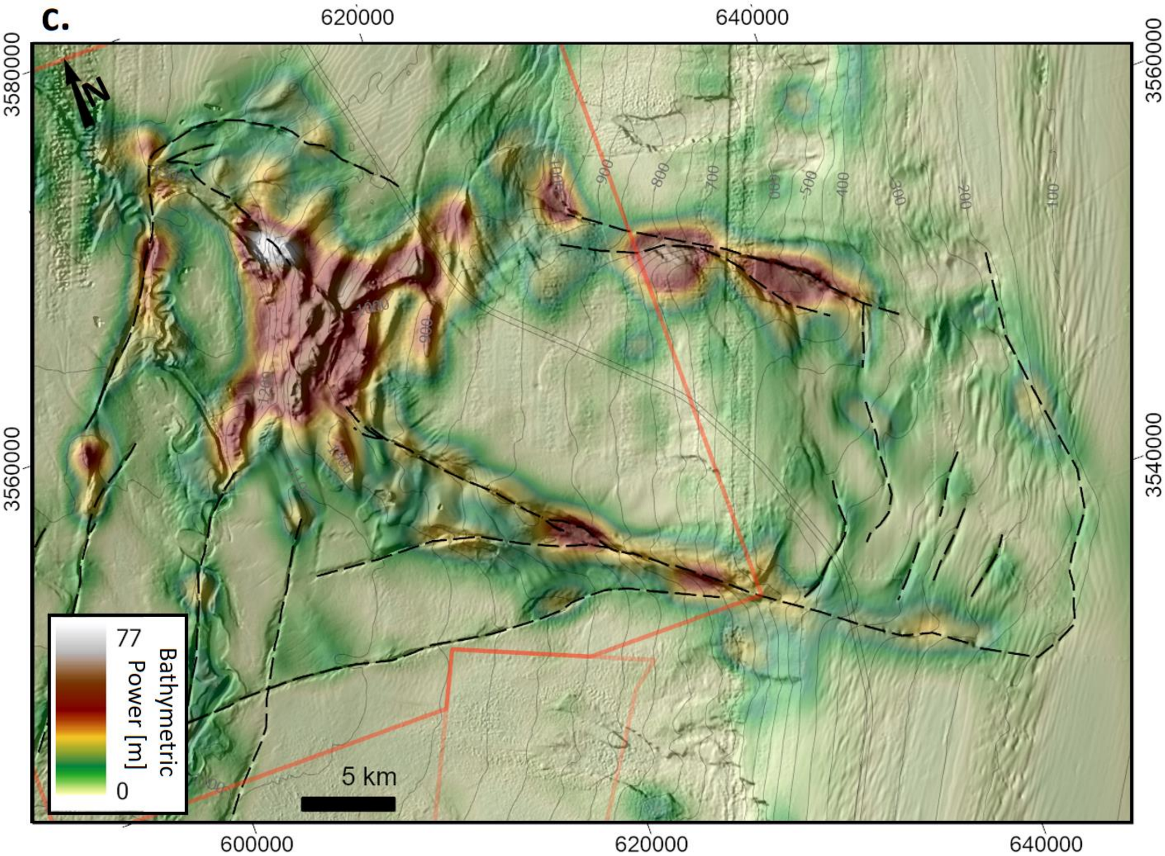
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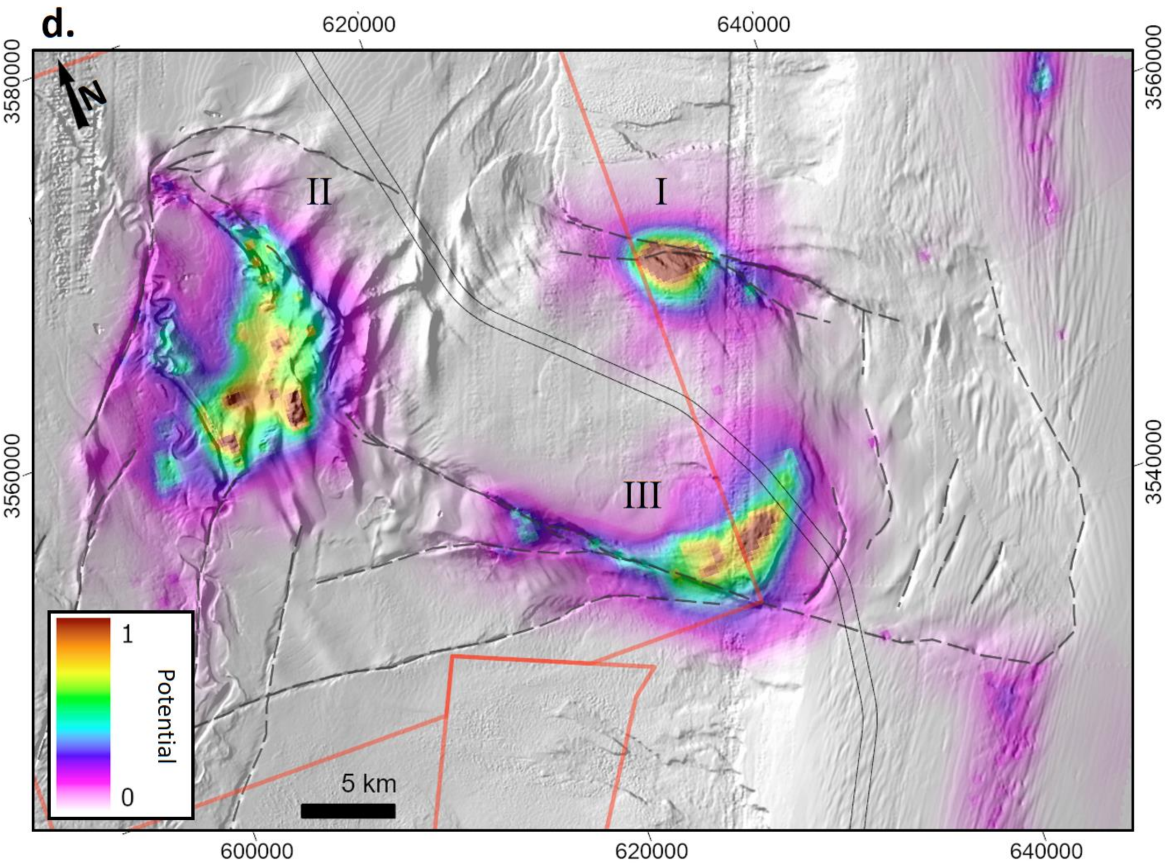
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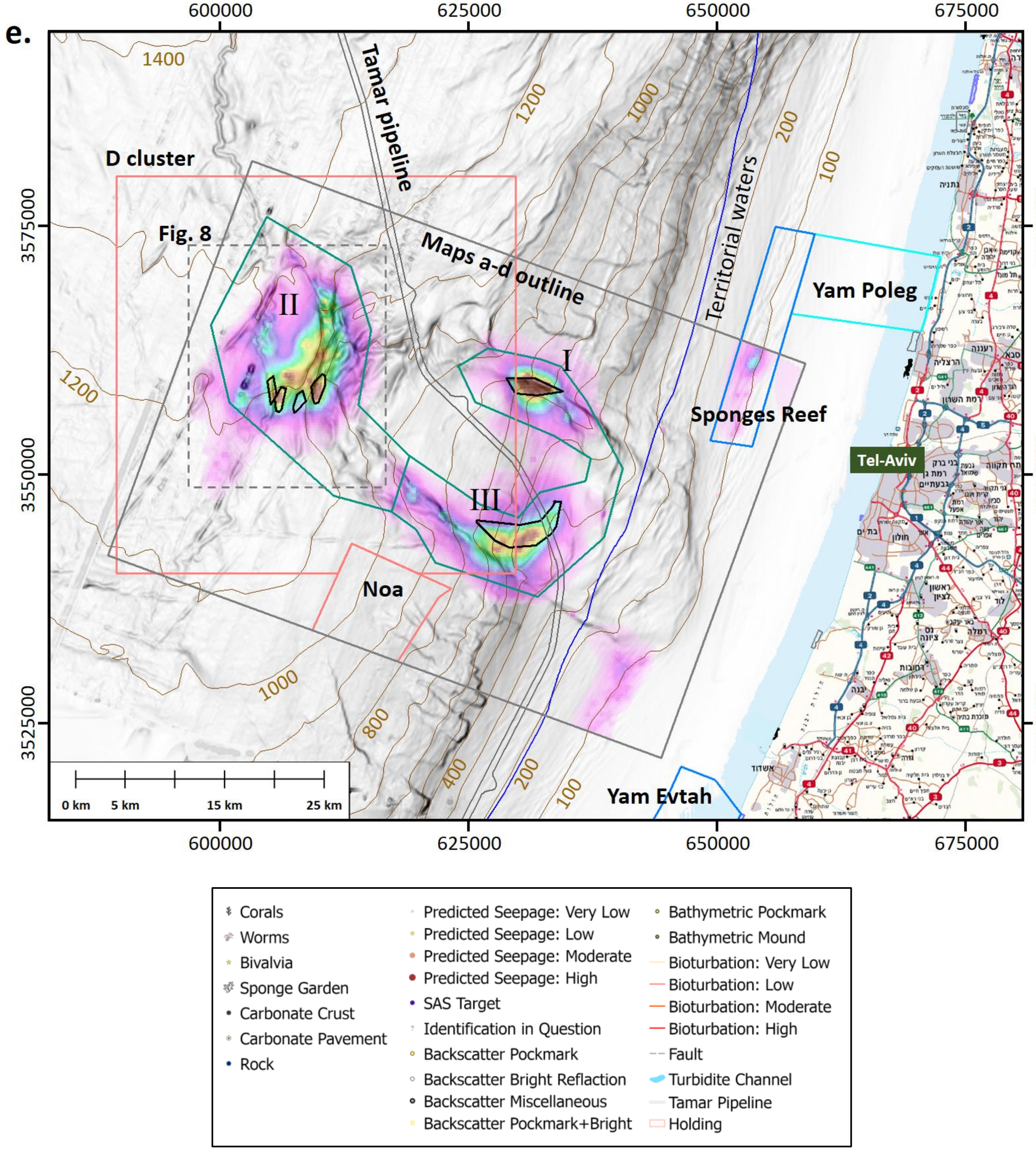


**Figure 7.** Mapping the potential for the presence of, and direct impact on, rare habitats on Palmahim Disturbance (the outline of a-d in marked in the broader context in e). **a.** The qualitatively classified database of existing observations (see the index for the meaning of the symbols), overlaid on the BPI at the horizontal scale of 500 to 2,000 m (green to brown, see color scale) and bathymetric shading. **b.** A quantitative classification of the observations in (a) to the range 0 to 1 (according to table 1). **c.** A map of the bathymetric complexity power at the horizontal scale of 500 to 2,000 m (green to brown, see color scale), and primary faults outlines (dashed lines). **d.** A map of the potential for the presence of, and direct impact on, rare habitats, normalized to the range 0 to 1, with a labeling of the three primary concentrations

of rare habitats discussed in the text (I to III). **e.** The potential map from (d) in the context of the Israeli offshore, including: Israel Nature and Park Authority outlines of approved marine reserves (purple), special marine areas (light blue) and areas of search for marine reserves in territorial waters (blue); Israel Planning Administration conservation areas to be examined (green) and search areas for marine reserves (black) in the exclusive economic zone (EEZ) of Israel; the territorial waters boundary (thin blue line); the outline of the maps in (a) to (d) (solid gray frame); the outline of Fig. 8 maps (dashed gray frame); and depth contours at a 100 m spacing (thin brown lines). Overlaid on all maps are the Tamar pipelines route (black thin lines doublet) and the petroleum rights: Noa Production Lease and D Exploration Licenses cluster (orange lines).

## 4. Mapping the potential for the presence of rare habitats on Palmahim Disturbance

Aiming to obtain a comprehensive view of the distribution of rare habitats on Palmahim Disturbance, we need to acknowledge the limitations of existing knowledge and the actual difficulty in detailed investigation of habitats at the relevant seafloor depths. Visual ROV surveying and samples collection and analysis, at the base of seafloor habitat characterization, are hampered by the limited deep water visibility (up to a few meters) and ROV samples collection capacity and by the relatively high operational costs.

Comprehensive mapping of the potential distribution of rare habitats require therefore the use of a geo-statistical model. The construction of such a model is based on defining the dependence of the distribution of organisms on the collection of geological-geomorphological and oceanographic conditions [18,19]. On Palmahim Disturbance we found, as described above, that the distribution of rare habitats is correlative to the geological structure and context. The latter are directly represented by the bathymetric complexity at a lateral scale of hundreds of meteres to kilometers, related with the Disturbance's ridges, terrace-step systems, faces and channels. Notably, the lateral scale that is related with the presence of the habitats is broader and less precise than the lateral scale that is related with the presence of organisms within the habitat (such as considered in Fig. 3). Here we map therefore the potential for the existence of, and direct impact on, rare habitats on Palmahim Disturbance (Fig. 7d) based on: (1) the combination of all available observations to a unified database (Fig. 7a), and their quantitative classification as markers for the presence of rare habitats (Fig. 7b); and (2) mapping the bathymetric complexity of Palmahim Disturbance at the hundreds of meteres to kilometers scale (Fig. 7c). Mapping and modeling, as detailed below, were carried in practice in ESRI ArcGIS software.

### 4.1. Construction of the unified database and quantitative classification of the observations

The database constructed collected together the full range of observations and analysis results, and is integrated with understandings gained over the last decade:

***The coral gardens*** on the north slope grow on the rock outcrops that are associated with the truncation of the broad anticline with the fault system forming the northern boundary of Palmahim Disturbance (Fig. 1,7a). These outcrops are associated with fine morphological steps, seen in the bathymetry to extend along the entire ~4 x 1.5 km face, also away from the surveyed ROV routes. In the course of three thesis works the locations of rocks and the different coral species, as defined by analyses of samples collected, were mapped into the GIS database. Furthermore, a detailed analysis was carried of the settlement distributions of each coral species with respect to the BPI (Fig. 3). Similarly, on the southern side of the Disturbance coral gardens grow on rock knoll outcrops on the southern truncation of the broad anticline. We mapped the disturbace of the rock knolls as foci of high-amplitude backscatter in deeply towed sidescan sonar data, which were collected by EV Nautilus in 2010, and multeabem data collected by RV

Bat-Galim in 2017. These structures and their partial sediment coverage are depicted of the bathymetry as mounds, which were also mapped to the database.

***The gas seeps and associated habitats***, which were observed in the ROV surveys in the area encompassing the western part of the Distubance and the Levant channel (Fig. 1), were mapped into the database (Fig. 7a) in the course of three thesis work, and some of the results were published [12,13]. Mapped features include the classified intensity of burrowing along the survey routes (low, middle, high), rock formations, seeps, gray patches, bivalves and tubeworms. In addition, we found that gas seepage associated with the deep-sea fan of the Nile is driven by proximity to the seafloor or/and outcropping of gas-charged buried paleo channel-lobe systems, which are characterized by clear high-amplitude reflectivity in 3D seismic data. Building on these characteristics, we developed a method (in the framework of Muhedeen Lawal Ph.D. work – in writing) for mapping potential seepage sites and predicting their seepage intensity, based on the RGB composition of multi-depth seismic reflectivity. This method was developed and calibrated based on the seepage sites discovered in the course of EV Nautilus 2011 cruise, and was since utilized for predicting the locations of four new seepage sites and negating the presence of seepage in one bathymetric pockmark. These results were verified by ROV surveying in the course of the 2016 SEMSEEP cruise, and a commercial environmental ROV survey. We therefore utilized our methodology for deriving a database of predicted seepage sites at the western area, and classifying semi-quantitatively their predicted intensity (low, medium, high; Fig. 8). In addition, we mapped into the database pockmarks that were observed in the available bathymetric and deeply towed sidescan sonar backscatter. These are distributed on Palmahim Disturbance along the southern boundary fault, on the broad anticline and along some of the bathymetric fault steps in the eastern part.

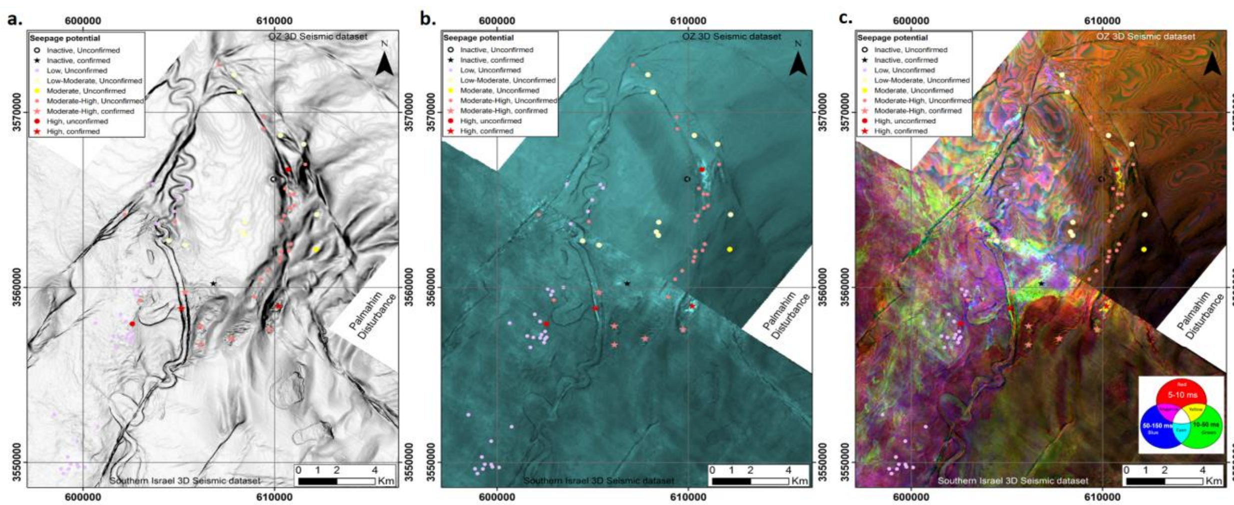


**Figure 8.** Predictive mapping of potential seepage sites and their classification (see index) overlaid on: **a.** the bathymetric gradient (gray scale); **b.** the seafloor seismic reflection amplitude; **c.** an RGB composition of multi-depth reflection amplitudes. The latter reflects the presence of gas charged elements in the subsurface, and their proximity to the seafloor (Muhedeen Lawal Ph.D. thesis – in writing). The extent of this figure in marked on Fig. 7e.

***The mesophotic Sponge gardens*** grow on rock knolls, outcropping at the edge of the continental shelf due to the activity of northwards bottom currents. These form a scour on the southern side of the rock knoll, and elongate moat 'tails' on its northern side. Based on these characteristics we identified the edge-of-shelf knolls on available bathymetry, and mapped them to our database. Several knolls were mapped to the north of Palmahim Disturbance, and a multitude of additional knolls were mapped along the southeastern corner of the Disturbance (Fig. 7a). Three of the northern knolls were pervasively studied through ROV dives, depicting rich sponge gardens [(14)] that were integrated into our database (Fig. 7a). In contrast, no information is available to us on the southern knolls that we mapped. An additional rock outcrop was imaged at a depth of 290 m on the northeastern corner of the Disturbance by an AUV-based synthetic aperture sonar(SAS), a state-of-the-art sonar with an exceptional imaging resolution of 3 cm.

The different observations described here were classified by us to numeric values in the range 0 to 1 (as detailed in table 1), according to our evaluation of the potential of such an observation to represent the presence of a rare habitat at the seafloor (Fig. 7b). This classification forms the quantitative base for our modeling of the presence of rare habitats on the Palmahim Disturbance seafloor.

**Table 1.** The evaluated potential for the presence of rare seafloor habitats based on the different observation types.

| **Observation type** | **Evaluated potential** |
|---|---|
| A visual observation of rare marker organisms (corals, tubeworms, sponges). | 1 |
| A visual observation of substrates that characterize rare habitats (rocks, gas seepage, high burrowing intensity, etc.), including the AUV SAS observation. | 0.9 |
| Geophysical mapping of a high-intensity potential seepage site (western area) | 0.8 |
| Mapping of high backscatter-amplitudes in multibeam and deeply-towed sonar (southern and central areas); geophysical mapping of medium-intensity potential seepage site (western area); medium borrowing intensity. | 0.7 |
| Mapping of seafloor features from available bathymetry (pockmarks, mounds, knolls, etc.; southern and eastern parts); geophysical mapping of low-intensity potential seepage site. | 0.6 |
| Bathymetric mapping of knolls along the southern corner of the Disturbance (an area in which we have no direct observations); low credibility or unidentified sonar targets. | 0.3 |

The definitions in table 1 have uncertainties at the order of one to two levels, but generally match the relation of known rare habitats to the different features. Moreover, we repeated the mapping procedure described below while varying these definitions, showing that the final mapping results are not highly sensitive to the exact quantification chosen here (as discussed below).

### 4.2. The bathymetric complexity power of Palmahim Disturbance and its surrounding

The bathymetric complexity power at a lateral scale of hundreds of meters to kilometers (Fig. 7c) highlights quantitatively the full variety of bathymetric features on Palmahim Disturbance, including broad and narrow ridges, fault steps and fracture notches, steep faces and channels. The computation of the bathymetric complexity power included the following steps:

a. Mapping of the bathymetric variability at the lateral scale between 500 to 2,000 m was carried by computing the BPI at this scale on a combined bathymetric DEM at a 50 m resolution (Fig. 7a).

Since no rare habitats were found so far to be associated with the submarine slide scars, which are abundant on the continental slope, they were removed from the bathymetric DEM based on their previously detected boundaries [(17)].

b. The gradient of the variability map, produced in (a), was computed and normalized to this variability map.

c. The bathymetric complexity power (Fig. 7c) was computed as the geometric mean (root mean square) of the maps produced in (a) and (b), and was smoothed with a 500 m special filter. In practice in our modeling we used the square root of the bathymetric complexity power, to avoid overweighing of the bathymetric complexity with respect to the distribution of existing observations.

### 4.3. The basic assumptions and computation of the potential for the presence of rare habitats

The computation and mapping of the potential for the presence of rare seafloor habitats on Palmahim Disturbance is based here, in the absence of more detailed knowledge, on three basic assumptions:

a. The potential for the presence of rare habitats increases with (the square root of) the bathymetric complexity power at the lateral scale between 500 and 2,500 m.

b. The potential for finding additional rare habitats, and directly damaging already known rare habitats, decreases with the distance from the existing observations.

c. The rare habitats stretch over limited areas, while the seafloor is generally desolate (signifying that the initial classification value of the potential for the presence of rare habitats = 0).

The first assumption is based on the collection of our observations, while the other two are simplistic assumptions.

Based on these assumptions we created an initial model grid (at a 500 m resolution for computational efficiency) with a constant zero value. Any grid element was then assigned the maximal value of any observations found within it (Fig. 7b). This grid was then sub-sampled to a resolution of 250 m, and was smoothed with a distance-dependent filter. The resulting grid was then sub-sampled to 50 m resolution and was multiplied with the square root of the bathymetric complexity power (Fig. 7c). The resulting map was then normalized to the range of 0 to 1, to obtain the potential model of Fig. 7d. Different computations made while varying the different parameters (such as grid sizes, smoothing filter sizes, etc.) demonstrated that the product map is generally not highly sensitive to these parameters, as long as it is based on the three basic assumptions outlined above.

## 5. The potential distribution of rare seafloor habitats and potential direct damage to these habitats on Palmahim Disturbance

The map Fig. 7d provides an estimate of the probability of finding rare habitats at the seafloor at a horizontal radius of ~250 m from any point on Palmahim Disturbance, and the probability of anthropogenic seafloor activity to directly damage such rare habitats. These are contingent on the three basic assumptions above. Notably, being a statistical value, the mapped probability is highly sensitive to the density of 500 m grid points in which there are observations, sometimes more so than to the actual maximal value of the observations within these grid points. Regardless, dense observations are lumped together by our methodology, and overlapping observations are only counted once. Thus, the mapped probability may be significantly lower than 1 even where visual observations of rare seafloor habitats exist, if they are concentrated together and isolated from other sites. This for example happens in the western area, where gas seeps are concentrated within isolated mega-pockmarks (compare Fig. 7a,b with Fig. 7d). We recommend therefore to treat even areas with relatively low probability (~0.2) as areas of rare seafloor habitats.

Our work and the maps of Fig. 7d,e do not incorporate the effects of water currents or the possible spreading of harmful substances from the surface and through the water column. The latter may impact at significantly larger distances than predicted here, and (as explained above) all the different rare habitats on Palmahim Disturbance receive at least some of their nutrition from above through the water column and are sensitive to impacts arriving from there. Thus, the map presented here provides a conservative estimate for the potential of direct impact by seafloor activity on rare seafloor habitats. It does not include the possible need of a safety distance for the conservation of these habitats (20-22), and does not reflect the possible existence of rare habitats or possible concentration of organisms in the water column [(23)].

The potential distribution map (Fig. 7d) highlights three principle zones of rare seafloor habitats on Palmahim Disturbance, which we recommend to define as marine protected areas. The delineation of each of these zones is backed by multiple verified seafloor observations, and markers that were not verified but are characteristic of the verified rare habitats (Fig. 7a,b). The first and most important zone (I in Fig. 7d,e) stretches over an area of ~15 x 9 km along the northern face of the central part of the Disturbance. This is a unique area by any standard, comprising the most pervasive and rich deep-sea coral gardens known to us in Israeli waters, and possibly in the entire southeastern Mediterranean Sea. The second zone (II in Fig. 7d,e) stretches over an area of ~17 x 16 km, encompassing much of the collision zone at the western part of the Disturbance and the proximate Levant channel area. This area in a unique concentration of the largest variety found so far of gas seepage and related habitats, including some of the most extensive and developed seeps known to us in the Israeli offshore. A more detailed survey of this area is required, and will partly be carried by us over the next months in the course of existing research projects. The third zone (III in Fig. 7d,e) arches within an area of ~22 x 10 km, covering the southern boundary of the central part of the Disturbance and the southern part of the broad anticline ridge. This is the least investigated of the highlighted zones, and it is primarily defined by a large number of bathymetric and geophysical observations that are scattered over a broad area. Yet, the only two relatively short ROV surveys that were carried by us in this zone found coral gardens, albeit less dense and rich than those found in the northern slope. In addition, we found that the western part of this area was densely plowed by trawl fishing equipment, which bulldozed rocks with corals overgrowth (Fig. 3c). In addition, Tamar reservoir gas pipeline system crosses through the northeastern edge of this zone. We argue for the importance of extensive surveying of this zone, that will include the improvement of existing bathymetric data and subsea vehicles (AUV, ROV) surveys. These highlighted zones, recommended here to be defined as marine protected areas, generally match and update the Planning Administration 'conservation areas to be examined in the EEZ of Israel', which are based on a conceptual free-hand definition (Fig. 7e). However, the highlighted zones are significantly larger than the Planning Administration 'search areas for marine reserves in the EEZ of Israel', which were defined based on a sub-set of our observations (Fig. 7e).

Two additional areas are highlighted in the map of the potential distribution of rare habitats at the edge of the continental shelf, to the north of the northeastern edge of Palmahim Disturbance and along the southeastern edge of the Disturbance (Fig. 7d,e). The northern of these areas is where rocky knolls with rich sponge gardens have been extensively investigated [14] and included into the bounds of the planned Yam Poleg marine reserve. The highlighting of the southern of these areas is based on the identification of multiple mounds in the available bathymetry as potential rocky knolls. Since no observation is available to us at this point for validating the presence of rare habitats in this area, we assigned low grading to these bathymetric mounds. However, taken together the resemblance in the bathymetric expression of these mounds with the sponge gardens rocky knolls to the north, and their significantly larger number, suggest that this area may include a large number of relatively densely spaced sponge gardens. We argue that there is an urgent need to investigate this area, in light of the high probability for the presence of an extensive and rich rare habitat that may be pressured by trawl and other fishing and waste from coastal sources or vessels traffic on route to the port of Ashdod. Such surveying should include the improvement of bathymetric analysis based on available higher resolution data and underwater vehicles (AUV, ROV) surveying.

We note the possibility for the presence of additional rare habitats on Palmahim Disturbance and its vicinity, which were not discovered as of yet and therefore are not represented in this report.


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