

CHAPTER 9/

Anthropogenic impacts

Anastasopoulou A., Rousakis G., Otero M., Mytilineou Ch., Kamidis N., Thasitis I., Papadopoulou K-N., Kiparisis S., Smith CJ., Samaha, Z., Lefkaditou E., Ali M., Kavadas S., Dokos I., Schöler M.

Anthropogenic impacts other than fisheries include marine litter, placement of underwater cables and pipes, oil and gas extraction, ship traffic (through noise generation, pollution, accidents and litter) and mining. The latter two are expected to increase in the future in the Eastern Mediterranean.

The anthropogenic impacts on the deep-water Mediterranean environment may have a strong influence on such a fragile ecosystem, although the number of studies addressing this issue is still limited, especially for the Eastern and Southern regions of the Mediterranean basin. Information concerning the anthropogenic impacts on the Mediterranean deep-sea environments and especially those of the Eastern Mediterranean has received much less attention than that of shallow habitats[1,2].

The following sections examine the knowledge available for each of these pressures in the Eastern deep-sea environment.

Marine Litter

Anthropogenic litter has been identified as a significant and increasing problem for the marine environment over recent decades worldwide. Considerable amounts of waste are generated globally each year while waste production varies among countries[3]. This problem has also been recognized as a critical issue in the Mediterranean[4,5]. Latest estimations indicate that the total plastic accumulated in the Mediterranean is in the order of 1,178,000 tonnes, with a possible range from 53,500 to 3,546,700 tonnes[5]. The annual plastic flow leaking in to the Mediterranean is estimated at 229,000 tonnes (low and high leakage estimates equate to 150,000 and 610,000 tonnes per year, respectively) and made up of 94% macroplastics and 6% microplastics. According to this latest report, the top three countries contributing to plastic leakage to the Mediterranean Sea are Egypt, Italy and Turkey.

Within the framework of the Barcelona Convention, in 1980 the Mediterranean countries adopted a Protocol for the Protection of the Mediterranean Sea against Po-

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Plastics are of particular concern because, although they fragment, they persist in the marine environment for hundreds to thousands of years and the toxins they contain can seriously affect ecosystems and bioaccumulate through trophic change^[11,12]”

lution from Land-Based Sources. This Protocol was later amended (1996) including in its Annex 1 a list of categories of substances and sources of pollution to serve as guidance in the preparation of action plans, programmes and measures. Among them, litter is defined as “*any persistent manufactured or processed solid material which is discarded, disposed of, or abandoned in the marine and coastal environment*”. Subsequently, a step forward towards dealing with the Mediterranean marine litter problem was the adoption of Decision IG.20/10 at the 17th Meeting of the Contracting Parties of the Barcelona Convention (Paris, February 2012) entitled “**Strategic Framework for Marine Litter management**”. This Strategic Framework provided a first analysis of the problem and proposed a number of activities to address, in a systematic way, the problem of Mediterranean marine litter. The parties of the Convention then went further with the adoption in 2013 of the **Marine Litter Regional Plan** by COP18 and a new updated plan is under negotiation. Other regional bodies and international instruments have also recognised this problem and developed legal frameworks and programmes for addressing this pressure such as the EU Marine Strategy Framework Directive (MSFD) and the disposal regulations under Annex

V of MARPOL 73/78 addressing ocean-based litter pollution from ships.

To date, the existing knowledge on litter density and composition in deep-sea ecosystems is, however, still limited, mostly due to financial and technical limitations on sampling at great depths. Deep-water litter information has been provided, usually incidentally, by bottom trawl surveys for benthic fauna^[6] or for fisheries, although valuable information has also been collected through video/ROV (Remotely Operated Vehicle) surveys documenting various types of litter and lost fishing gears^[7,8,9]. Deep-sea surveys targeting litter are important because ca. 50% of plastic litter items sink to the seafloor and even low-density polymers such as polyethylene and propylene may lose buoyancy under the weight of fouling^[10]. Plastics affect marine species by ingestion, suffocation and entanglement as well as by introducing possible toxic contaminants as additives and hydrophobic chemicals that can become adsorbed from the surrounding water. Floating litter can also transport non-native species into new environments and tiny plastic fragments, ‘**microplastics**’, have been shown to be long-term sources of pollutants, such as phthalates.

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The highest percentage of marine litter found on the Mediterranean seafloor is plastics”

Studies on marine litter in the Mediterranean Sea have mainly been carried out over the last 20 years. Most of these available studies are from shelf habitats, while very little has been done on deep waters. A review of the available information on the marine litter in the deep waters of the Mediterranean have been published for a few initiatives^[1,5]. The known published information for the deep waters of the Eastern Mediterranean is much less than that for the Western part.

The following section presents the available information collected from published works, congress contributions and grey literature reports for the deep-waters in the Eastern basin in terms of marine litter density and composition. Some of these studies are based on direct on-board collection of litter data from trawl hauls, others have used photographic material from trawl hauls, while still others have been based on ROV underwater videos. Differences in the sampling design among the various studies, as well as the depth range of the works, make comparison of their results and findings difficult. Nonetheless, they present an assessment of the existing knowledge, data gaps and impacted areas and species for the Deep Eastern Mediterranean Sea.

such as photographic material from trawl hauls, direct on-board collection of litter data from trawl hauls, and ROV underwater videos. Results from these and observations in other Eastern Mediterranean regions are presented in Table 9.1.

Even with the differences in the sampling design among the various studies, the results of the available information provide the following conclusions and suggestions:

- Litter density in terms of number of litter items per surface area, in the deep Eastern Ionian Sea ranged from 72 to 679 items/km². The highest density of litter items was found off northern Corfu Island coasts. However, the high rates encountered should not be considered representative of the Eastern Ionian deep waters, because only a few sampling stations were conducted in these deep waters.
- An annual increasing trend of litter density from 1996-2008 has been observed on the slope along the Eastern Ionian Sea, particularly of metallic and glass/ceramic litter^[13]. This trend seems to be continuing (Lefkaditou, personal communication) over time with an increase in the litter density from 74 items/km² until 2008 to 100 items/km² in 2016. However, these differences may be due to the fact that the most recent observations were based on on-board collection of litter from trawl catches, whereas those of the first works were derived from the analysis of trawl catch photographs, which may result in underestimating litter occurrence and density. The hypothesis of an increasing trend in litter density over time is nonetheless strengthened by the fact that the area of the Echinades Gulf, located on the west coast of Greece, also shows a higher density of litter (300 items/km²) compared to previous estimations (89 items/km²)^[14,15].
- Considering the relation of marine litter at depth in the deep waters of the Eastern Ionian Sea, a previous review analysing litter from 4 depth layers, indicated that the density of marine litter decreased from 300 to 900 m but increased again in waters deeper than 900 m depth^[16].

1

EASTERN IONIAN SEA

For the deep waters of the Eastern Ionian Sea, information on marine litter was derived from study surveys carried out in the area targeted towards the study of a variety of issues and with different survey techniques

Table 9.1. Density of marine litter (items/km²) in the deep waters of the Eastern Ionian Sea, North Aegean Sea, South Aegean Sea, Libyan Sea and Levantine Sea from the available literature during the period 1993-2016. Information on sampling location, sampling date, sampling gear, depth, and percentage of plastics is also shown. (*) indicates sites where more information is given in the text.

Eastern Ionian Sea						
Survey Location	Date	Survey Type/ Sampling gear	Depth (m)	Density (items/ km ²)	Plastics	Reference
Off Pylos Gulf	1993	Beam trawl	3,838	12**	42%	17
Eastern Ionian Sea	1996-2008	Trawl (20 mm mesh size) #	10-800	75	36%	13
Echinades	1998	Trawl (15 mm mesh size)	247-360	89	79%	14
Northern E. Ionian Sea	1999-2000	Trawl (32 mm mesh size) *#	300-1200	98	70%	16
Southern E. Ionian Sea	2000	Trawl (32 mm mesh size) *#	323-855	111	58%	18
Messiniakos Gulf	2000	Trawl (32 mm mesh size) *#	360-865	103	48%	18
Echinades	2000-2003	Trawl (15 mm mesh size)	15-320	72	56%	19
Corinth Gulf	2000-2003	Trawl (15 mm mesh size)	15-320	116	56%	19
E. Ionian (off Kephallinia Isl.)	2010	ROV (Remotely Operated Vehicles)	300-800		26%	7
Echinades*	2013	Trawl (50 mm mesh size)	Max 320	300 (in 200 isobath)	67%	15
Off Corfu Island*	2014-2015	Trawl (40 mm mesh size) *	43-281	679	91%	20
Eastern Ionian Sea & ArgoSaronikos Gulf	2014 & 2016	Trawl (20 mm mesh size)	10-800	100		Lefkadiou (in preparation)
NE Ionian*		Trawl (40 mm mesh size) *	43-287	679	91%	21

North Aegean Sea						
Survey Location	Date	Survey Type/ Sampling gear	Depth (m)	Density (items/ km ²)	Plastics	Reference
Saros Bay to Bodrum area (northern to mid Aegean eastern coasts)*	2008	Trawl	65-880	211-299 (in gulfs); 48 (in open sea)	84.13%	22

South Aegean Sea						
Survey Location	Date	Survey Type/ Sampling gear	Depth (m)	Density (items/ km ²)	Plastics	Reference
Saronic Gulf*	2013	Trawl (50 mm mesh size)	Max 450	1,423 (250 isobath); 979 (300 isobath); 1,182 (350 isobath)	95 ± 12%	15
Argo-Saronic Gulf	1996-2008	Trawl (20 mm mesh size)	226-778	87	47%	13

Libyan Sea						
Survey Location	Date	Survey Type/ Sampling gear	Depth (m)	Density (items/ km ²)	Plastics	Reference
Crete-Rhodes Ridge (Continental slope)	2009	Trawl (40 mm cod-end mesh)	1,500	110 ± 30 kg/km ²	17%	8
Crete-Rhodes Ridge (Deep basin)	2009	Trawl (40 mm cod-end mesh)	3,000	120 ± 30 kg/km ²	19.5%	8
Crete-Rhodes Ridge	2009	Trawl (40 mm cod-end mesh)	1,200-3,000	< 200 kg/km ²	In 80% of the samples	23
S. of Crete	1993	Beam Trawl (10 mm cod-end mesh)	1,363	64 items/cm ²	17.2%	17

Levantine Sea						
Survey Location	Date	Survey Type/ Sampling gear	Depth (m)	Density (items/ km ²)	Plastics	Reference
Antalya Bay*	2012	Trawl (44 mm cod-end mesh)	200-800	115-2,762	81.1%	24
Limassol Gulf	2013	Trawl (50 mm mesh)	60-420	24 ± 28	67.4%	15
Levantine	1993	Beam Trawl (10 mm cod-end mesh)	227-2,812.5	184*	42.4%	17
Antalya coasts*	2014-2015	Trawl (44 mm cod-end mesh)	10-300	13.3 and 651.1	72.1%	25
Lebanese deep waters	2016	ROV				26

* stretched mesh; # analysis based on photographic material of each haul; ** items/cm²

The litter densities published to date for the Eastern Ionian Sea showed that in most areas of the Ionian Sea, the values are lower than those reported for many other areas in the Mediterranean (Gulf of Lion, East-Corsica, Adriatic Sea and NW Mediterranean)[27] and those reported for eastern Corsica and the waters around Cyprus[28]. Litter density for Echinades[15] (in the isobath of 200 m) is similar to that reported for the Adriatic Sea[27]. As an example, in eastern Corsica, recent studies indicated more than 800 items/km² at 500-800 m depth[28]. However, as noted before, comparisons are difficult because of the use of different sampling schemes for each of the studies. Although there are not yet agreed reference points for the litter density in the Mediterranean, the comparison with the mean baseline of 179 items/km² proposed previously[4] showed that the litter densities for the E. Ionian Sea are lower than the above number.

As with other regions, plastics were the dominant material found on the seafloor of the areas investigated in the Eastern Ionian Sea, ranging between 42 to 91% of the total litter items.

Plastic litter composition in the deep waters of the northern part of the Eastern Ionian Sea (Fig. 9.1) indicates that sheets, industrial packaging and plastic sheeting were the most dominant subcategories of plastics observed[21]. Other litter categories identified in the deep waters of the E. Ionian Sea were metal, glass, ceramic, wood, clothing, rubber, synthetic and package/use (food packaging, beverage packaging, general packaging).

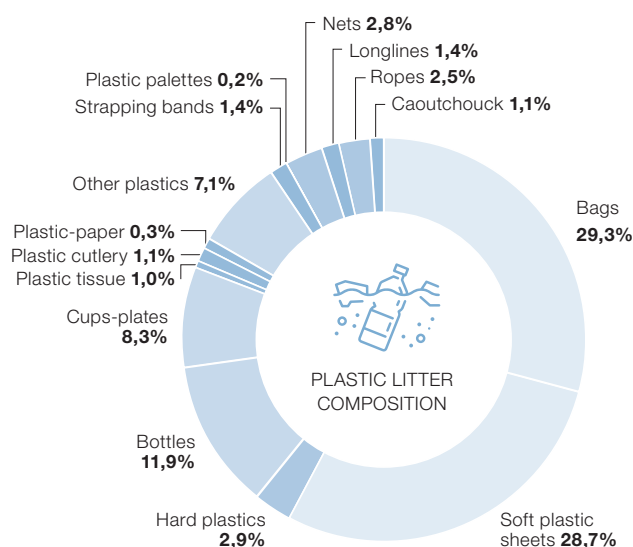


Fig. 9.1. Plastic litter composition in the deep waters of the northern part of the Eastern Ionian Sea[16]

Marine litter on the seafloor in an area of high ecological value, Kephallinia Island

Presence of marine litter off Kephallinia Island (also known as Cephalonia or Kefalonia) of the Ionian Sea in a deep-water coral area was also evident in ROV (Remotely Operated Vehicle) videos. Observations from coral and no-coral close by areas reported that, from a sub-sampling of 15 hours of video tran-

sects (observing 10 seconds every minute), visible litter items appeared in 5.1% of seabed observations. Most of the litter was plastic, metal, and glass in both coral and no-coral areas (Fig. 9.2) The presence of ghost nets was also documented in some locations of deep-water coral areas.

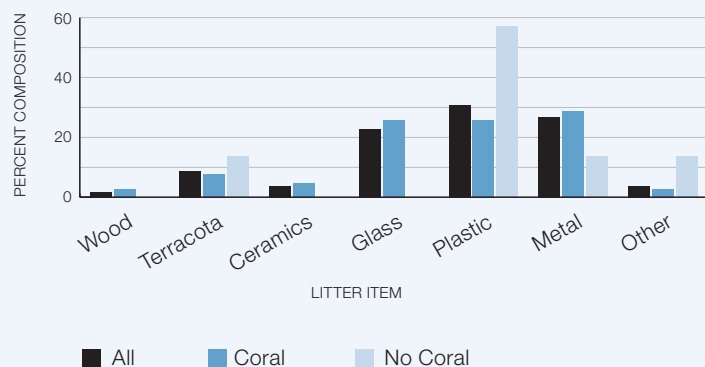
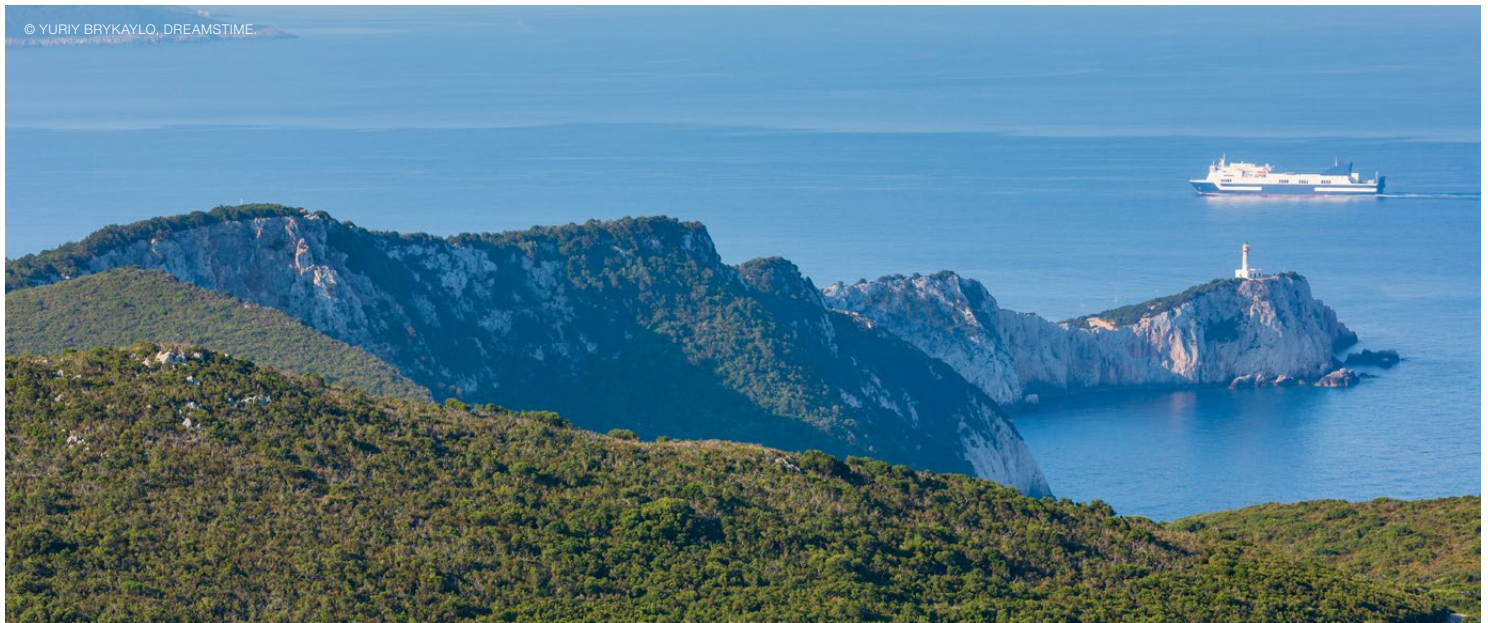


Fig. 9.2. Composition of the litter for pool data (all), coral area, and no-coral area. Source: Smith et al., 2012[7]

A compilation spatial distribution map of litter density (items/km²) from recent scientific surveys (INTERREG, RESHIO, MEDITS¹) at depths > 200 m of the Eastern Ionian Sea shows that the range of values reported are similar to previous works (Fig. 9.3). The deep-water areas with the highest litter density (> 1,000 items/km²) were Southwest of Lefkas Island (2,475 items/km²,

South of Zakynthos Island (1,253 items/km²) at depths between 500-700 m and in the Othonioi Islands (1,291-2,024 items/km²) at 270 m (Fig. 9.3). These values are much higher compared with those derived from the published literature. However, the mean litter density of all studied stations showed moderate litter pollution (159 items/km²) with the highest litter density (1,612

¹ MEDITS survey programme (International bottom trawl survey in the Mediterranean)



Lefkas island.

items/km²) found, as in the previous years, Southwest of Lefkas Island at 533 m depth, an area very close to navigation routes[29]. Here it seems that **the highest**

litter density Southwest of Lefkas Island coincides with shipping lanes (Fig. 9.3).

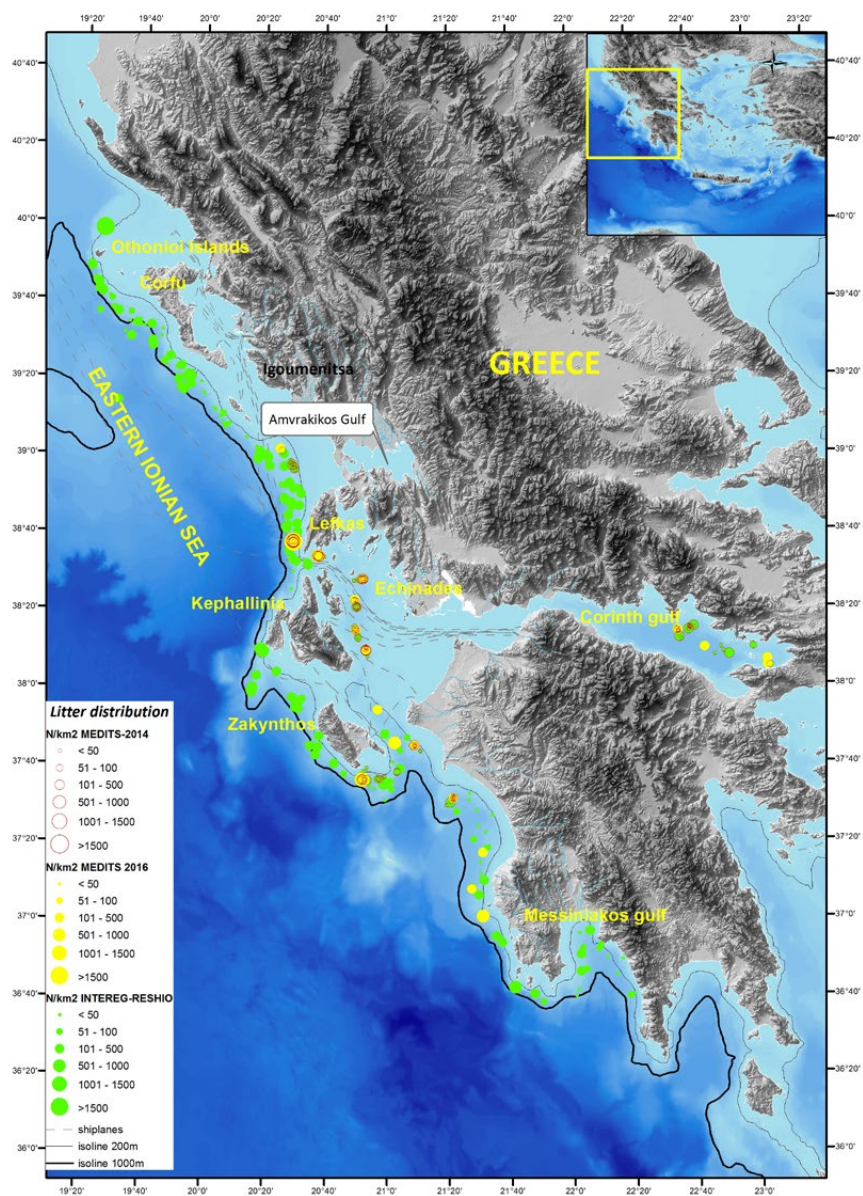


Fig. 9.3. Compilation map of the litter density in the deep waters (> 200 m) of the southern E. Ionian Sea including all unpublished data from the HCMR database. (○): litter records based on photographic material of INTERREG (1999-2000) and RESHIO (2000) hauls; ●: litter records based on photographic material of MEDITS hauls; ●: litter collected on board during MEDITS survey). Shipping lanes are also shown with dashed lines on the map.



Fishing related litter (abandoned, lost or disposed fishing gear) was not found to be of major importance for this sub-region, as the activity is quite low in the deep waters of the Eastern Ionian Sea[14,7,16] (Fig. 9.4). However, it is worth mentioning that small litter items linked to fishing (e.g., pieces of strings) are not easily detectable in underwater observations or in photos.

To date, information on the ingestion of litter by marine organisms in the Eastern Ionian Sea has been reported by few studies[30,31,32,33]. Litter ingestion studies in deep-water fishes showed that 1.9% of the examined species had litter in their guts[34]. Sharks and rays such as the pelagic sting ray *Pteroplatytrygon violacea*, the

blackmouth catshark *Galeus melastomus*, longnose spurdog shark *Squalus blainville*, and the velvet belly lantern shark *Etmopterus spinax* have been shown to ingest litter more frequently than bony fishes (e.g. black-spot seabream *Pagellus bogaraveo*) and the ingested litter was primarily plastics (86.5%). The presence of macroplastics has also been reported in the stomachs of four marine mammals (the harbour porpoise *Phocoena phocoena*, the Risso's dolphin *Grampus griseus*, the Cuvier's beaked whale *Ziphius cavirostris* and the sperm whale *Physeter macrocephalus*) as they stranded along the Greek coasts from 1993 to 2014. This supports the idea that plastics are ingested by the half of the cetacean species that regularly occur in the Greek Seas[35].



Discarded plastic is a marine menace for Risso's dolphins, entangling them and filling their stomachs.



Evoikos Gulf in the North Aegean Sea.

1

NORTH AEGEAN SEA

To date, there has been no published study to show the presence of marine litter in the deep waters of the North Aegean Sea, with the exception of one scientific study carried out in the eastern part in 2008[22] and the information provided by the MEDITS surveys. According to the results of the study of 2008 (Table 9.1), litter was abundant mainly in the gulfs of the Turkish coasts ($211.75\text{--}299.98\text{ items/km}^2$), whereas it was very low (48 items/km^2) in the open sea between Lesbos and Chios Islands. Low amounts of litter had also been observed by underwater video observations during ROV missions.

From MEDITS surveys, litter density values in the deep waters ($> 200\text{ m}$) of the North Aegean Sea were found to be between 7.7 and 766.4 items/km^2 (Fig. 9.4). The three sites with the highest litter density ($> 300\text{ items/km}^2$) were in the **central basin of the North Evoikos Gulf** (at

depths from 430 to 440 m), the area **between Limnos Island and Chalkidiki Peninsula** at a depth of around 550 m and **north of Lesbos Island** at 223 m depth.

The North Evoikos Gulf is a semi-enclosed marine gulf with limited communication with the open Aegean Sea. The central part of the N. Evoikos Gulf, where the high litter density was found, is very steep and the vertical throw exceeds $1,000\text{ m}$, which may contribute to the litter accumulation. The area off Limnos Island situated on the Limnos Plateau has a water circulation that creates various thermohaline fronts and gyres especially in the summer season[36], which could be the reason for the observed litter accumulation. The third area, north of Lesbos Island, is very close to the Turkish coasts and 56.8% of the litter found in its north-eastern coastline has been reported to be related with the immigration taking place in this area[37].

According to the results derived from MEDITS surveys across the North Aegean Sea, the mean litter density of all studied stations in the North Aegean Sea was 114.2

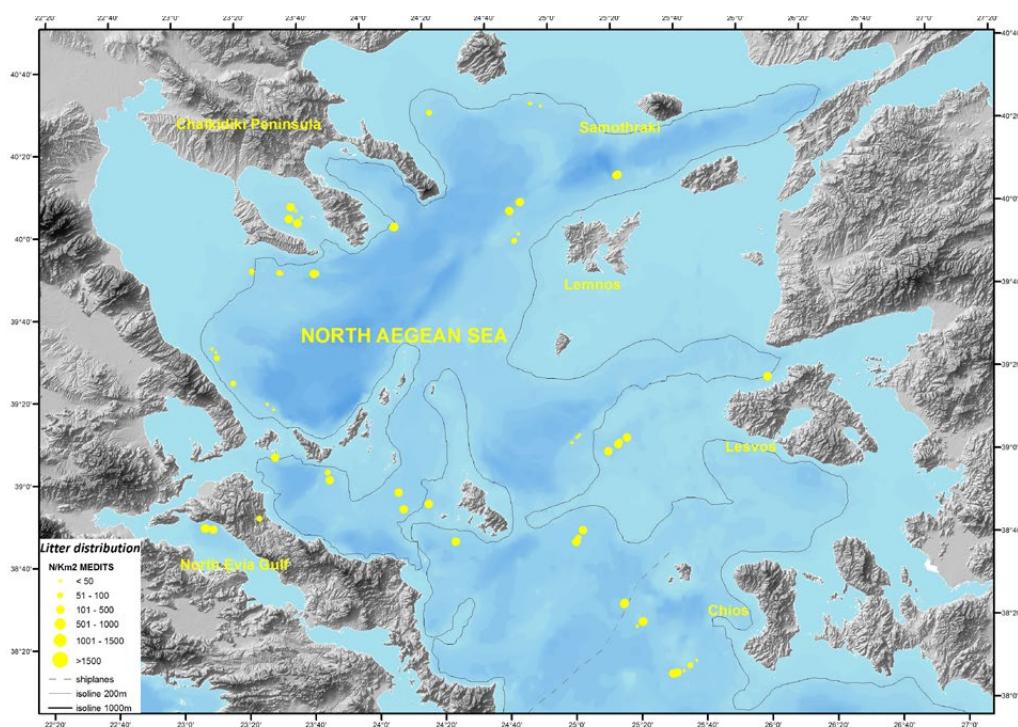


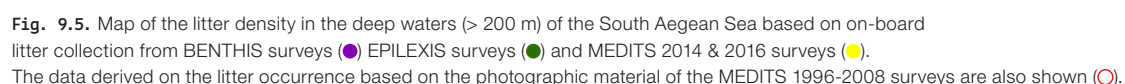
Fig. 9.4. Map of the litter density in the deep waters ($> 200\text{ m}$) of the North Aegean Sea based on MEDITS surveys for the years 2013, 2014, 2016 and 2018.

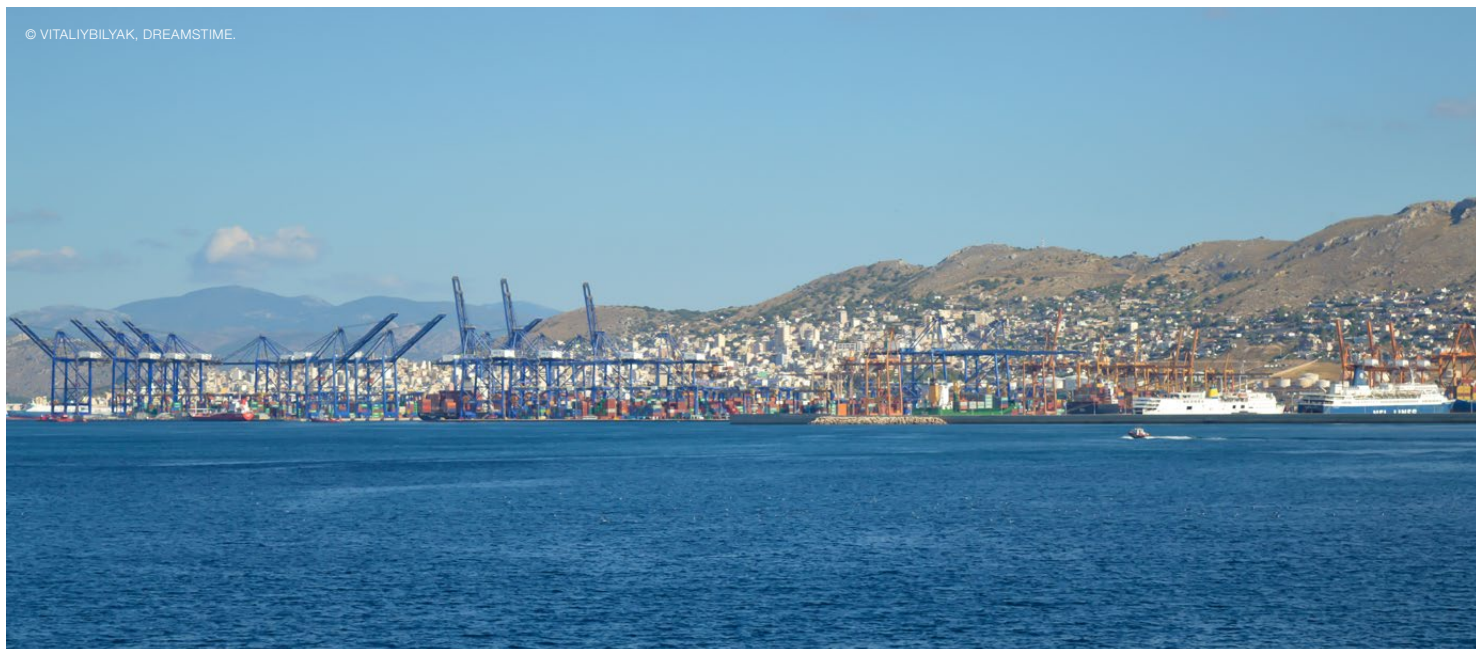
Low amounts of litter had also been observed by underwater video observations during ROV missions.

SOUTH AEGEAN SEA

3

The **highest values of litter density (> 1,000 items/km²) were observed in two locations in the western basin of the Saronic Gulf** in 2014 (3,057 items/km²) and 2016 (1,286 items/km²) at 381 to 404 m depths. These values were much higher than those previously reported for the same area during the period 1996–2013.





Piraeus port in Saronic Gulf.

Lower litter density values (95-1,056 items/km²) were found in the Saronic Gulf from the data derived by the MEDITS survey of 2018, although stations of shallow waters (< 200 m) were also included which might be responsible for the large variation observed. Among the deep-water stations, the highest litter density with 1,054 items/km² was found, as in the previous years, in the western basin of the Gulf[29].

The Saronic Gulf is a semi-enclosed embayment and constitutes the natural marine gateway of the city of Athens and the Piraeus harbour and thus is affected by multiple coastal and marine activities. The anticyclonic circulation in the Saronic Gulf has been documented to be responsible for the increase of floating litter particles in the broader area[39] making these available to sink and accumulate in the Gulf. Other factors, which also contribute to the high litter density in the area, maybe related to the tourism and maritime traffic that take place there.



4

LIBYAN SEA

Information on the seafloor litter in the deep-waters of the Libyan Sea has only been documented in a few published works mostly related to surveys along the Crete-Rhodes Ridge (Table 9.1). The results from these works derived by using different sampling gears (e.g., different trawl and mesh sizes) and seafloor litter density metrics (kg/km² or items/cm²) make comparisons between them, as well as with the findings from other areas, difficult to interpret. Important gaps exist for much of this region such as from the deep waters of the Gulf of Sirte where maritime traffic and activities are considerable.



The deep basin of Antalya Bay in Turkey record high densities of marine litter on its seafloor.

5

LEVANTINE SEA

As with other regions, information on the seafloor marine litter in the deep Levantine Sea is documented in very few published works and grey literature. For Turkey, the highest litter density has been reported for the bathyal grounds (200-800 m) of the Antalya Bay with densities of 500-3,000 litter items/km² (South Turkey) [40]). In this area, 81% of the litter reported was plastic. The coast of Antalya is under the influence of large affluence and touristic activities, commercial and touristic boat traffic, particularly over the summer period. Relat-

ed pressures with the intense fishing activity, affluent of residential areas and river discharges are also identified causes of the increase of land-based pollutants. The hydrodynamic circulation of currents along neighbour coastal areas and local upwellings further increase the transportation of debris in this area.

A widespread presence of marine litter has also been reported with ROV observations in deep Lebanese waters ("Deep-Sea Lebanon" project[26]) with plastic debris, urban waste and oil drums found in all the canyons examined (Fig. 9.7). Moreover, evidence of indirect fishing impacts (e.g., lost or discarded fishing gears) were also observed mainly in areas of canyon heads.

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Deep-sea canyons along the coast of Lebanon are plastic dumps and also biodiversity hotspots”

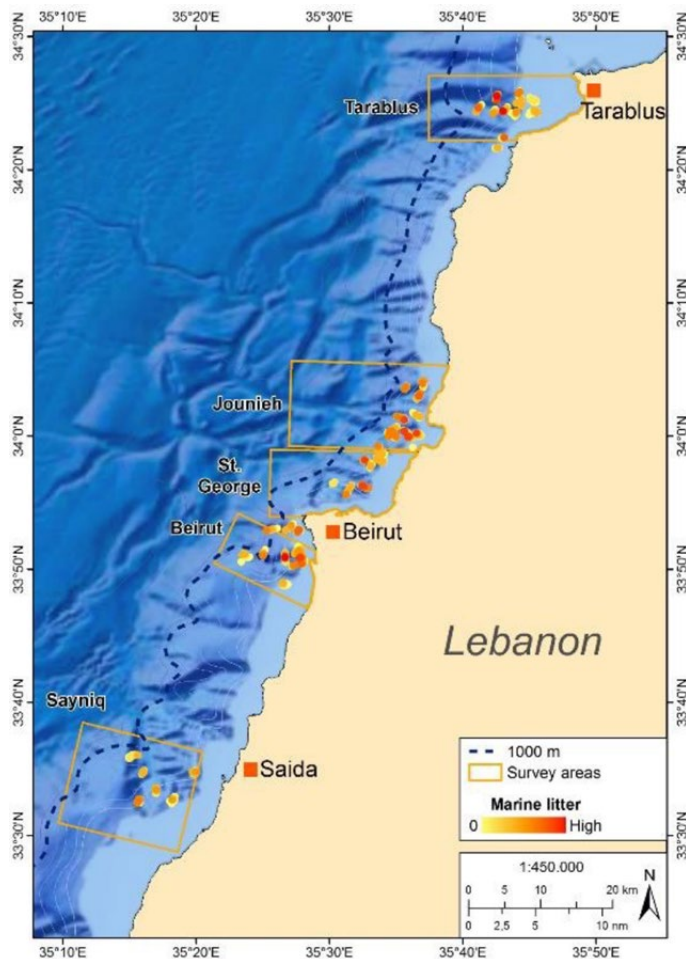


Fig. 9.7. Marine litter distribution and density in the Lebanese deep seafloor[26].



Marine litter observed in the sea canyons of Lebanon.
© Oceana/IUCN/RAC-SPA Deep Sea Lebanon Project

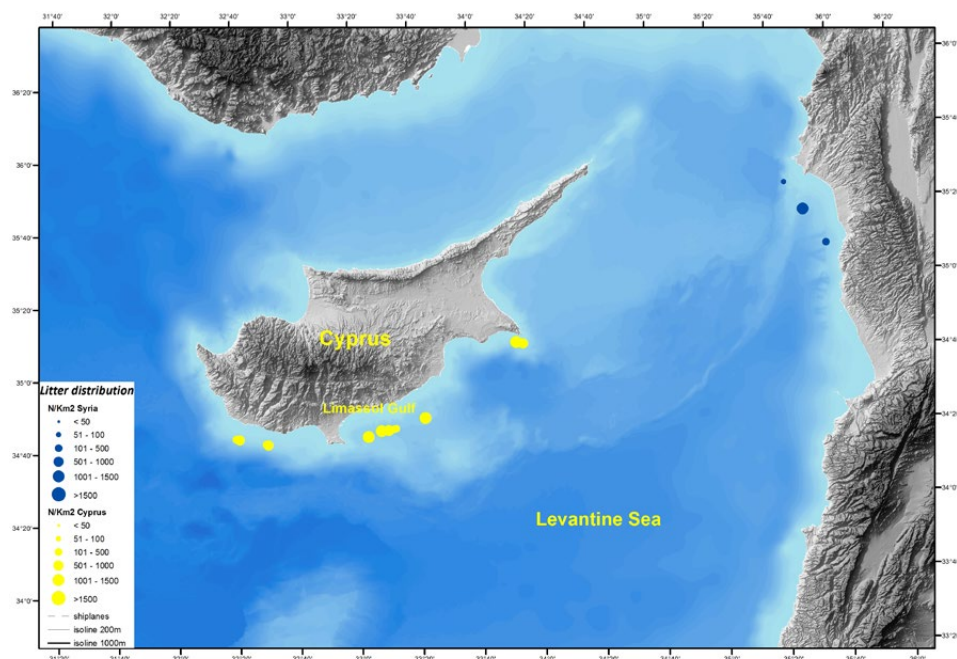
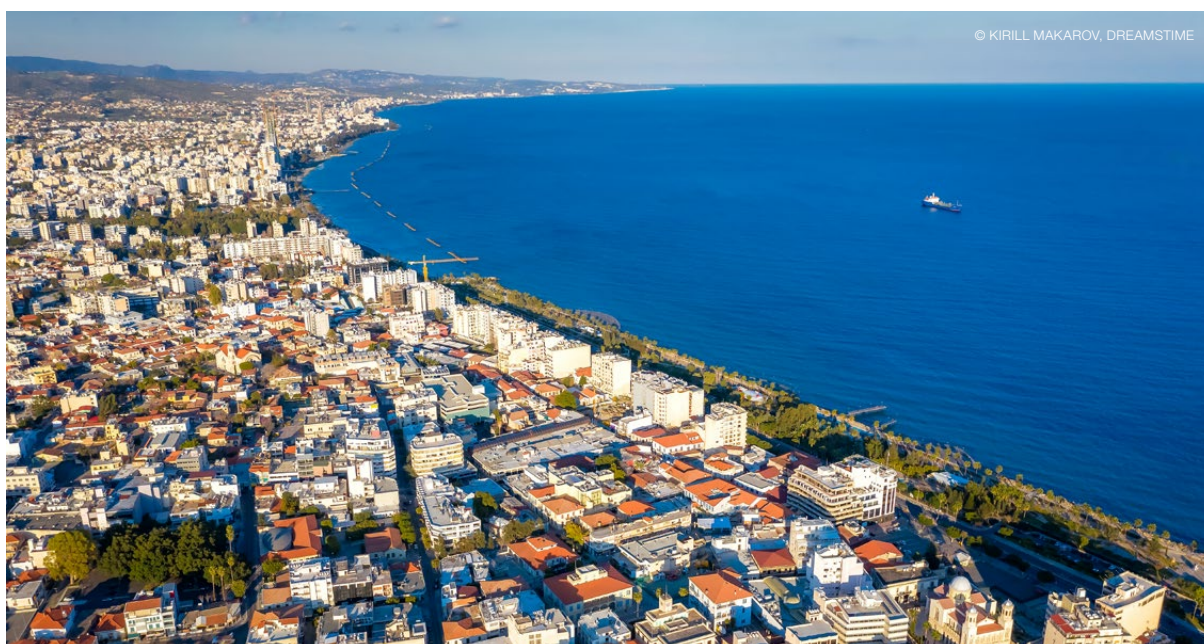


Fig. 9.8. Map of the litter density in the deep waters (> 200 m) off Cyprus (litter collected on board during MEDITS surveys; yellow circles) and Syria (litter defined based on photographic material; blue circles).

Litter density in the deep-waters (> 200 m) off Cyprus Island (Levantine Sea) from the MEDITS surveys of Cyprus and from photographic material of trawl hauls conducted off Syria (Fig. 9.8) ranged between 56 and 1,345.9 items/km². **The highest values of litter density (1,132-1,346 items/km²) was observed in the deeper part of the Limassol Gulf,** south of Cyprus, at 575-620 m depths and very close to marine

navigation routes. In the South-eastern area of Cyprus, another area of high litter density has also been observed (1,000 items/km²) at 300-350 m. The Limassol Gulf, although it is a gulf of open topology, receives litter carried by the existing currents and from various kinds of land and sea activities in the area (urbanization, tourism, commercial, industry, crafts, warehouses and aquaculture).



The Limassol Gulf, although it is a gulf of open topology, receives litter carried by the existing currents and from various kinds of land and sea activities in the area (urbanization, tourism, commercial, industry, crafts, warehouses and aquaculture).

Preliminary work on marine litter carried out in the deep-waters (> 350 m) off Syria in 2017 reported density that ranged between 81 and 911 items/km². The highest value of litter density (911 items/km²) was observed in the open waters west of the Jablah area, at 400 to 680 m depth.

The cyclonic and anticyclonic gyres, interconnected by jets and currents that occur in the Eastern Levantine basin, may enhance litter accumulation in the northern shores and some of the deep waters. The eastern part of the Levantine Sea is an important habitat for whales, dolphins, and sea turtles as many sightings and strandings of several species have been recorded there². Ingestion of pieces of plastic bags, for example, has been reported for stranded Risso's dolphins (*Grampus griseus*) and leatherback marine turtles *Dermochelys coriacea* along the Mediterranean coast of Israel[42,43].

GENERAL CONSIDERATIONS

The spatial distribution and accumulation of litter on the seafloor is a result of complex interactions between the geomorphology, hydrography, environmental, meteorological conditions and anthropogenic activities. In some geographical areas, there is also a notable temporal, particularly seasonal, variation of marine litter accumulation, indicating the varying effect of different environmental or anthropogenic factors. Other factors contributing to litter distribution, accumulation and density on the seafloor are related to river inputs, proximity to urban and industrial areas, maritime traffic, agriculture and aquaculture, fishing effort, proximity to coast, tourism and extreme oceanographic events[8,44]. Plastic hotspots tend to appear in shallow waters near the mouth of major rivers (e.g. the Nile) and close to large cities or urban areas[5].

The mean litter density derived from scientific survey data was under the baseline of 179 items/km² in most of the examined areas except the deep waters of the S. Aegean and the Levantine off Cyprus[4]. However, in some locations (e.g., S. Aegean: western basin of the Saronic

Gulf; Levantine: Limassol Gulf, Antalya Bay) there are extremely high values (> 1,000 items/km²), which are much higher than those reported for the North West Mediterranean. In contrast, these values were much lower than those reported for the Gulf of Seine located in northern France[27,28]. It seems that litter density is higher in highly urbanized gulfs and particularly in the deeper parts of them. Furthermore, very high litter densities (> 1,000 items/km²) were also found in the open sea (e.g., E. Ionian Sea: southwest of Lefkas Island, south of Zakynthos Island, Othonioi Islands; Levantine: south of Cyprus, off Jablah in Syria), which may indicate different reasons of litter accumulation, among them maritime traffic. Submarine canyons have also been reported to act as the main vectors for the transport of marine litter, conveying it from the continental shelf into the deep seafloor. These observations from other areas in the Mediterranean also correspond to those in the Lebanese canyon systems, located close to the coastline.

Nonetheless, certain considerations regarding the present values of marine litter density are needed as they do not necessarily reflect the general pattern of litter density in the Eastern Mediterranean due to the lack of extensive specific monitoring surveys for litter detection and the lack of a common methodological approach for assessments in the whole area. Many deep-sea ecosystems seem to be very vulnerable and marine litter may have a large impact on the species inhabiting these ecosystems.

A recent review[45] estimated that up to seventy-eight taxa resulted impacted by marine litter on Mediterranean reefs, and the majority belonged to the phylum Cnidaria (41%), including endangered species like the red coral (*Corallium rubrum*) and the madrepora coral (*Madrepora oculata*). Entanglement, caused mainly by abandoned, lost, or otherwise discarded fishing gear (ALDFG), has been reported the most frequent impact, playing a detrimental effect mainly on coralligenous arborescent species and cold-water corals (CWCs). However, there is a gap in the knowledge about the extent of litter in the deep waters of the Eastern Mediterranean and its impact on its biota and habitats. From ingestion, reports already indicate that highly affected species may include deep-sea fish, invertebrates, sea turtles and cetaceans. Lost fishing gears can also harm

² The Whales & Dolphins of Cyprus: Summary of 2016 & 2017 Research Surveys, 2017

benthic organisms and habitats but the information is limited in this regard besides the presence of lost fishing gears entangled on corals, rocks or soft sediment and bottom trawl traces on the seabed.

Although monitoring of marine litter is expensive and time consuming, further studies are necessary to address this gap and to provide data on the density, distribution, impacts and qualification of different litter categories in the deep-sea. This will assist to enhance a more complete comprehension of the marine litter issue and to provide early detection of potential problems in areas of high ecological value.

Plastics represented the highest proportion of marine litter in the deep waters of the Eastern Mediterranean as has been reported for the seafloors of all seas and oceans of the world and particularly in deep waters. Plastic production has obtained popularity in manufacturing and packaging applications because of the ease of processing, durability and relatively low cost. Despite their benefits, plastics have now become a global concern due to their effects on the environment, the economy and marine life when not properly disposed of or recycled.

In the Mediterranean, the problem of marine litter and plastics in particular, has also been behind the adoption by the Barcelona Convention parties for **“The Strategic Framework for Marine Litter management”**. This also enables the subsequent development of the **“Regional Plan for the Marine Litter Management in the Mediterranean”** (Decision IG.21/7) with a series of main objectives to prevent and reduce this type of pollution, enhance knowledge, and remove, to the extent possible, marine litter by using environmentally respectful methods. For EU countries, the EU’s Waste Framework Directive has further prioritised prevention measures in waste management[46].

Moreover, in order to develop effective strategies, it is useful to understand the problem of plastic waste in coastal and deep-water environments as well as the sources, impacts and the risks. Both the EU’s Marine

Strategy Framework Directive (MSFD) and the Barcelona Convention, with the implementation of the IMAP programme (the EcAp based integrated monitoring and assessment programme) have included descriptors for marine litter monitoring to support the country’s assessments and national monitoring programmes for litter and mitigating actions towards addressing hotspots (rivers and coastal cities) and waste water management and ban certain plastic products would be most beneficial[5].

Comparing results across countries or areas proves difficult as seafloor monitoring with visual surveys using ROVs or with bottom trawls, whether fishing and research vessels, can lead to differentiated handling operations and observation results. Moreover, these programmes collect litter data in an opportunistic manner or voluntary basis (e.g. MEDITS trawl survey, Fishing observer’s surveys) or do not necessarily cover the whole region. In order to enhance the monitoring of marine litter on the seafloor and facilitate the implementation process of the EU MSFD and the UNEP/MAP Regional Plan on Marine Litter Management with regards to setting baselines towards achieving GES, it is highly recommended to make the collection of seafloor litter data mandatory for ongoing sea survey programmes.

Efforts have been made to enhance marine litter knowledge, although information from deep waters is still scarce. A move towards increased awareness within society is needed including all stakeholder sectors e.g., manufacturers, consumers, citizens, and governments, focusing on changes in attitudes and behaviours in relation to marine litter and plastics (e.g. recycling, plastic usage). Several successful initiatives from businesses, entrepreneurs and the public have focused on the reduction of plastics, e.g., the legal banning of plastic bags and bans on single-use plastic products, zero-waste cities initiatives, beach clean-ups, research into new technological solutions to deal with waste, and proposals to use international legal frameworks to address plastic pollution globally[47] (MARPOL for ships). Further initiatives and exchange of good practices considering the needs of adaptation and enabling conditions will help to take these experiences further.



Submarine power cables and telecommunications networks

The importance of submarine power cables and telecommunications networks has increased steadily in recent decades and its demand will continuously grow in the near future. Submarine power cables are electricity transmitting cables laid in the sea to provide energy between countries, supply power to islands and oil platforms and transferring electricity from offshore marine renewable energy devices on shore (i.e., wind, waves, tides, and water currents)[48].

“

Today, there are around 428 underwater cables in operation around the world, spanning a length of over 1.2 million km. The offshore expansion of submarine power grids associated with wind-turbine farms and telecommunications has raised concerns on its impact on the marine environment”

Most of the power cables are used to transfer electricity at a high voltage. In 2015, almost 8,000 km of commercial High Voltage Direct Current (HVDC) submarine cables were present on the seabed worldwide. In comparison, the total length of all submarine cables deployed (including using alternating current “AC” and direct current “DC” power cables and telecommunication cables) was in the order of 10^6 km[48].

The main existing marine power cables in the Mediterranean (SAPEI, SACOI, HVDC Italy-Greece and COMETA HVDC), stretch for about 945 km and there is another 1,000 km of cables to be laid within the new Euro-Asia Interconnector programme in 2022 in the Eastern ba-

sin. In addition to power cables, an extensive submarine fibre-optic cable network for telecommunications is also present in the whole Mediterranean basin.

Fig. 9.9 and Fig. 9.10 show a compilation of high resolution maps of the present power cables and telecommunication cable routes for the Ionian Sea and for the Aegean Sea. A denser network of cables is evident in the Libyan and Levantine Seas (Fig. 9.11 and Fig. 9.12, respectively) linking individual countries with Europe and Asia. In addition, landing stations for new submarine cables are planned in several of these countries, which will further increase international broadband connectivity in the coming years.

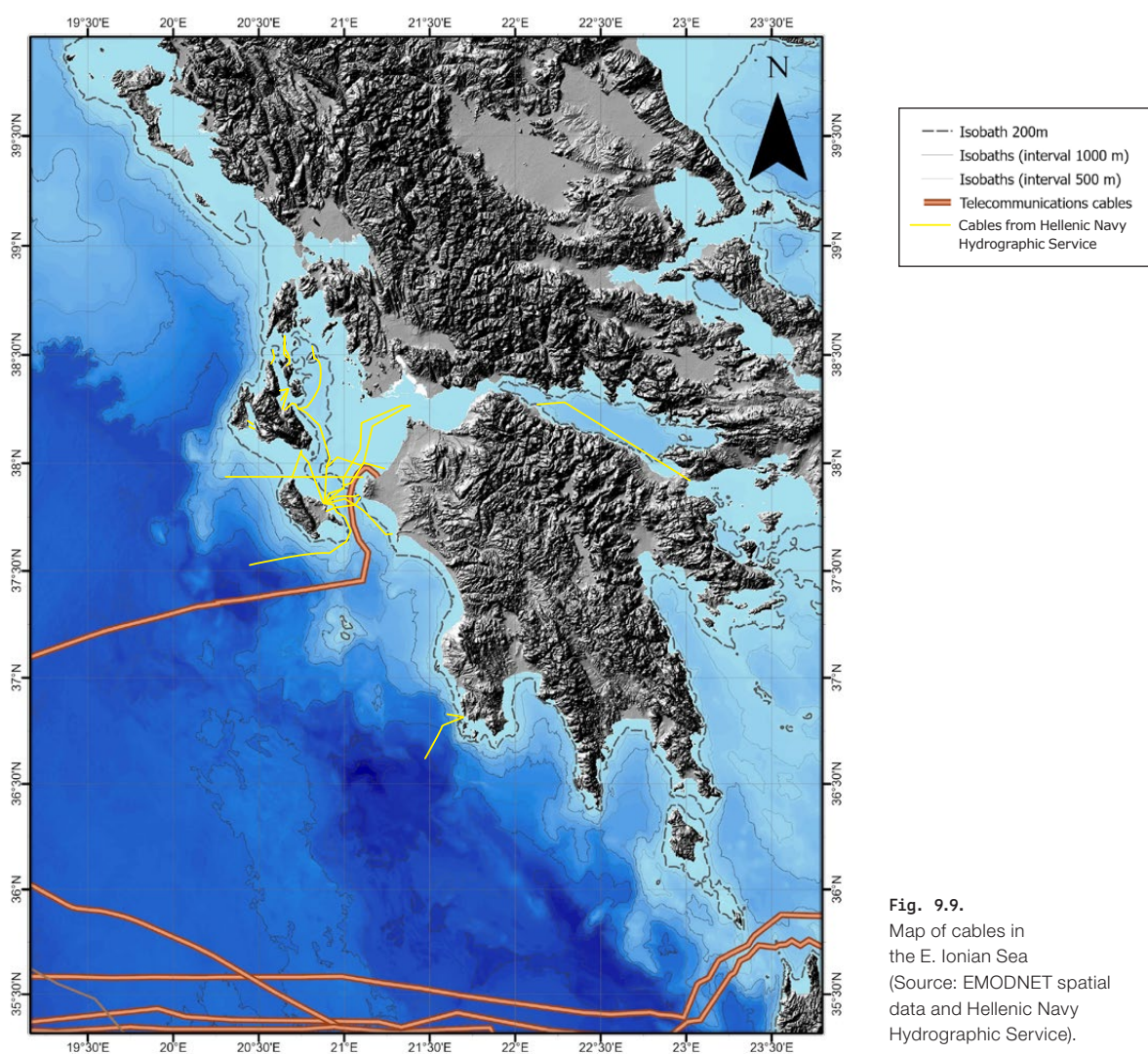


Fig. 9.9.
Map of cables in
the E. Ionian Sea
(Source: EMODNET spatial
data and Hellenic Navy
Hydrographic Service).

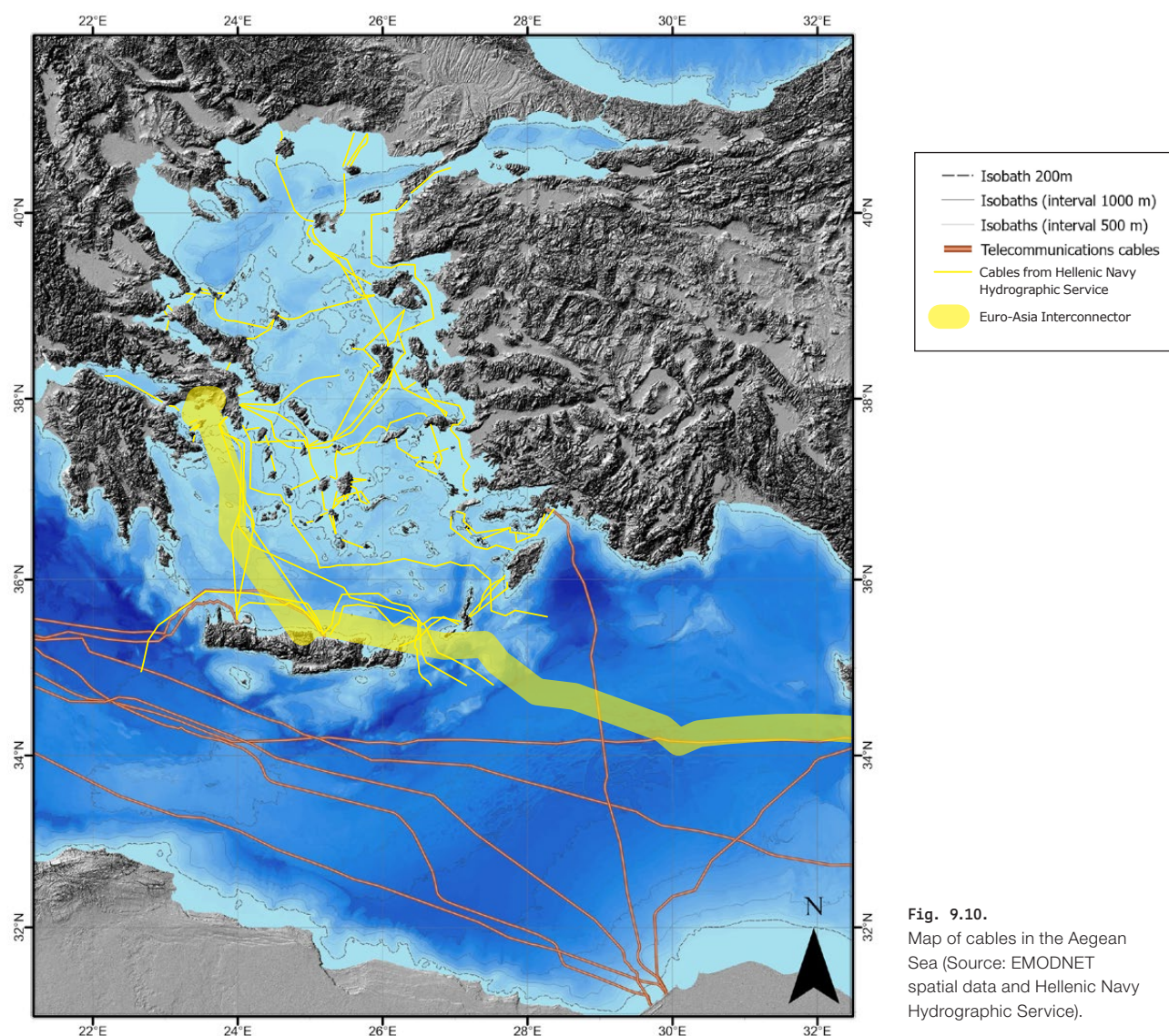


Fig. 9.10. Map of cables in the Aegean Sea (Source: EMODNET spatial data and Hellenic Navy Hydrographic Service).

A number of recent studies to examine the environmental impacts of submarine cables and cable laying on marine communities and habitats suggest that the impacts are either small or moderate or only temporary as a result of cable laying. Although many uncertainties remain regarding the impacts of the different types of submarine power cables, particularly concerning electromagnetic effects[49]. They are often specific for a certain phase in cable life, such as during the laying, operation and removal. The potential impacts that occur, whether in shallow or deep-waters, include seabed disturbance, contamination, heat dissipation, production of underwater noise, electromagnetic fields and heat emission.

Impact assessment studies for cable projects in the Eastern Mediterranean deep-waters are not currently available. Research and the application of effective monitoring programmes to on-going developments are needed to examine aspects such as the spatial extent, timescale (duration, frequency, reversibility), and magnitude of impacts as well as their relevance for the various cable types and different phases in cable life. Given the vulnerability of deep-sea ecosystems and marine fauna communities, understanding the impacts such as those caused by electromagnetic fields on fauna (e.g. sharks, marine mammals), physical disturbance and associated impacts of fauna living on the seabed and those re-

sulting from the effects of heat dissipation or concentration of cables and other infrastructure (e.g. gas pipelines) in designated corridors would provide information to allow the development of adequate assessments and mitigation programmes.



Sperm whales. © Martin Procházka, Dreamstime.

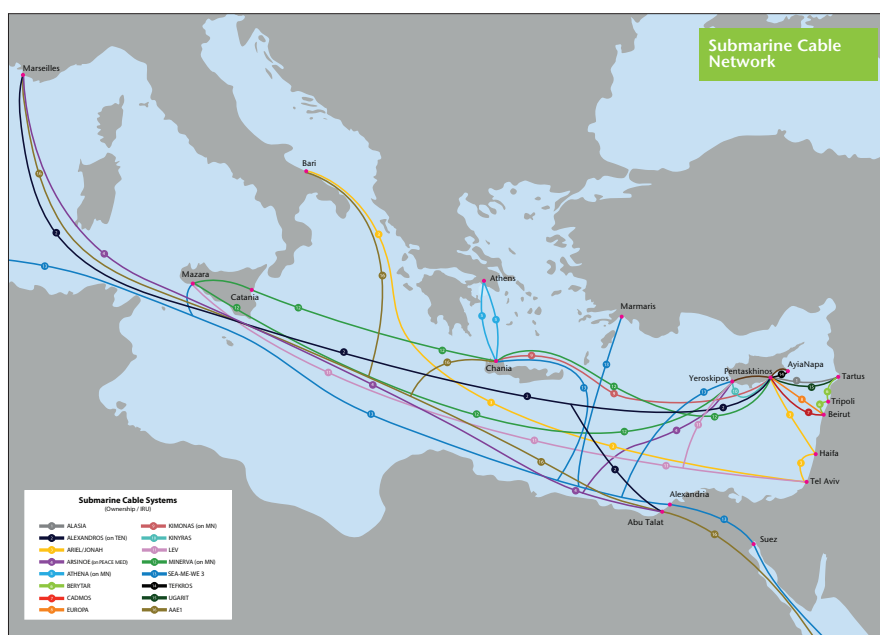


Fig. 9.11. Schematic map of telecommunication (fibre-optic) cable network in the Eastern Mediterranean basin based on the submarine fibre optic cable systems currently in service. (Source: Submarine Cable Networks (<https://www.submarinenetworks.com/>))

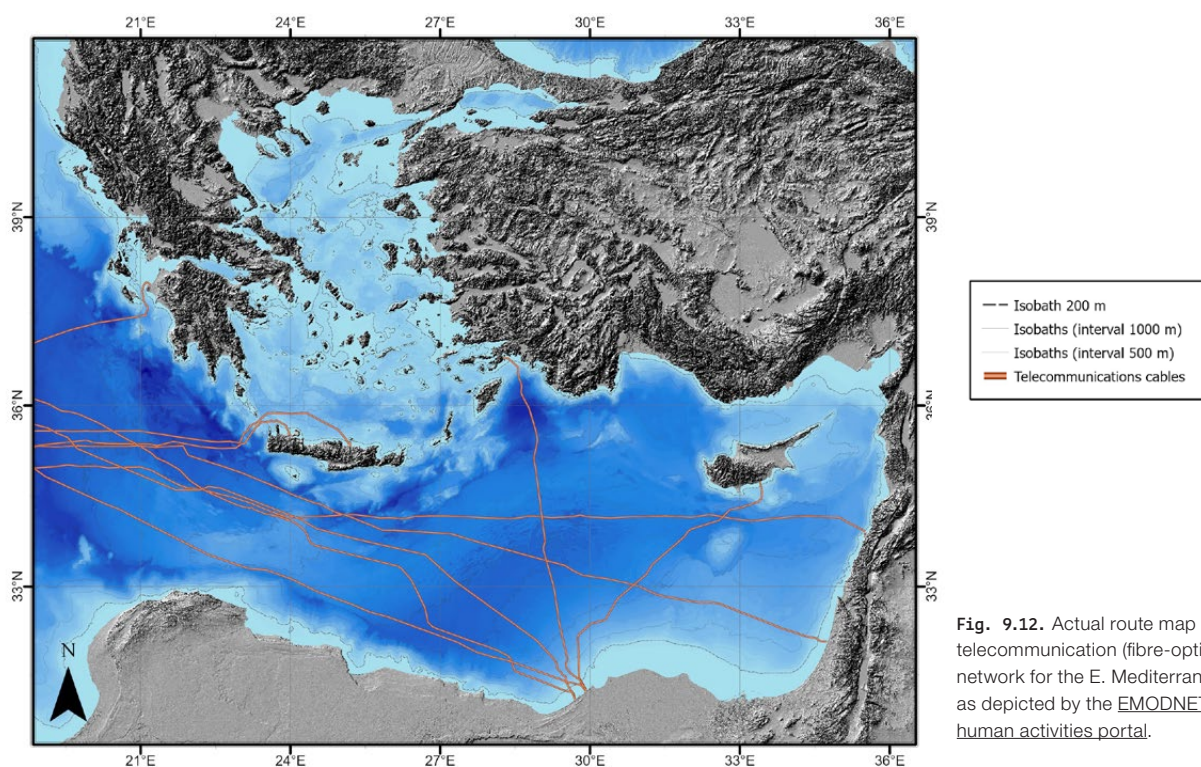


Fig. 9.12. Actual route map of telecommunication (fibre-optic) cable network for the E. Mediterranean as depicted by the [EMODNET](https://www.emodnet.eu/) human activities portal.



Oil and Gas Exploration and Extractions

The Mediterranean region has so far been a relatively small producer of offshore oil and gas as compared to world production. However, marine petroleum exploration projects and associated drilling activity have greatly increased all around in recent years, including in environments with extreme physical conditions in the deep-sea floor^[50].

Significant amounts of natural gas have continued to be discovered offshore in the Eastern Mediterranean, mainly in the last ten years, making the basin an important natural gas field worldwide. These findings bring new opportunities for countries to develop massive gas fields (with offshore and onshore infrastructure), increase their energy security and even export natural gas to other regions. Offshore natural gas and oil licensing rounds for extractions and production are already taking place in the region (e.g. Israel, Greece, Egypt) and timetables to start have been announced by other Eastern Mediterranean countries (e.g. Lebanon). The findings of additional gas and oil reserves in deep areas off the Levant Basin, the Aegean Basin, offshore Greece and the Nile Delta Basin, if developed fully, will pose significant challenges, risks and impact to the marine environment.

1

EASTERN IONIAN SEA

This region contains important oil and gas shale reservoirs³. Even though the scientific knowledge and research in Greece is very limited, the existence of oil reserves in the E. Ionian Sea is widely known because of the great number of surface oil shows, for example, in the Epirus region, the Keri oil seep on Zakynthos Island or the oil shows in Kyllene (NW Peloponnese)[51]. The first oil wells were drilled by companies in the areas of Keri (Zakynthos, E. Ionian), NW Peloponnese (E. Ionian) and Evros in NE Greece (N. Aegean). Several licences were

granted in 1995 to start marine explorations in the NW Peloponnese, Aitolokarnania and the off-shore Western Patraikos Gulf in the Eastern Ionian Sea, which were later stopped due to technical and administrative issues⁴ (Fig. 9.13a). New explorations have been granted since then in deep areas, although they are currently on hold due to the unfavourable market conditions, the costs of exploitation, as well as climate change policies being adopted⁵. The Katakolo license is one of the new explorations and covers onshore, shallow water and deep waters on the west coast of the Peloponnese. The block, 545 km² both offshore and onshore, contains 3 discoveries and multiple leads. The water depth is 200–300 m while the depth of the reservoir is 2,300–2,600 m⁶.

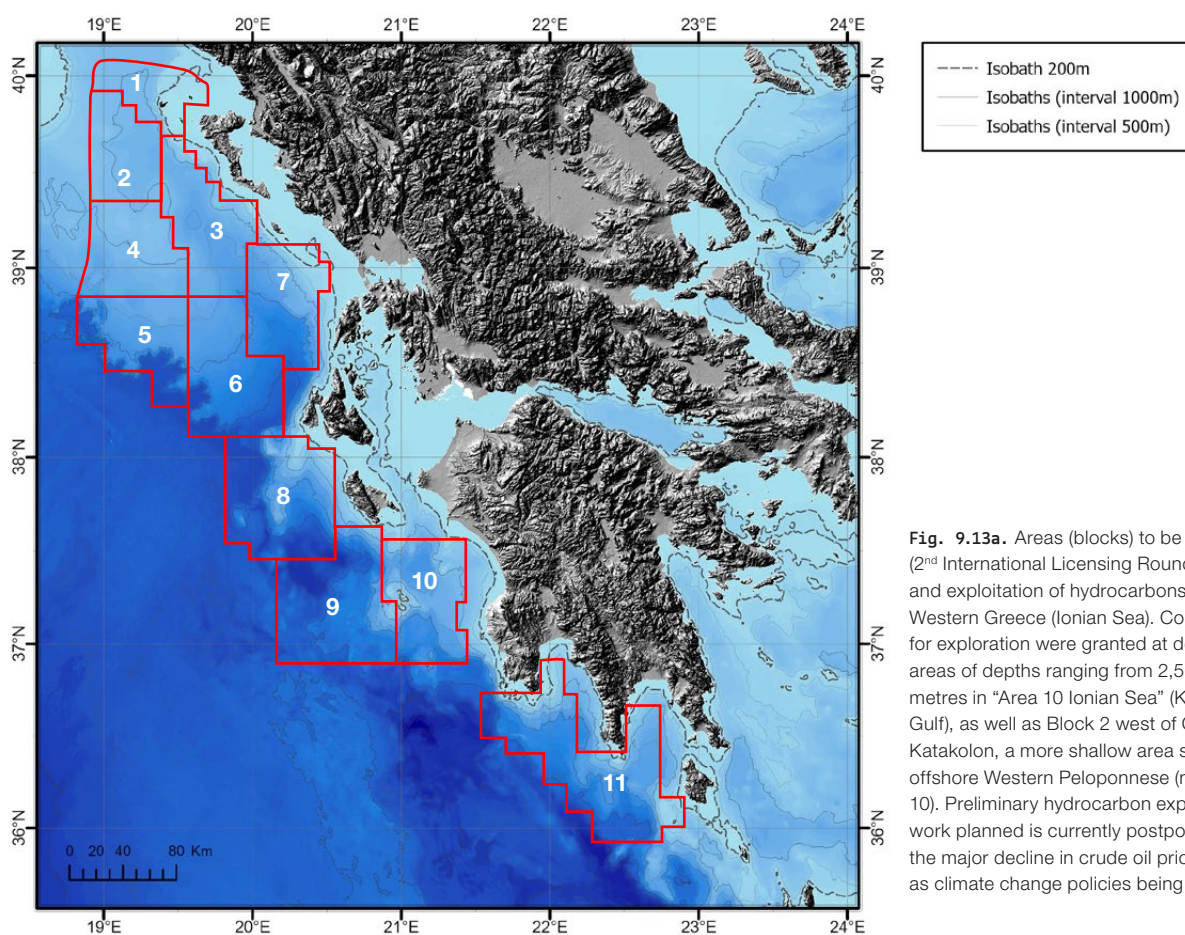


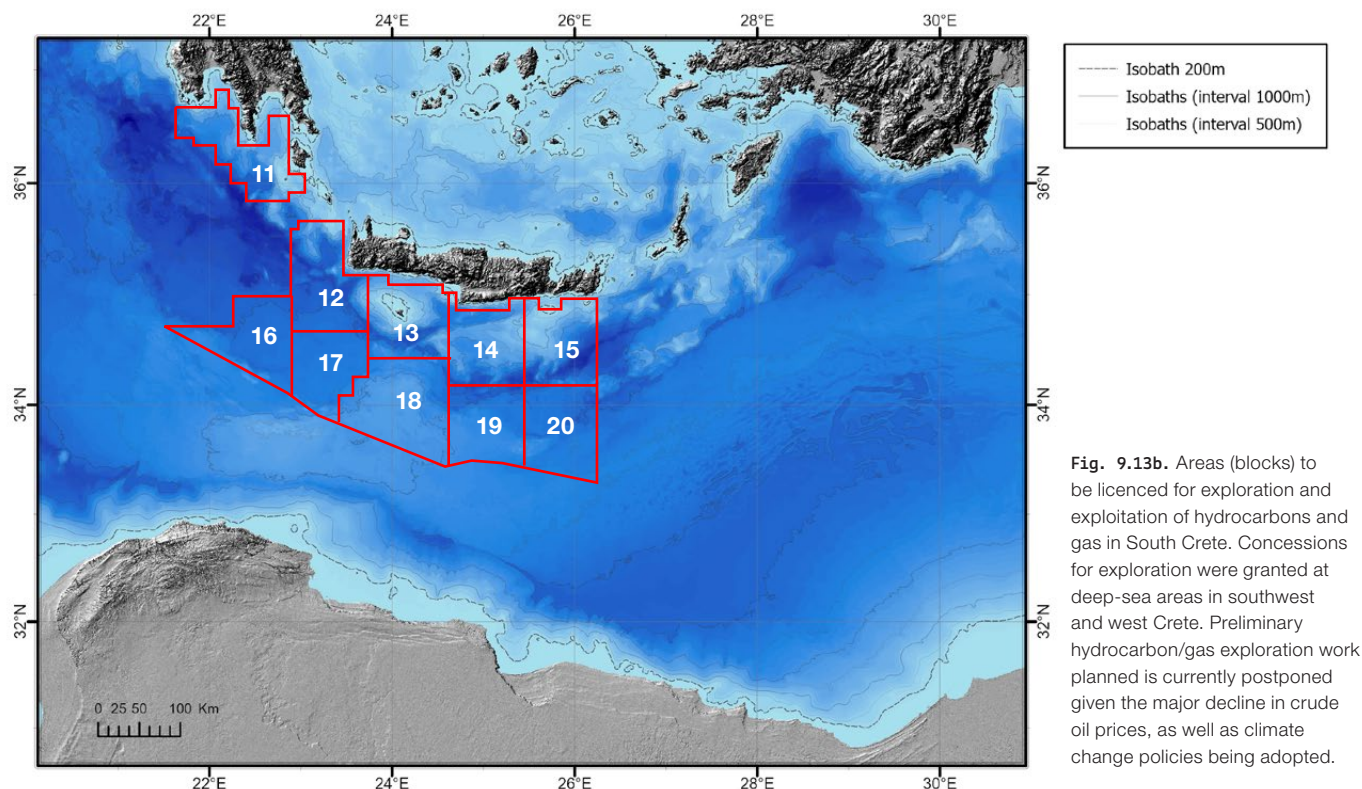
Fig. 9.13a. Areas (blocks) to be licensed (2nd International Licensing Round) for exploration and exploitation of hydrocarbons in Offshore Western Greece (Ionian Sea). Concessions for exploration were granted at deep-sea areas of depths ranging from 2,500 to 3,000 metres in “Area 10 Ionian Sea” (Kyparissia Gulf), as well as Block 2 west of Corfu and Katakolon, a more shallow area situated offshore Western Peloponnese (north of block 10). Preliminary hydrocarbon exploration work planned is currently postponed given the major decline in crude oil prices, as well as climate change policies being adopted.

³ Shale gas reservoir is a natural storage where natural gas is created through the decomposition of organic matter and it is stored in the shale formation.

⁴ Greek Ministry of Environment and Energy official site: <http://www.ypeka.gr/Default.aspx?tabid=765&locale=en-US&language=el-GR>

⁵ <https://energypress.eu/tag/ionian/>

⁶ https://www.greekhydrocarbons.gr/en/Katakolon_en.html



2

NORTH AEGEAN SEA

Oil and gas exploration in the North Aegean Sea began in 1969, when Greece granted 26 hydrocarbon exploration concession rights, in the Gulf of Kavala, to a Consortium of foreign companies. The first 27 well drilling in the region was the «EAST THASSOS-1» in 1971, while in 1972 the “SOUTH KAVALA” 28 natural gas reservoir was discovered. Nowadays, there are three sour crude oil reservoirs in the 29 Prinos area and one sweet gas reservoir in south Kavala, which has been found in shallow waters between the city of Kavala and the island of Thassos[52].

LIBYAN SEA

Current exploration licenses for oil and gas in the region correspond to three offshore blocks. Two of them (blocks 12 & 13) in the west and southwest of Crete covering a large sea area of 40,000 km² (Fig. 9.13b) and one in the Libyan waters. Other offshore areas for hydrocarbon research off western and north-western Crete for oil and gas exploration are also being undertaken⁷.

The Crete licences cover a huge area in very deep-water, averaging 3,200 m. As yet, the potential of these reserves is unknown but the technology needed to allow drilling in these deep waters will be developed in the near future⁸.

Additionally, Libya also has some offshore oil and gas fields (at Bouri and Al-Jurf) although more than 85% of its oil production is onshore. In 2010, it was estimated that there are still undiscovered oil and gas fields within the geologic province of Sirte Basin in Libya[53].

3

SOUTH AEGEAN SEA

No information is available concerning the South Aegean Sea.

4

⁷ <http://www.ekathimerini.com/230302/article/ekathimerini/business/helpe-total-exxonmobil-consortium-selected-for-oil-exploration-off-crete>

⁸ https://www.greekhydrocarbons.gr/news_en/PetroleumEconomist_Sep2018.pdf

Offshore flaring operation in Zohr gas field, Egypt.



5

LEVANTINE SEA

In the past few years, large gas fields have been discovered in this sub-region and interest to explore the seabed for petroleum resources has picked up elsewhere. In 2010, the United States Geological Survey (USGS) estimated the undiscovered oil and gas resources of the Levant Basin Province to be at 1.7 billion barrels of oil and 3.5 trillion cubic metres of natural gas^[54]. Currently, the best known discoveries in this part of the Eastern Mediterranean are Israel's Tamar (1,700 m depth) and Leviathan (at 1,500 m depth) fields, discovered in 2009

and 2010, respectively; Aphrodite about 1,700 m depth in 2011 in offshore Cyprus, followed a few years later by the giant field Zohr in 2015 at a depth of 1,450 metres in offshore Egypt (Fig. 9.14). Most recently, other potentially significant discoveries were in 2018 and 2019 off Cyprus with the reserves called Calypso at 2,074 m depth and Glaucus-1 at 2,063 m depth. Lebanon and Turkey have also started drilling in deep-waters⁹. Syria's marine oil and gas reserves are more uncertain due to halted exploration activities caused by the current political and military conflict and international sanctions on the country. Another smaller reservoir, the Gaza Marine gas field, at a water depth of 603 m, is still not developed.

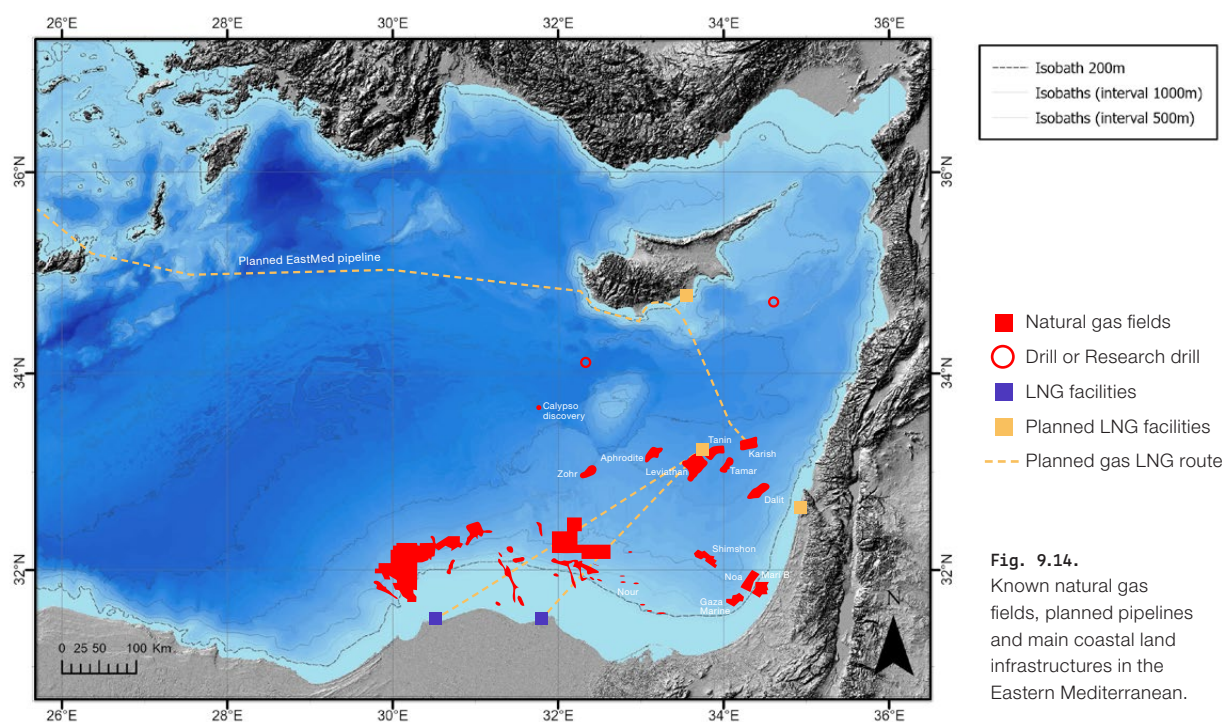


Fig. 9.14. Known natural gas fields, planned pipelines and main coastal land infrastructures in the Eastern Mediterranean.

⁹ <https://www.dailysabah.com/energy/2019/05/08/turkish-drilling-in-eastern-mediterranean-in-compliance-with-international-law>;
<http://www.hurriyetdailynews.com/turkey-starts-shallow-water-drilling-in-mediterranean-sea-139217>;
<https://www.offshore-technology.com/news/total-deepwater-well-lebanon/>

Table 9.2. Locations, sites and blocks of oil and natural gas exploration and extraction in Eastern Mediterranean deep waters (2020).

Site	Location	Area	Block	Status	Company
Katakolo	W. Peloponnesse	Ionian Sea	-	Development	Energean Oil & Gas (100%)
Patraikos Gulf (west block)	W. Peloponnesse	Ionian Sea	-	Research	Hellenic Petroleum (50%), Edison (50%)
Ionian Block	Ionian Sea			Research	REPSOL (50%) & Hellenic Petroleum (50%)
Kyparissiakos Gulf	W. Peloponnesse	Ionian Sea	10	Research	Hellenic Petroleum (100%)
Paxoi	South of Corfu	Ionian Sea	3		Public Petroleum Corporation and Exploitation of Hydrocarbons (DEP-EKY).
West Corfu Isl.	West of Corfu	Ionian Sea	2	Research	Total (50%), Edison (25%) & Hellenic Petroleum (25%)
West of Crete	Cretan Sea	Creatan Sea	-	Research	Total (40%), ExxonMobil (40%) and Hellenic Petroleum (20)
SW of Crete	Libyan Sea	Libyan Sea	-	Research	Total (40%), ExxonMobil (40%) and Hellenic Petroleum (20)
South of Cyprus	Cyprus-offshore	Levantine Sea	2		ENI Cyprus Limited (60%), Kogas (20%) & TOTAL E&P Cyprus BV (20%)
South of Cyprus	Cyprus-offshore	Levantine Sea	3		ENI Cyprus Limited (50%), Kogas (20%) & TOTAL E&P Cyprus BV (30%)
Calypso Gas field	Cyprus-offshore	Levantine Sea	6		ENI Cyprus Limited (50%), TOTAL E&P Cyprus BV (50%)
South of Cyprus	Cyprus-offshore	Levantine Sea	7		TOTAL E&P Cyprus BV (50%) as Operator, & ENI Cyprus Limited (50%)
South of Cyprus	Cyprus-offshore	Levantine Sea	8		ENI Cyprus Limited (60%) & TOTAL E&P Cyprus BV (40%).
South of Cyprus	Cyprus-offshore	Levantine Sea	9		ENI Cyprus Limited (60%), KOGAS Cyprus Limited (20%) & TOTAL E&P Cyprus BV (20%)
Claucus-1 Gas field	Cyprus-offshore	Levantine Sea	10		ExxonMobil Exploration and Production Cyprus (Offshore) Limited (60%) & Qatar Petroleum International Upstream LLC (40%)
South of Cyprus	Cyprus-offshore	Levantine Sea	11		TOTAL E&P Cyprus BV (50%) & ENI Cyprus Limited (50%)
Aphrodite	Cyprus-offshore	Levantine Sea	12		Noble Energy (35%), Delek Drilling (30%), and BG Group (now Shell)
Zohr	within the offshore Shorouk Block, approximately 190 km away from Port Said, Egypt	Levantine Sea	-	unknown	ENI (50%), Rosneft (30%), BP (10%) & Mubadala Petroleum (10%). It could house 850 billion m ³
West of Lebanon	Lebanon	Levantine Sea	4	On hold further research exploration	Total(40%), ENI (40%), Novatek (20%)
SW of Lebanon	Lebanon	Levantine Sea	9		Total (40%), ENI (40%), Novatek (20%)
Tamar Gas field (50 miles from Haifa)	Israel-offshore	Levantine Sea	-	Development	Under operation since 2013. Nobel Energy holding a 36% stake in the field, and the three Israeli partners - Delek Drilling (31%), Isramco (29%) and Dor Alon (4%). Its reserves are estimated at 238 billion m ³ .
Leviathan (located 130 kilometres off the coast of Haifa)	Israel-offshore	Levantine Sea	-	Development	Noble Energy operates Leviathan with a 39.66% working interest; Delek Drilling holds 22.67%; Avner Oil Exploration holds 22.67%; and Ratio Oil Exploration holds the remaining 15%. Delek Drilling began exploiting in January 2020. Discovered in 2010, it is thought to contain 539 billion m ³ of natural gas
Tanin and Karish Gas Fields	Israel-offshore	Levantine Sea		Research	Energean Oil & Gas (subsidiary Energean Israel)

GENERAL REMARKS

There are still significant obstacles and challenges to exploit many gas and oil resources due to geo-political struggles, military conflicts, border disputes, as well as a large requirement of financial resources due to the technical complexity and high development costs (including oil and natural gas transit pipelines) for many of these fields at deep-waters. Nonetheless, some of the exploration and production fields are well underway. In the very near future, extensive natural gas pipeline networks will also be installed. The construction of the East-Mediterranean Pipeline expanding from the natural gas fields occurring off Cyprus and Israel to the Aegean Sea and the Greek mainland will be one of them. It will have 1,300 km of pipeline in the maritime domain connecting the offshore fields to Greece and Italy. These pipeline systems will inevitably extend from the coastal zone down to deep-waters and they will include diverse operations from installation tie-in, commissioning and decommissioning aspects and an environmental impact.

The potential environmental effects of offshore oil and gas development have long been recognized[55], including an awareness of the potential and documented hazards from oil spills associated with offshore production. Risk evaluation for offshore gas and oil exploration and production should involve examining the potential impact of the operations generated from exploration activities (e.g. seismic prospections) to drilling activities, setting facilities offshore, installation of pipelines as well as potential spills and blowouts. Examining all these aspects with short-long term effects should enable the identification of the mitigation procedures to be followed to eliminate any risk of contamination. However, it is also important to stress that there is hardly any published information on the effects of oil and gas exploration activities in the deep-waters of the Eastern Mediterranean or its effects on populations or communities. Existing monitoring data does not allow us to confirm whether or not the observed biological responses are of significance for marine life and ecosystems. Moreover, extensive activities can also lead to risks of bioaccumulation and biomagnifications through the continuous use of chemicals and their release into the surrounding environment.

Due to the risks and following recent environmental drilling disasters, the Barcelona Convention Contracting Parties have recently adopted new environmental standards and requirements for these offshore activities (2019): **(a) Common Standards and Guidance**

on the Disposal of Oil and Oily Mixtures and the Use and Disposal of Drilling Fluids and Cuttings; (b) Common Standards and Guidelines for Special Restrictions or Conditions for Specially Protected Areas (SPA) within the Framework of the Mediterranean Offshore Action Plan (Decision IG.24/09). These new guidelines bring a series of recommendations for countries to enable legislations as well as for operators to prepare environmental impact assessments, site-specific contingency plans and emergency response plans for offshore exploration and production. To mitigate potential impacts, offshore geophysical surveys in Specially Protected Areas (SPA) of the Mediterranean should be permitted and approved by the relevant Competent Authority taking particular account on the most up to date knowledge of the spatial and temporal distributions and life cycle stages of protected species existing within the proposed area of investigation so that sensitive locations and periods can be avoided. Additional relevant regulations are also established for avoiding the introduction or expansion of non-native species, detecting the presence of marine mammals and avoiding collisions, carrying out Environmental Impact Assessments (EIA) and minimising the risk of damage to sensitive habitats and species.

Impacts from deep-water oil and gas development activities begin during seismic surveys that are used to reveal the subsurface geology and locate potential reservoirs; these impacts include underwater sound and light emissions and increased vessel activity[56].

Seismic activities, used to discover oil and gas deposits under the seafloor, have been accountable for introducing a significant amount of underwater sound energy in the marine environment[57]. Animals that are exposed to elevated or prolonged anthropogenic noise may experience direct injury ranging from bruising to organ rupture and death (barotrauma). This damage can also include permanent or temporary auditory threshold shifts, compromising the animal's communication and ability to detect threats[56,58].

A number of studies have shown that the effects of anthropogenic sound on marine organisms can range from no influence to immediate death, depending on the differences in the intensity and frequency of the noise and the distance from the noise source. However, there is still a fundamental knowledge gap on the impact of seismic surveys on species in general. Marine mammals have been studied more than the other organisms



Gas exploration seismic vessel for identifying geological features that could contain oil or gas deposits. Observations onboard and undersea on the consequences of the sounds generated from seismic operations could help to build a good code of conduct for limiting acoustic disturbance to marine mammals and other vulnerable fauna.

for the impact of the anthropogenic underwater noise, which is one of the major threats for them in the Mediterranean Sea[58]. Although there is no current information on the overlapping of oil and gas activities with marine mammal species, there is a potential impact of underwater noise resulting from the offshore oil and gas industry in relation to seismic and drilling activities. Hotspot sites will be around the marine area of Southern Crete, which has been identified as an Important Marine Mammal area (IMMA)¹⁰ for Cuvier's beaked whale *Ziphius cavirostris* and the sperm whale *Physeter microcephalus*. For the latter, this region is considered the core habitat for the Eastern Mediterranean sub-population, which is believed to number no more than two to three hundred individuals[59]. Furthermore, the Hellenic trench, as well as the south Ionian Sea, are also identified as Cetacean Critical Habitats by the ACCOBAMS Agreement.

The potential effects of noise sound to other fauna remains poorly understood but may be significant[56]. The sensitivity to certain frequencies varies in different fish species. For instance, the cartilaginous fish (sharks, rays), which lack gas-filled air bladders, are highly sensitive to low frequency sound (approximately 20 to 1,500 Hz). Fish with swim bladders are more susceptible to

physical injury such as barotrauma and some invertebrates have structures which enable detection of sound waves in their immediate vicinity[58].

During production on reservoirs and transportation, there may occur potential impacts that directly affect marine life as a result of the physical and sound disturbance and indirectly, through the water quality.

- **Physical disturbance:** Benthic habitats and species associated with the seabed at oil or gas rigs will be affected by the direct physical disturbance resulting from drilling activities or the laying of pipelines[60]. For this reason, activities conducted in areas of rich biodiversity or vulnerable habitats, such as where deep-water corals (which are fragile and have low resilience to physical forces) occur, might be evaluated carefully before potential impacts happen.

For example, the presence of the critically endangered bamboo coral, *Isidella elongata* was documented in the Hellenic Trench (Oil and gas Blocks 11-15)[61]. Future plans for offshore oil and gas exploration along these areas can pose a threat for the species conservation in the area. Fig.

¹⁰ <https://www.marinemammalhabitat.org/imma-eatlas/>

9.15 (a & b) represents the occurrence of benthic habitat forming species in relation to the areas in which the oil and gas blocks in the East Ionian, SW. Peloponnese and the Hellenic Trench were located. It seems that block locations are close to *I. elongata* habitats mainly in the SW Peloponnese and Eastern Ionian (Fig. 9.15).

- **Noise:** It will be generated during the equipment mobilization and primary installation activities. The sound and vibration generated during drilling may lead to the migration of some mobile species from the immediate vicinity of the drilling area.
- **Drilling Fluids and disposal waste:** Different based muds are commonly used as a drilling fluid, which are thereafter dumped with its cuttings into the sea. The chemical composition of these drilling fluids is diverse and range from the more toxic oil-based fluids to more modern synthetic and water-based fluids[56]. Drilling operations can also generate oil contaminated fluids during well clean-up, cementing, mud pit cleaning and operations where well bore fluids become contaminated with oil-based mud, crude oil or condensate.

Disposal of these fluids and derived products on the surrounding environment will therefore vary according to the materials used and the system procedures exposure (e.g. closed or open circulation drainage system for the drilling fluids). The current decision (Decision IG.24/09) by Barcelona Convention parties with the Offshore Protocol adopted the common standards (limits and prohibitions) for the disposal of drilling fluids, oil and oily mixtures from installations into the Protocol (Mediterranean) Area.

- **Accidental releases of hydrocarbons and other components:** Oil and gas operations have the potential to result in accidental releases of hydrocarbons and other components. Accidental pollution (potential oil spills) can originate from different sources of oil pollution caused by offshore installations (e.g. well blowouts, sub-sea equipment, pipelines, structural failure or damage to production or pumping platforms, platform-tanker loading activities and other accidental spillage) [62]. Examples of such accidental pollution are the El-Jiyeh oil spill in Lebanon in 2006 that released 15,000 tn of oil in the coast line or the explorato-

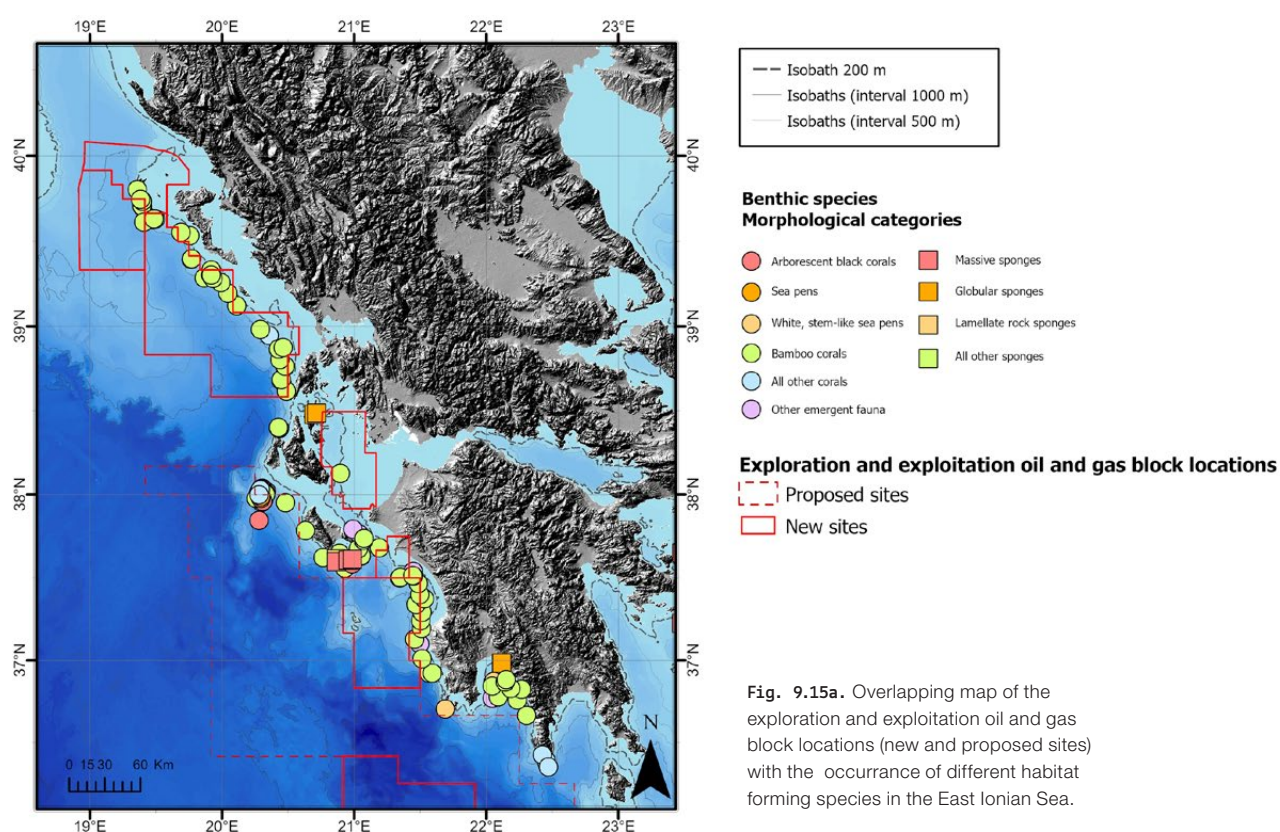


Fig. 9.15a. Overlapping map of the exploration and exploitation oil and gas block locations (new and proposed sites) with the occurrence of different habitat forming species in the East Ionian Sea.

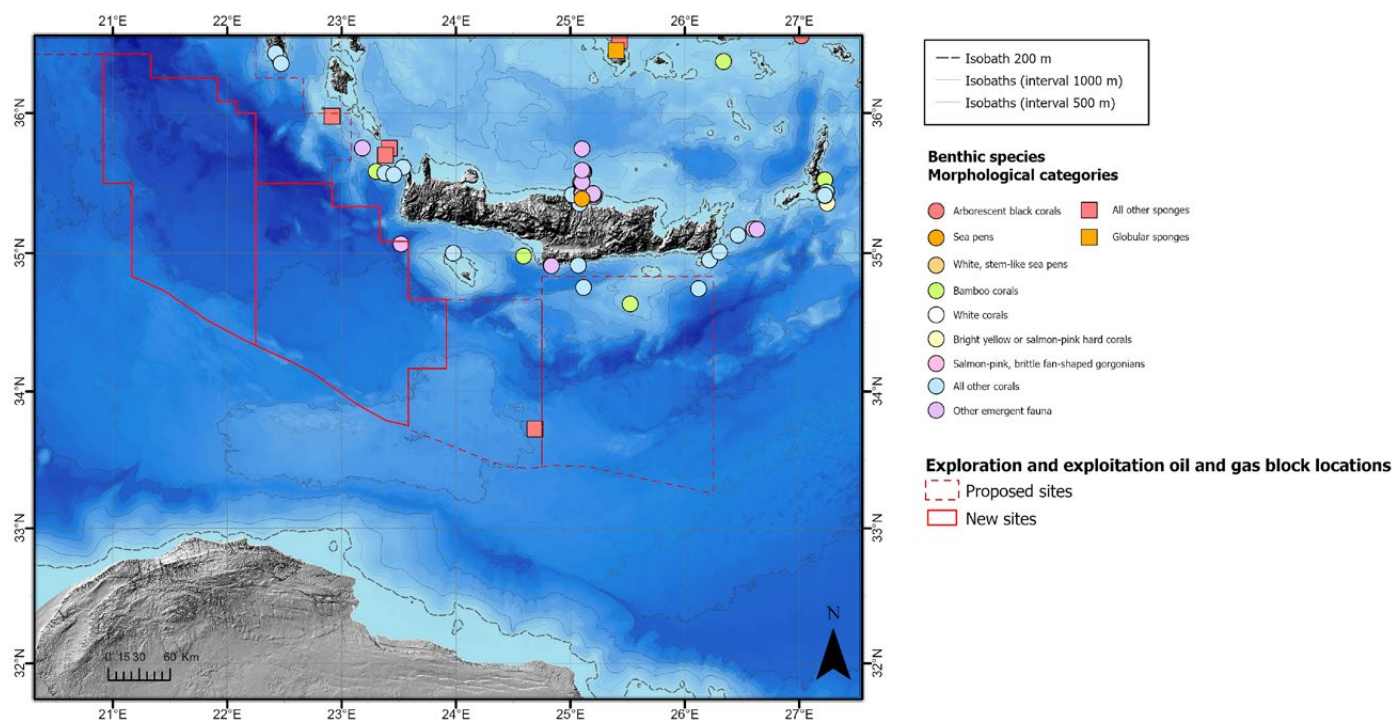


Fig. 9.15b. Overlapping map of the exploration and exploitation oil and gas block locations (new and proposed sites) with the reported presence of habitat forming benthic species occurrence in the NW Peloponnese and the Hellenic Trench.

ry deep drilling in the Leviathan gas field (Israel) that caused a major leak of brine[63]. Oil spill accidents in the Eastern Mediterranean would have dramatic consequences for the entire region for marine life, which can lead to economic impacts in other sectors (e.g. fisheries, tourism). The risk of widespread, long term impacts on the deep-water may persist for many years, and likely longer, for its more fragile ecosystems.

Overall, given the increasing oil and gas exploration activities in the Eastern Mediterranean and the limited knowledge and baseline data of its deep-sea ecosystems, an effective management strategy will need to assess the potentially significant effects, at species and ecosystem levels, from the different operational activities, ensure the effective implementation of regulations of the activity itself (e.g., discharge practices, materials used), monitor the changes and establish spatial (e.g., avoidance rules on sensitive areas and/or with endangered fauna), and temporal measures (e.g., restricted activities during certain periods for sensitive fauna) to mitigate risks.



Mining

Marine minerals could contribute to the future supply of the rapidly growing demand of raw materials, including certain metals such as rare earth elements and cobalt.

Three types of deep seabed mineral deposits have attracted commercial interest: i) **seafloor massive sulphides** (also known as polymetallic sulphides or hydrothermal sulphides), ii) **polymetallic nodules** and iii) **cobalt-rich ferromanganese crusts** [64].

The formation of polymetallic (or ferromanganese) crusts occur as pavements on seamounts, ridges and plateau, and, like nodules, take millions of years to form. Sulphide deposits, on the other hand, are made in active and inactive hydrothermal vent fields and can accumulate rapidly or take thousands of years to develop significant deposits [64].

“

Polymetallic nodules, develop over millions of years to recoverable size, and require stable environments for their formation in deep-sea abyssal environments”



Deep-sea mineral mining involves the excavation of mineral deposits at great depths and requires the installation of mining systems, operating high pressure hoisting pipes and surface-level mining platforms connected to transportation vessels[64]. So far, there are currently no ongoing commercial exploration or exploitation operations in the Mediterranean Sea, but some potential areas for deep seabed mining for sulphide deposits and ferromanganese crusts have been identified in the Alboran Sea, the Italian coastline, the Aegean Sea and South of Cyprus¹¹[65,66]; (Fig. 9.16).

Nonetheless, the outlook for seabed mining at great depths remains uncertain given the difficulties and the low technological development, the high costs involved and the potential environmental impacts. Moreover, the exploitation of these resources in the Mediterranean probably does not represent a great opportunity when compared to the richer resources found at other locations such as the Pacific Ocean[67,66].

The potential impacts of deep-sea mineral mining on deep sea ecology are almost unknown, however, there have been an increasing number of scientific studies that suggest effects will be long-lasting and widespread[68]. These include a) disturbance of the seafloor during exploitation, for example, excavating and ploughing of the seabed; b) stirring up potentially toxic sediment plumes and c) pollution from noise, vibration and light, or through dumping of waste[69]. As a consequence, fragmentation and habitat loss (for example through the removal of nodules and associated attached fauna), impacts on biodiversity, and loss of unique endemic fauna as bio-chemosynthetic benthic communities associated to hydrothermal vents and chimneys can occur[70].

The only study carried out in the Mediterranean looking at potential effects of deep mining was carried out at Palinuro Seamount in the Central Mediterranean Sea. Here, rock drilling and dredging was observed

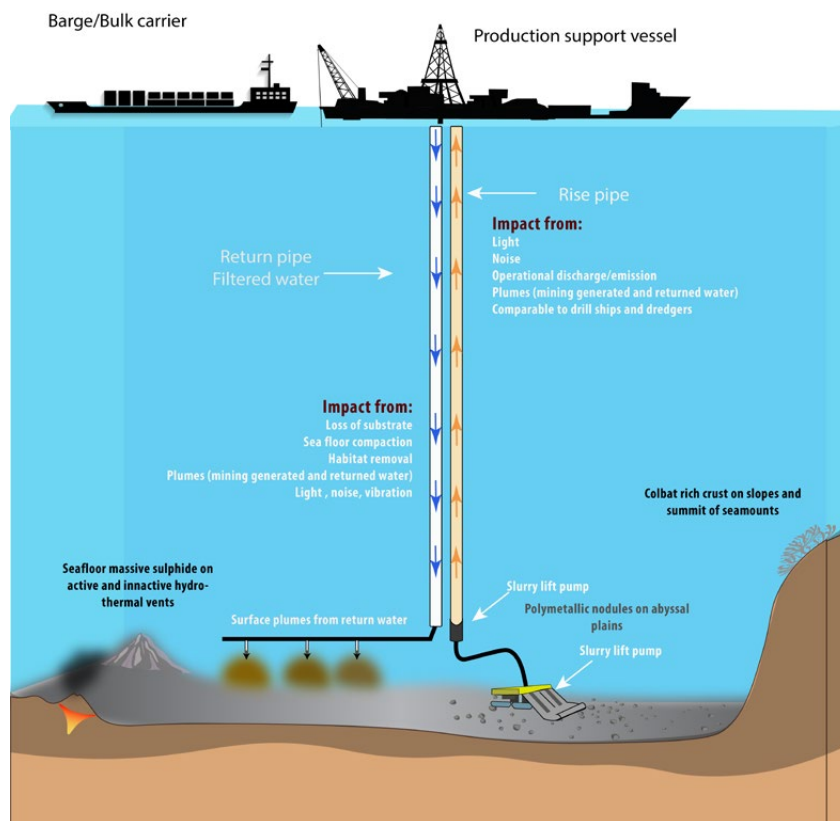


Illustration of potential impacts from deep-sea mining.
© IUCN, Mira Housseini, adapted from Secretariat of the Pacific Community (2013).

¹¹ Until 2021, only one request for exploration has been submitted by a deep-sea mining company to examine seafloor massive sulphides located at a depth of 500 to 1000 metres in the Tyrrhenian Sea in 2014



Fig. 9.16. Deep-sea mineral resources in the Mediterranean.
Source: [62]; GeoERA-MINDeSEA EU project, 2020.

▲ Cobalt deposit
● Sulphide deposit

to cause localised disturbances. Seven years after the disturbance event, abundances, biomass and diversity of microscopic meiofauna were fully recovered, whereas community composition had not returned to control conditions[71].

The scale and potential severity of deep mining-impacts requires careful consideration, innovation and environmentally friendly technology that could limit adverse environmental impacts during mining (e.g. precautionary controls and improving mining equipment to reduce seafloor disturbances). Notwithstanding this, reducing the commercial demand for these minerals by repair, recycling and reuse of products and by developing adjusted policies will be key in mitigating the development of these activities in these fragile environments.

“

The East
Mediterranean
Sea is among the
world's riskiest
seas for accidents
involving ships"



Maritime traffic

The Mediterranean Sea is among the busiest shipping routes in the world accounting for 25% of global shipping and 30% of the world's oil traffic. Major hub ports serve as redistribution points for the largest container ports, with passage via maritime hubs; among them, in the Eastern Mediterranean near the entrance/exit to the Suez Canal, in the central Mediterranean area with Maltese and southern Italian ports, and in the Straits of Gibraltar area with Algeciras and Tangiers. Most recent estimations state that around 120,000 ship transits annually pass through the Straits of Gibraltar, over 18,500 vessels through the Suez Canal, accounting for over 963 million tons in 2018 (Fig. 9.17).

In the Eastern Mediterranean, there are 16 large ports for passenger cruises^[71] and cargo^[71] besides a number of intermediate container hubs and liner shipping networks (Fig. 9.18). Intensive traffic density is observed

within the Aegean Sea, while there are other high traffic branches towards the Levantine Sea. With the increased renewable energy production, offshore oil and, in particular, natural gas projects, a significant part of the traffic will also increase in the future due to offshore support vessels, such as, offshore construction vessels, dive support vessels, stand-by vessels, inspections, etc. The dense maritime traffic could increase the risk of accidents, including in important conservation areas (Fig. 9.19).

The large cargo and passenger shipping traffic along the region produces a number of negative effects on the marine environment. Of particular environmental concern are the emissions caused by ships, risk of accidents and acute pollution events, underwater noise, introduction of invasive alien species with ballast waters, collision, and habitat degradation^[72,73]. Shipping also contributes to the eutrophication of marine waters through emissions, and is intensified through cumulative activities.

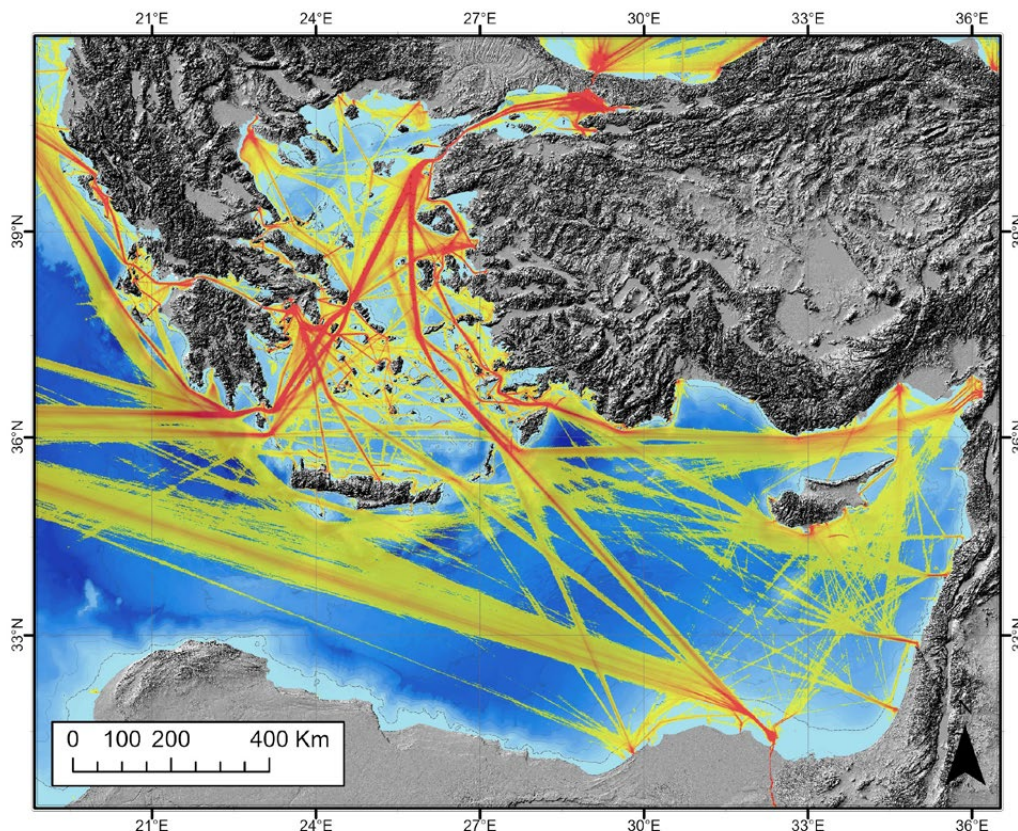
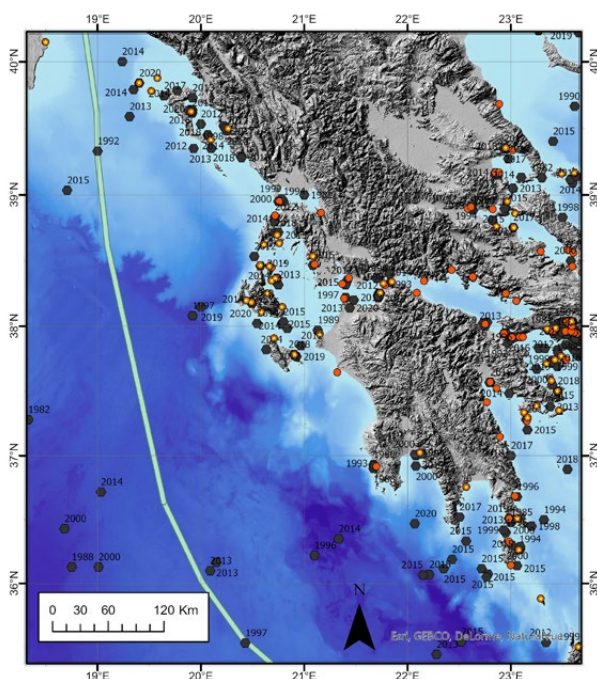
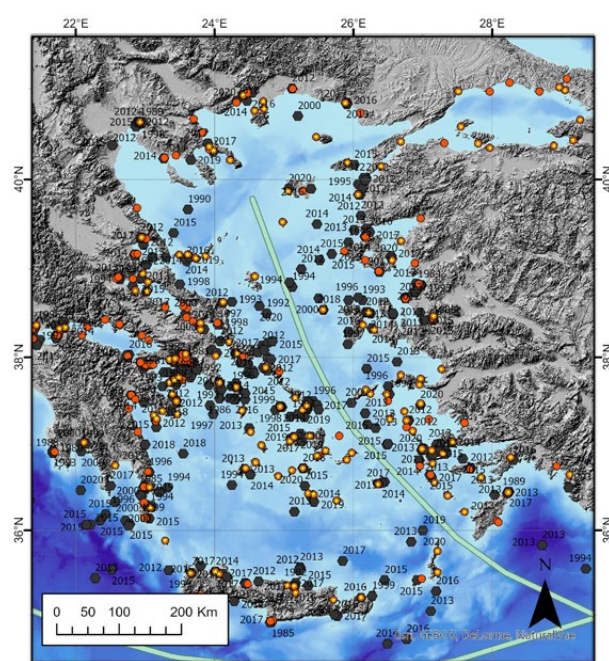


Fig. 9.17. Maritime traffic density in the Mediterranean Sea. (Source: EMODnet Human Activities portal).



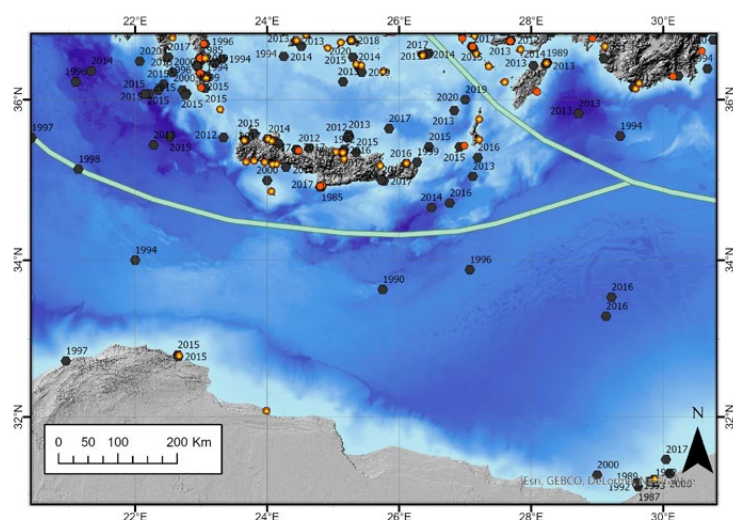
Legend

- Historical oil spill accidents (1977-2020)
- Ports
- Ferry & cruise ports
- Highways of the Sea



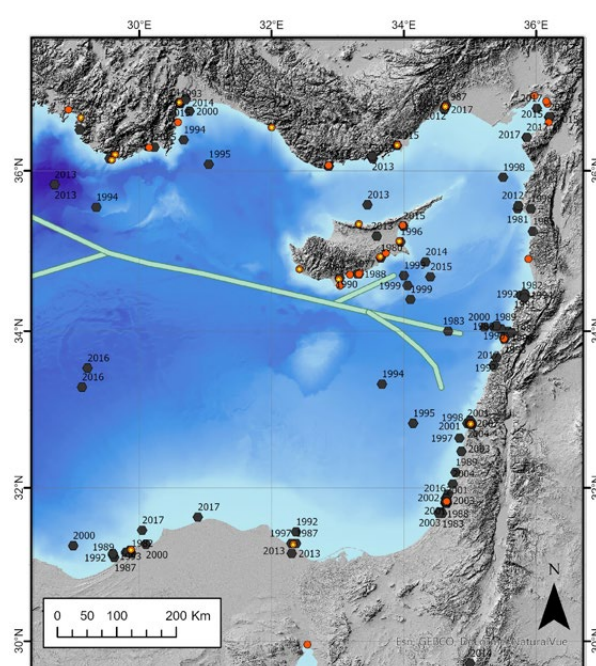
Legend

- Historical oil spill accidents (1977-2020)
- Ports
- Ferry & cruise ports
- Highways of the Sea



Legend

- Historical oil spill accidents (1977-2020)
- Ports
- Ferry & cruise ports
- Highways of the Sea



Legend

- Historical oil spill accidents (1977-2020)
- Ports
- Ferry & cruise ports
- Highways of the Sea

Fig. 9.18. Main ports for ferry and passenger cruises as well as cargo container ports with the historical reports of oil spill accidents (1977-2020).

“

As mentioned previously, some of the major maritime routes cross priority areas for the conservation of marine mammals affected by pollution and noise[62]. Marine noise pollution is reported to interfere with: (1) vocalizations emitted by many animals to communicate with their conspecifics, (2) natural sounds that animals perceive and use as clues for orientation in space, movements in search of food, migration to reproductive areas, and detection of appropriate habitats for settlement[74].

With the increasing trend of maritime traffic in the Mediterranean, a cleaner shipping and an increase of the regulation for the traffic control and noise, particularly in hotspot areas, requires urgent attention”

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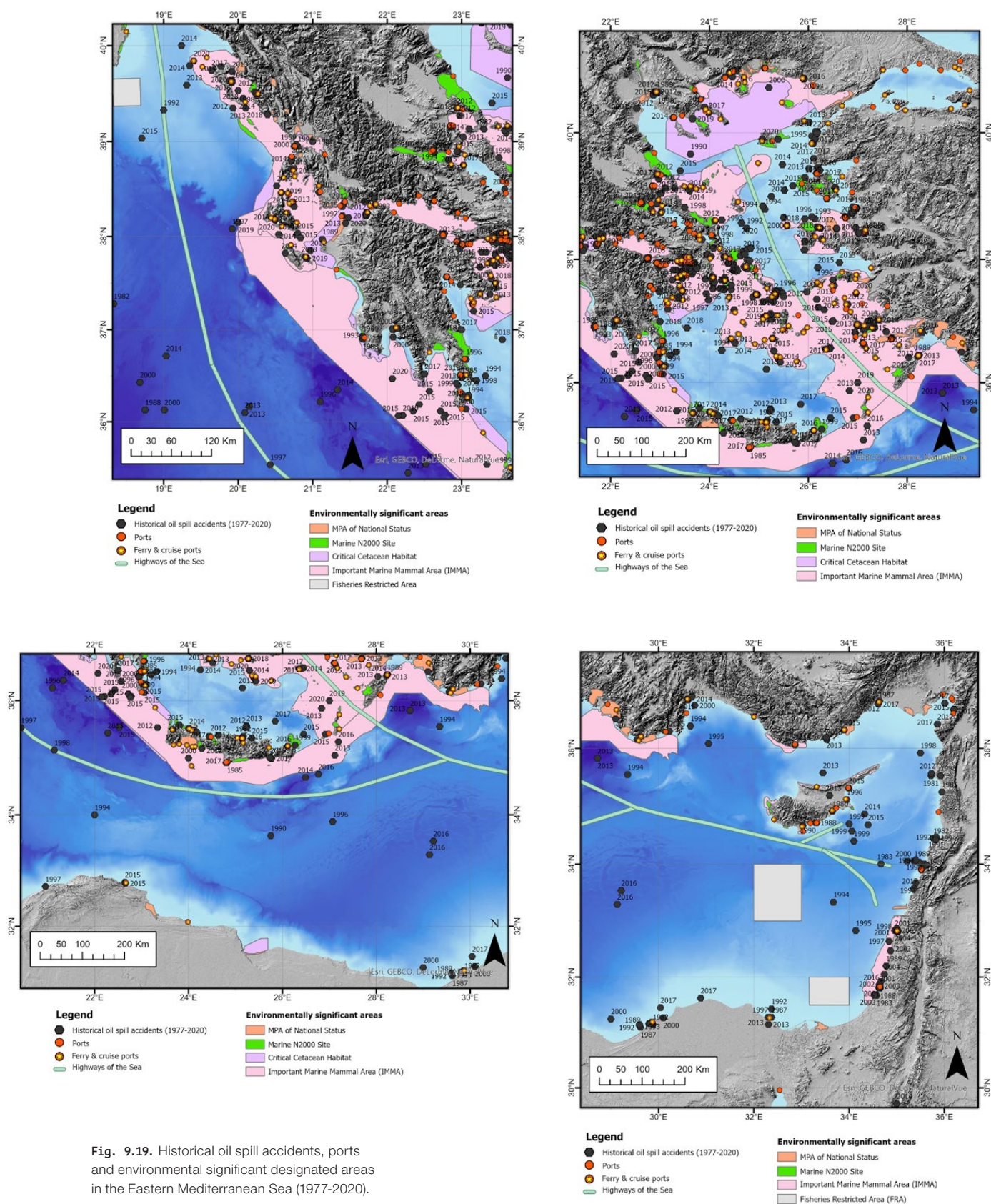


Fig. 9.19. Historical oil spill accidents, ports and environmentally significant designated areas in the Eastern Mediterranean Sea (1977-2020).

Similarly, collision with fast moving vessels is also of concern for vulnerable megafauna such as sea turtles and cetaceans[41] and reported cases of ship strikes with sperm whales are relatively common in the region. A clear example comes from the Hellenic Trench with the overlap of the major shipping routes and the encounters with sperm whales in both the Aegean and Ionian Seas (Fig. 9.20). In the Hellenic Trench, the average shipping density that whales are exposed to ($220 \text{ km}^{-1} \text{ year}^{-1}$) is among the highest in the Eastern Basin[59]. These results highlight that alternative traffic routes could considerably reduce the overall collision risk for sperm whales and other cetaceans in these areas.

There have been remarkable efforts aimed at the regulation of maritime traffic operations at the EU and Mediterranean level with the recent introduction of further international standards. Among them:

- the control and management of ballast water and sediments of ships and water treatment systems (Convention of Ballast Water; Ballast Water Management Strategy for the Mediterranean Sea (2022-2027).
- legislation regarding port reception facilities for ships' operating waste and cargo residues (EU Directive 2000/59/EC) regulations regarding the energy efficiency of shipping vessels with progressively restrictive policies on air pollution from ships, green house emission targets and sulphur content used in marine fuel oils (MARPOL Convention). The designation of the Mediterranean Sea, as a whole, as an Emission Control Area for Sulphur Oxides (MED SOx ECA) pursuant to MARPOL Annex VI will be proposed for the possible designation by the IMO.

- the common standards for the oil and gas industry with the Offshore Protocol of the Barcelona Convention.
- the maritime surveillance and the European Union Maritime Security Strategy (EUMSS) adopted in 2014; Marine Strategy Framework Directive (MSFD), with targets for healthy and sustainable marine and coastal ecosystems with the descriptions of Good Environmental Status (GES) and the Integrated Maritime Policy (IMP).

The forecast of increasing maritime traffic in the Mediterranean and the concentrations of maritime transport will continue to place direct and indirect pressures on marine ecosystems (including deep-sea environments) caused by both regular operating activities as well accidents or incidents. The recent policy and regulatory mechanisms established should help to partially address the environmental pressures that will occur. Other policies to enhance cooperation and information sharing between countries, the impacts of underwater noise and the spatial or temporal impacts of maritime traffic in certain areas are also needed. Additional research should also be conducted in order to further determine these impacts and address new regulations or measures. •

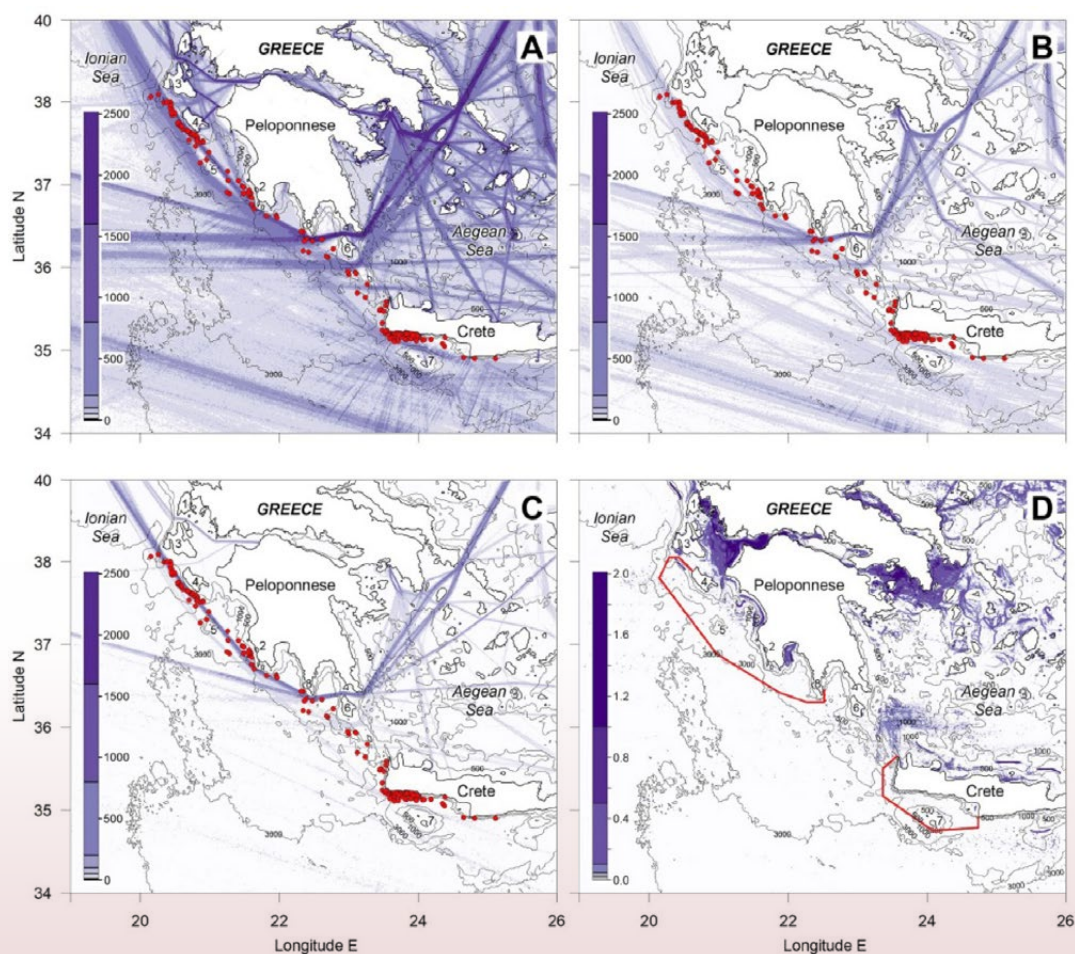
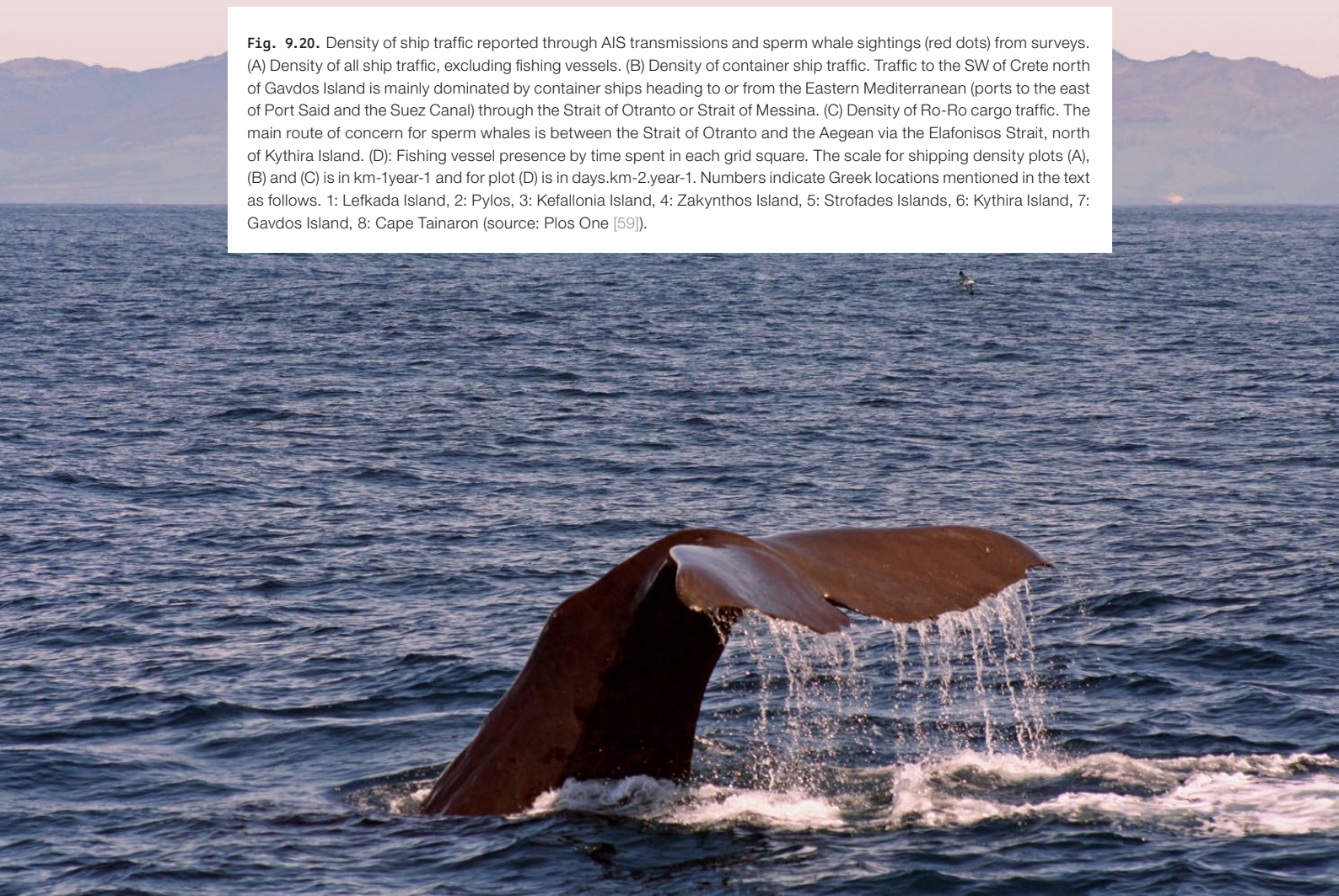


Fig. 9.20. Density of ship traffic reported through AIS transmissions and sperm whale sightings (red dots) from surveys. (A) Density of all ship traffic, excluding fishing vessels. (B) Density of container ship traffic. Traffic to the SW of Crete north of Gavdos Island is mainly dominated by container ships heading to or from the Eastern Mediterranean (ports to the east of Port Said and the Suez Canal) through the Strait of Otranto or Strait of Messina. (C) Density of Ro-Ro cargo traffic. The main route of concern for sperm whales is between the Strait of Otranto and the Aegean via the Elafonisos Strait, north of Kythira Island. (D): Fishing vessel presence by time spent in each grid square. The scale for shipping density plots (A), (B) and (C) is in $\text{km}^{-1}\text{year}^{-1}$ and for plot (D) is in $\text{days.km}^{-2}\text{year}^{-1}$. Numbers indicate Greek locations mentioned in the text as follows. 1: Lefkada Island, 2: Pylos, 3: Kefallonia Island, 4: Zakynthos Island, 5: Strofades Islands, 6: Kythira Island, 7: Gavdos Island, 8: Cape Tainaron (source: Plos One [59]).



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