Chapter 14

Conservation challenges in the face of new hydrocarbon discoveries in the Mediterranean Sea

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The Mediterranean Sea marine biodiversity hotspot

The Mediterranean Sea is the largest and deepest semi-enclosed basin in the world (Boudouresque 2004). It constitutes less than 1% of global ocean surface space, but it contains immense biodiversity relative to its size (Bianchi & Morri 2000). This area supports ~ 18% of the world's macroscopic marine species, of which 25–30% are endemic (Cuttelod et al. 2008). Emblematic species of conservation concern include the endemic Mediterranean monk seal *Monachus monachus*, 11 cetacean species (Franzosini et al. 2013), Atlantic bluefin tuna *Thunnus thynnus*, and sea turtles *Caretta caretta* and *Chelonia mydas*. The Mediterranean Sea also features unique ecosystems and habitats such as the endemic seagrass *Posidonia oceanica* that forms large underwater meadows, vermetid reefs built by sea snails *Dendropoma petraeum*, and Mediterranean coralligenous assemblages (Bianchi & Morri 2000; Boudouresque 2004). The rich and unique marine species and habitats of the region distinguish it as a global Biodiversity Hotspot (Cuttelod et al. 2008).

At the same time, the biodiversity of the Mediterranean Sea is threatened by a wide range of sea-based and land-based anthropogenic activities (Coll et al. 2010; Micheli et al. 2013a). The coastal areas are highly populated, with ~ 600 cities and a population of ~ 250 million inhabitants, along with ~ 250 million tourists that visit annually (Cuttelod et al. 2008). The Mediterranean Sea is surrounded by over 20 countries from Asia, Africa and Europe. Anthropogenic perturbations such as habitat degradation, pollution, by-catch, invasive species, climate change and exploitation of marine species and resources threaten the unique ecosystems (Bianchi & Morri 2000). In addition, social (e.g., cultural, religious and political) and economic divisions, such as the large contrast between Europe and North Africa, greatly challenge both the ability to minimise and control threats to the surrounding environment and to coordinate conservation efforts (Fraschetti et al. 2009).

To protect the biodiversity of this global Biodiversity Hotspot, marine spatial plans that meet specific goals and fit within realistic socio-economic constraints must be developed. Conservation initiatives and spatial planning processes are increasing in the region, with much focus on the promulgation of marine reserves and networks (Portman et al. 2012; Micheli et al. 2013b). Surprisingly, most initiatives ignore how marine spatial planning can address the rapidly expanding, and potentially vastly damaging, threat for the region's biodiversity: hydrocarbon exploration and extraction.

Recent hydrocarbon discoveries in the Mediterranean Sea

Some of the largest natural gas fields globally have recently been discovered in the Mediterranean Sea and they are being developed at a rapid pace. There are currently 152 existing offshore natural gas and oil fields in the region, and 172 planned for development over the next four years (Pruett 2013; Infield 2013). Two-thirds of both present and potential natural gas and oil fields lie beyond the 12-nautical mile territorial waters (Figure 14.1a). The U.S. Geological Survey estimates that the eastern Mediterranean holds 9.8 trillion cubic metres of recoverable natural gas, 417 billion litres of recoverable oil and 715 billion litres of natural gas liquids (Schenk et al. 2010; Kirschbaum et al. 2010). Recent gas discoveries by Israel and Cyprus, including the large Leviathan gas field, are estimated to hold a combined 980 billion cubic metres of natural gas (see Figure 14.2). These discoveries have spurred a flurry of exploration, especially in the Levantine Basin, which is situated in the eastern and south-eastern Mediterranean (Darbouche et al. 2012; Figure 14.1).

The present distribution of drilling wells is mostly limited to shallow waters (< 500 m) (Figure 14.1a). However, technological advances are enabling offshore operations in the Mediterranean to expand into deeper waters, as seen by the location of oil and gas concessions (Figure 14.1a). The spatial distribution of past oil spills appears closely related to shipping routes and ports, rather than to the location of drilling wells (Abdulla & Linden, 2008). However, some concessions are located in seismically sensitive areas (e.g., in the Aegean and Ionian Seas), where higher risks of earthquakes must be considered (Figure 14.1c). These active areas also provide important habitats for many marine species, such as the globally Endangered Mediterranean monk seal and green sea turtles (International Union for Conservation of Nature 2012).

Hydrocarbon operations and their conservation challenges

Research on the ecological impacts of offshore oil and gas exploration is often focused on the negative consequences of oil and gas spills on marine ecosystems and species (e.g., Davies et al. 2007; Fisher et al. 2014). While these potential impacts (Chapter 8) are crucial to account for in marine spatial planning processes (Cordes et al., 2016), oil and gas exploitation might also provide some benefits and opportunities for conservation that should also be considered (Kark et al. 2015; Chapters 3, 10, and 11). Below we describe four

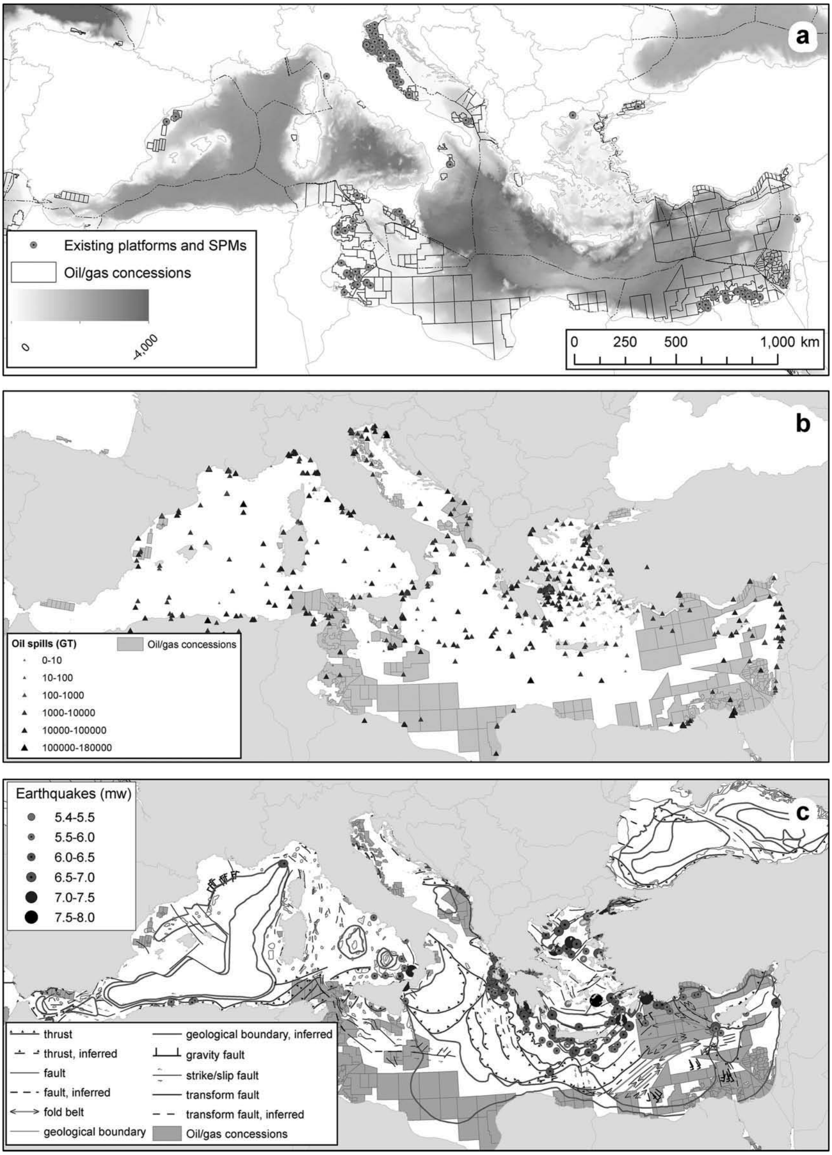

Figure 14.1 Oil and natural gas concession areas, existing platforms and offshore single-point moorings (SPM) in the Mediterranean Sea, based on data from Infield Offshore Energy Database (Infield 2013): (a) location of concessions areas and existing drilling with respect to the bathymetry and marine boundaries of Exclusive Economic Zones (thick black lines) (The Flanders Marine Institute 2012), (b) recorded oil spills in Mediterranean concessions in the 35 years between January 1977 and July 2013 (n = 778; Supporting Information; REMPEC 2013) and (c) seismic activity (major earthquakes in the 20th Century) and major faults in the Mediterranean relative to oil and gas concessions (fault data, Asch 2003; earthquake data, ISC 2013).

Source: Adapted from Emerging conservation challenges and prospects in an era of offshore hydrocarbon exploration and exploitation, Kark *et al*., Conservation Biology, 2015, doi:10.1111/cobi.12562, Copyright © [2015], Published by Wiley on behalf of Society for Conservation Biology, Wiley Periodicals, Inc.

Figure 14.2 Tamar gas field production platform in the Mediterranean Sea. Photo by Ilan Nisim.

challenges that hydrocarbon operations present for the Mediterranean Sea's biodiversity and explore possible collaborations and opportunities that could be gained for conservation and marine planning in the region.

Challenge 1: Oil spills and gas leaks

The Mediterranean Sea is one of the regions with the highest risk of oil pollution (Martini & Patruno 2005) and has been identified as an area of global concern for oil spills from tankers (O'Rourke & Connolly 2003). A total of 778 oil spills was recorded in the Mediterranean Sea between January 1977 and July 2013 (International Maritime Organisation 2013). Using remote-sensing methods, 897 to 2,297 oil slicks (covering 1382 to 3885 square degrees) were identified annually between 1999 and 2004 (Ferraro et al. 2009). Surprisingly, oil-spill preparedness in this region is limited (Moller et al. 2003). While the probability of a large oil spill is low, such a spill could have extensive negative impacts on biodiversity. Impacts of oil spills could be even greater in the Mediterranean Sea than elsewhere, due to its enclosed geography and its deep isolated basins.

Many preparedness plans exist for oil spills of Mediterranean Basin governments; however, cooperative international plans rarely exist due to conflicts between nations, particularly in the eastern Mediterranean (Khadduri 2012). Cooperative agreements, such as bilateral and trilateral partnerships between countries, could improve the readiness of the eastern Mediterranean for oil spills (Martini & Patruno 2005). The shared risk of the region might encourage collaboration to facilitate the safe exploration and exploitation of hydrocarbon resources as evident in other regions around the globe (e.g., US-Mexico Transboundary Hydrocarbon Agreement; The Bureau of Safety and Environmental Enforcement 2015). Such agreements and treaties that help forge ties between countries could be a catalyst for strengthening collaborative potential of improved disaster prevention as well as future marine conservation plans and actions (Levin et al. 2013).

Challenge 2: Deepwater exploration

International oil companies are now drilling in the Mediterranean to depths of > 6,000 m (e.g., Hodoa field, Egypt,Khadduri 2012). The scarcity of data on the ecology and oceanography of the deep waters of the Mediterranean (Costello et al. 2010; Levin et al. 2014) and the unknown impacts to biodiversity resulting from developing marine oil and natural gas operations challenges conservation efforts and environmental decisions. Previously, the deep Mediterranean Sea was once thought to hold few species; however, it has now been estimated that approximately 2,805 species inhabit the Mediterranean's deep-sea, with ~ 66% of these species still yet to be discovered (Danovaro et al. 2010).

In general, there is poor understanding of how deep-water ecosystems recover from disturbances (Gates & Jones 2012). Research has suggested that deep-sea ecosystems provide critical habitat for global ocean functioning, so any large disturbances could alter biological processes of the whole marine ecosystem (Danovaro et al. 2008; Loreau 2008). Deep-sea drilling could provide an opportunity to gain research funding and access to operate remote underwater vehicles. This in turn could enable us to enhance our limited knowledge of the deep-sea regions and to study the interaction of drilling within deep ecosystems (e.g., Before-After Control-Impact studies). Furthermore, deep-sea operations could encourage countries to devise multi-national marine spatial plans, which extend beyond territorial waters and aim to protect deeper habitats.

Challenge 3: Marine borders and cross-country collaboration

Cross-country collaboration of conservation efforts in the Mediterranean Sea is highly valuable for efficient planning and protection of marine biodiversity (Mazor et al. 2013). Hydrocarbon operations can either hinder or facilitate such collaboration potential. A momentum of Exclusive Economic Zone declaration can be observed in recent years in the eastern Mediterranean as increased offshore exploitation and hydrocarbon discoveries occur in the region. Cyprus and Israel, for example, have recently reached an agreement on their maritime boundaries following the discovery of large offshore gas in Israel (Leviathan: the largest gas field found in the Mediterranean; Wählisch 2011; Energy Information Administration 2013). The prospect of joint exploration of oil and gas reserves and collaboration in a proposed natural gas pipeline to export gas to Europe (via Greece and Italy) between Cyprus and Israel enhances socio-economic relations (Shaffer 2011). Cooperation arrangements between national companies regarding joint exploration, drilling and production, as well as preparedness for the mitigation of possible oil spills, even when maritime claims are not settled, could strengthen socio-political ties that could in turn enhance conservation and spatial planning collaborations (Buszynski & Sazlan 2007; Levin et al. 2013).

On the other hand, several countries have not officially declared their Exclusive Economic Zones (The Flanders Marine Institute 2012; Katsanevakis et al. 2015), and not all marine boundaries have been agreed. Disagreements over marine borders are one of the causes for political tension between countries, for example, between Cyprus and Turkey (Naylor 2011). Oil and gas discoveries also provide countries with great economic and political independence (Shaffer 2011), but given the complicated political history of the region, they also have the potentail to stimulate conflicts and impede collaborative planning.

Challenge 4: Hydrocarbon infrastructure

Hydrocarbon infrastructure in the sea could facilitate indirect protection for marine biodiversity. The International Maritime Organization (2013) enforces a 500-m safety zone around drilling platforms, which excludes all fishing and recreational activities. This safety zone is followed by all Mediterranean countries and is extended in some regions with security issues (e.g., 5-km radius is enforced in Israel). If correctly managed in collaboration with conservation managers, this safety zone has the potential to act as a *de facto* marine protected area (Chapter 11). Another possible benefit is that hydrocarbon infrastructure could act as artificial reefs. In many areas of the Mediterranean, rocky substrata are scarce, especially in the deep-sea where clay and silt are more common. Hydrocarbon pipes and rigs could enhance the recruitment and reproduction of rare and endangered fish, algae or coral species (e.g., Gass & Roberts 2006; Davies et al. 2007, Chapters 10 and 11). Platforms might also have other functions for conservation, such as providing stopping sites for migratory bird species, or as potential stations for monitoring biodiversity and gaining new biological information. Nevertheless, challenges remain. Hydrocarbon infrastructure can have many negative impacts on the marine environment, including pollution (Henderson et al. 1999; Ko & Day 2004), habitat damage (Grant & Briggs 2002; Davies et al. 2007), and increased prevalence of invasive species (Rivas et al. 2010), all of which can lead to biodiversity loss and reduced ecosystem resilience (see Chapter 8 for more details). The extent to which potential biodiversity benefits or negative impacts are realised will depend to some extent on where instillations are situated in the seascape (Chapter 11).

Conservation plans and initiatives

Marine conservation initiatives in the Mediterranean are increasing, mostly in the form of networks of marine protected areas at local, national and regional scales (Levin et al. 2013). Yet, broad-scale conservation initiatives have rarely considered the negative impacts of oil and gas exploration

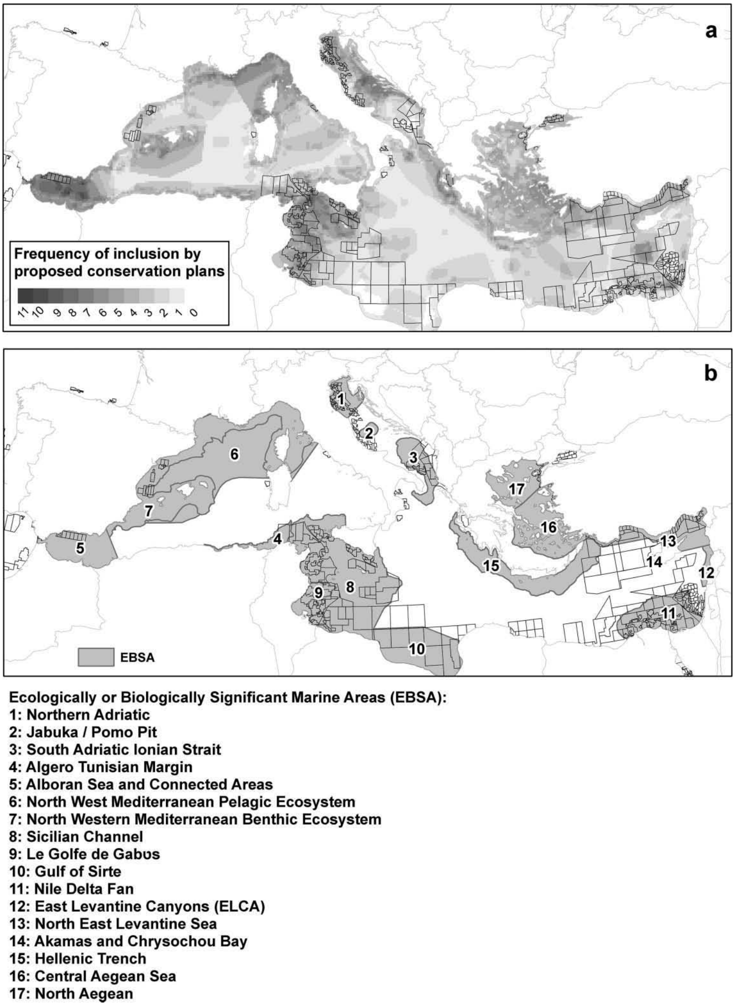

Figure 14.3 Oil and natural gas concession areas (black outline; Infield 2013) in the Mediterranean Sea and their overlap with (a) conservation priority areas shared between five or more proposed schemes (adapted from Micheli et al. 2013b), and (b) Ecologically or Biologically Significant Marine Areas (EBSA; www.cbd.int/ebsa).

explicitly, and how they overlap or compete with conservation objectives (Micheli et al. 2013b). For instance, a synthesis of priority marine conservation areas in the Mediterranean (areas selected by five or more initiatives; Micheli et al. 2013b) has a 27% overlap (130,000 km^2) with gas and oil concessions, equal to 17% of the total size of the concession areas (Figure 14.3a).

Furthermore, 46% (566,200 km^2) of Ecologically or Biologically Significant Marine Areas (EBSA) in the Mediterranean overlap with gas and oil concessions (Figure 14.3b). Future work in the Mediterranean Sea would benefit from incorporating emerging oil and gas plans into spatial planning (e.g., Mazor et al. 2014). One of the major challenges for marine spatial planning will be to optimise the siting of many new installations to minimise negative impacts and maximise potential conservation benefits. Table 14.1 outlines some possible tools and techniques that could be used to do so.

Table 14.1 Proposed tools and their approaches for incorporating offshore energy information into marine spatial plans, with examples from literature. Given the limited inclusion of offshore energy operations in marine conservation planning, examples from the terrestrial literature were included.

Tools	*Approach*	*Literature*
Cost or threat layer	Including oil and gas exploration and extraction as a cost layer or as a threat layer within systematic conservation planning tools such as *Marxan*, *Marxan with Zones*, *Marxan with Probability* or *Zonation*. The cost layer could include areas that are licenced or leased to oil and gas companies, actual hydrocarbon fields or drilling platforms.	Schneider et al. (2011, 2012); Mazor et al. (2014)
Discovery scenarios	Accounting for uncertainty in the location of future oil and gas developments. Modelling scenarios predict future discoveries and then are incorporated into conservation plans.	Wilson et al. (2013)
Avoid strategy	Avoiding potential hydrocarbon exploration areas from the marine plan. For example, the 'lock out' term used in *Marxan* where planning units are left out of the analysis. Thus, conservation priorities can be selected around hydrocarbon features to avoid conflicting priorities.	Kiesecker et al. (2009)
Distance and buffers	Creating a buffer zone around drill sites or calculating a 'safe' distance from hydrocarbon features could minimise some local impacts (e.g., pile cuttings released during drilling operation restricted to a zone within 100 m of the discharge; Neff 2010).	Rogers et al. (2005)

(*Continued*)

Tools	*Approach*	*Literature*
Trade-off analysis	Quantifying the value of hydrocarbon reserves and other economic activities of the sea.	Mazor et al. (2014); Chapter 2
	Examining the trade-offs for reaching conservation goals (e.g., protecting a percentage of a species distribution) and maintaining energy-generation operations.	
Simulation analysis	Incorporating a simulation model or various scenarios of oil spill/disaster events into a marine plan (e.g., *Marxan with Probability*) to avoid potential spill areas.	Goldman et al. (2015); Gopal et al. (2015)
Food web modelling	Hydrocarbon threats can be examined in the context of a food web model to estimate and predict cumulative impacts on biodiversity. Spatial plans can then prioritise actions that minimise specific components of hydrocarbon operations.	Giakoumi et al. (2015)
Including linear features	Avoiding planning marine reserves near pipelines and transportation routes from drill sites. These features can be difficult to plan around given their linear structure.	Mazor et al. (2014)
Co-location options	Examining the impacts of co-locating offshore energy operations and other activities in marine spatial plans (e.g., aquaculture farms, marine reserves, and fishing).	Yates et al. (2015); Chapters 10 and 13.

Ways forwards for marine spatial plans

Hydrocarbon operations are rapidly moving ahead in the Mediterranean Sea, while multi-sector marine spatial plans are only slowly emerging. To protect the region's marine biodiversity, transparent marine spatial plans incorporating hydrocarbon operations need to be proposed quickly. While the incorporation of hydrocarbon activities and impacts into marine plans demands some estimates and approximations, including such developments is important for sufficiently protecting marine biodiversity from the threats they pose. To move forward, planning initiatives for the region should aim to leverage opportunities (e.g., funding for deep-sea biological surveys; Kark et al. 2015) from current and future hydrocarbon operations (Chapter 3). Marine spatial plans need to incorporate objectives of different sectors (e.g., conservation, commercial fisheries, offshore energy) and quantify trade-offs between sectors for efficient decision-making and successful uptake of plans (Yates et al 2015).

Highlights

- The Mediterranean Sea Biodiversity Hotspot is facing rapid exploration and exploitation of hydrocarbon resources.
- Hydrocarbon activities pose many challenges for biodiversity of the Mediterranean region due to its enclosed basin shared by >20 countries.
- Opportunities can be gained by collaborating with the hydrocarbon industry: funding to explore the deep-sea, *de facto* marine protected areas, and strengthened ties between countries.
- Future marine spatial plans should include hydrocarbon activities to improve biodiversity protection.
- There are a range of tools and approaches available for explicitly accounting for hydrocarbon activities in marine spatial plans.

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