Incorporating Socioeconomic and Political Drivers of International Collaboration into Marine Conservation Planning

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International collaboration can be crucial in determining the outcomes of conservation actions. Here, we propose a framework for incorporating demographic, socioeconomic, and political data into conservation prioritization in complex regions shared by multiple countries. As a case study, we quantitatively apply this approach to one of the world's most complex and threatened biodiversity hotspots: the Mediterranean Basin. Our analysis of 22 countries surrounding the Mediterranean Sea showed that the strongest economic, trade, tourism, and political ties are clearly among the three northwestern countries of Italy, France, and Spain. Although economic activity between countries is often seen as a threat, it may also serve as an indicator of the potential of collaboration in conservation. Using data for threatened marine vertebrate species, we show how areas prioritized for conservation shift spatially when economic factors are used as a surrogate to favor areas where collaborative potential in conservation is more likely.

Keywords: marine conservation planning, international collaboration, Marxan, Mediterranean Sea, spatial prioritization

International collaboration has been shown to be a key to success in tackling a range of environmental issues (e.g., the Montreal Protocol on Substances that Deplete the Ozone Layer; Velders et al. 2007). Developing transboundary marine parks is one useful strategy used to facilitate a collaborative approach in conservation planning (Mackelworth 2012). This approach is often applied at the subregional scale and poses substantial challenges, because it depends on the availability of appropriate funding, resources, and political will, among other factors (Mackelworth 2012). A range of factors may be associated with a country's willingness or ability to take collaborative conservation actions (Sarkar et al. 2006, McDonald and Boucher 2011). These include socioeconomic factors (e.g., gross domestic product [GDP]) and political factors, such as governance—the competency, incorruption, and accountability of public administrations (Leftwich 1993). It is recognized that international protocols and legislative agreements for biodiversity conservation can legitimize sociopolitical interests (e.g., Groves et al. 2002, Sarkar et al. 2006).

In recent decades, wide application of systematic conservation planning has been in place, with the aim of designing and implementing protected area networks on the basis of specified conservation goals (Moilanen et al. 2009, Hooper et al. 2012). However, conservation goals that are focused on preserving a target proportion of endemic or threatened biodiversity in a given area are often ambitious and costly, and the funding available for conservation is usually less than what is required (Balmford et al. 2003, 2005). Limited funds therefore need to be spent in a cost-effective and efficient manner (Moilanen et al. 2009). It is increasingly acknowledged that collaborative conservation actions can lead to improved efficiency and economic savings (e.g., Rodrigues and Gaston 2002, Wells et al. 2010). For example, Kark and colleagues (2009) found that collaboration between countries can improve conservation efficiency and can potentially allow countries to save conservation funds and to achieve more conservation targets for the same area size. In marine environments, between-country collaboration and coordination is of special importance because of factors such as currents and the natural flow of material in the oceans (e.g., nutrients, pollution), the high mobility of many marine species (both native and alien), the common use of marine resources (Hardin 1968), and the varying levels of

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marine sovereignty (e.g., territorial waters, exclusive economic zones [EEZs]; Suárez de Vivero et al. 2009).

Traditionally, systematic conservation planning has been focused on achieving biodiversity targets, such as species richness and complementarity (Margules and Pressey 2000). However, various studies have illustrated that incorporating economic costs into conservation planning can achieve substantial conservation gains in terms of the biodiversity protected (e.g., Stewart and Possingham 2005, Naidoo et al. 2006). Nonetheless, only a few conservation-planning studies have incorporated the potential for intercountry collaboration in conservation prioritization (but see Kark et al. 2009, Moilanen et al. 2012, Mazor et al. 2013). Collaboration has many benefits to conservation, including the sharing of expertise and technical capacity, as well as knowledge (e.g., Lacher et al. 2012). In addition, collaboration can reduce the overall costs of conservation actions (Kark et al. 2009) and has the potential to reduce conservation costs by lowering transaction costs (e.g., those related to negotiations), which can be substantial (Michaelowa et al. 2003). Clearly, successful implementation of conservation plans requires the incorporation of socioeconomic, political, and demographic considerations into conservation planning (McDonald and Boucher 2011). This is especially important in regions in which resources are shared by multiple countries and particularly at the international scale. A range of activities (e.g., trade and resource extraction) can have direct impacts on biodiversity beyond a single country's boundaries. Trade between countries is often considered a vector for threats to biodiversity, especially in relation to threatened species, because of, for example, habitat loss or the hunting or fishing of threatened species, such as in the shark fin trade (Clarke 2004) and the ivory trade (Lenzen et al. 2012). However, trade may also facilitate successful collaboration in conservation efforts. Countries that develop strong commercial ties among one another may have greater potential to collaborate on additional factors, including environmental issues and conservation efforts in particular (Bunnefeld et al. 2011, Fulton et al. 2011; for examples of such collaboration, see Sandwith and colleagues [2001]).

International environmental regulations and agreements are important components of international collaboration in conservation (Donald et al. 2007, Rands et al. 2010). Numerous international and regional conservation-related agreements have been signed, such as the Convention of Biological Diversity and the Convention on International Trade in Endangered Species, in an attempt to stem the tide of species extinctions and loss of ecosystems (see supplemental appendix S1, available online at *http://dx.doi.org/10.1525/bio.2013.63.7.8*). International environmental agreements are important because they set international standards; draw global attention to environmental issues; lead to national legislation on conservation matters; and direct governmental funding, legal action, and awareness into environmental issues, and they may therefore lead to better governance (Bennett and Ligthart 2001, Biermann et al. 2012). Although collaboration may have substantial benefits in advancing conservation efforts, there are numerous barriers to effective collaboration between countries in conservation efforts (Kark et al. 2009, McDonald 2009). Such barriers include, for example, political, linguistic, and cultural differences. A history of political instability or military conflict has also been shown to lead to a reduced ability to participate in collaborative conservation programs and therefore hampers the political feasibility of between-country collaboration (Didia 1997, Neumayer 2002). In addition, political will, which, in itself, is a function of societal values, is required in order to provide funding for conservation (Brechin et al. 2002). New conflicts also arise in times of increasing usage and exploitation of natural resources, including newly discovered deep-sea hydrocarbons (e.g., natural gas; see Borgerson 2008), further emphasizing the urgent need for advancing collaborative conservation in marine areas.

In the present study, we quantify the strength of collaborative potential between countries with respect to various socioeconomic and political factors and explore methods and approaches for incorporating international collaboration between countries into systematic conservation planning in marine systems, including marine protected areas (MPAs). We focus on the Mediterranean Sea as a case study. The Mediterranean Sea is a unique ecosystem, being a largely enclosed internal sea surrounded by more than 20 countries spanning three continents (Europe, Asia, and Africa), all of them sharing its natural resources. The Mediterranean Sea's rich and endemic biodiversity faces increasing threats (Bianchi and Morri 2000, Coll et al. 2012). This has led to recent calls for the creation of an effective network of MPAs in the area (de Juan et al. 2012, Giakoumi et al. 2012, Micheli et al. 2013) and for large-scale conservation planning in the sea beyond the territorial waters.

The Mediterranean Sea is unique in the fact that once all countries declare their respective EEZs, there will be no international waters within it. Currently, coastal MPAs in the Mediterranean Sea cover less than 0.5% of the coastal area (Abdulla et al. 2008). Although the European Union can influence the establishment of new MPAs (e.g., through the Natura 2000 [EU 1992] initiative), so far, the network of MPAs in the Mediterranean Sea is lacking (Giakoumi et al. 2011, 2012). According to Abdulla and colleagues (2008), there are 93 MPAs (with a median area of 26 square kilometers [km^2]) in the Mediterranean Sea, all but one within coastal territorial waters (also, in part, because most countries have yet to formally declare their EEZs). The only international MPA in the Mediterranean is the Pelagos Sanctuary (shared among Italy, France, and Monaco), which was declared in 1999 and has an area of 87,500 km^2 (Notarbartolo di Sciara et al. 2008). Italy has the largest number of MPAs (25) and the largest total area (2738 km^2), compared with all other Mediterranean countries (appendix S4). MPAs larger than 500 km^2 ($n = 6$) are found only in the waters of Italy (2 large MPAs), Greece (1), Turkey (1), Croatia (1), and France (1). Aside from two MPAs in Spain that are between 100 and

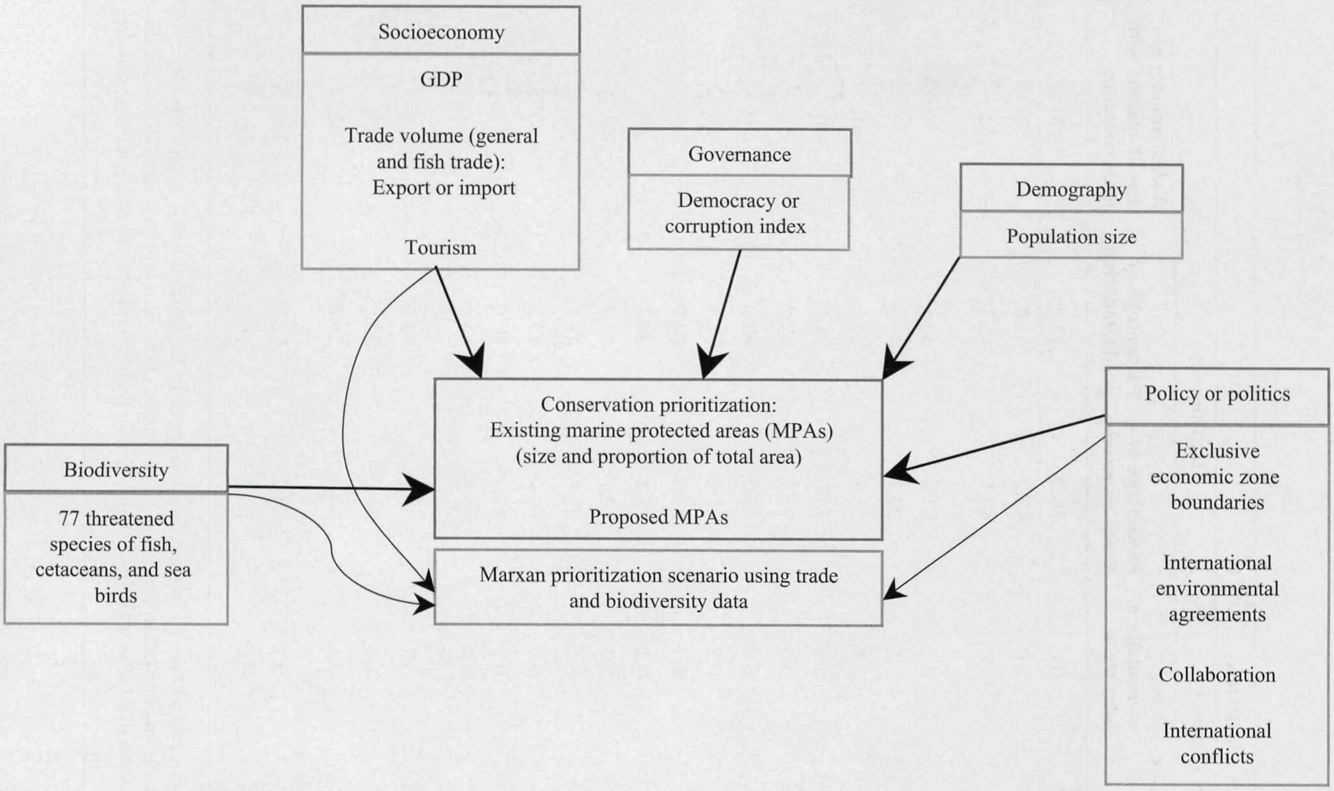


Figure 1. Schematic flowchart showing the framework and variables used in the present study. The variables used in the case study on marine protected areas (MPAs) in the Mediterranean Sea (see the "Mapping and quantifying collaboration" section) are connected with thin black lines. Abbreviation: GDP, gross domestic product.

500 km^2, all 16 other Mediterranean countries currently have only MPAs smaller than 100 km^2.

Here, we use biodiversity, demographic, socioeconomic, policy, and political characteristics of the countries bordering the Mediterranean Sea to examine the correspondence among the multiple factors with the extent of current conservation efforts, reflected by the total area and number of MPAs per country (figure 1). We present an approach for estimating the potential for collaboration between countries when taking conservation actions. Our working hypothesis is that neighboring countries with stronger commercial, social, and political ties will also be in a better position to collaborate in marine conservation efforts. Our main research questions in the present study are the following: What is the potential of economic and political factors to predict conservation efforts at the country level? How do existing economic and political collaborations between countries correspond with their collaboration in conservation? How can information about collaboration be applied in spatial conservation prioritization? Last, how does the incorporation of socioeconomic and political information affect spatial conservation-planning outcomes?

Mapping and quantifying collaboration

We collated a database of the biological, socioeconomic, and political characteristics of the countries bordering the Mediterranean Sea (shown schematically in figure 1). After analyzing the correlations between the countries' characteristics and their conservation efforts, we constructed matrices quantifying the strength of economic collaboration between all pairs of countries. Finally, we demonstrated how information about collaboration between countries can be used for spatial prioritization of conservation efforts using the Marxan conservation-planning software package.

Altogether, 23 countries (including Gibraltar and the Palestinian Authority; table 1) are located along the coast of the Mediterranean Sea. We created a binary matrix of the shared marine borders for all 23 countries that have a stretch of coast along the Mediterranean Basin (following Suárez de Vivero and Mateus 2002). We defined two countries as sharing an international boundary on the basis of their marine EEZ boundaries. Although most Mediterranean countries have not yet formally claimed or agreed on the spatial delimitation of their exact EEZ boundaries (Suárez de Vivero and Mateus 2002), for this analysis, we adapted the EEZ boundaries in the MARBOUND Marine Regions database (*www.vliz.be/vmdcdata/marbound*). We excluded Monaco from most analyses because of a lack of trade data (see below for details), which left us with 22 Mediterranean countries for the analysis. The data collected for each country included the following factors: biodiversity (the spatial distribution of *threatened* species), demography (human

Table 1. General geographic, demographic, and trade statistics for each of the Mediterranean countries.

Country	2008 population (in millions of people)	2008 GDP per capita (in dollars)	Shared borders	Total export: Absolute value (in billions of US dollars)	Total export: Providers' percentage of total trade	Total import: Absolute value (in billions of US dollars)	Total import: Users' percentage of total trade	Dependency: Percentage of goods exported	Dependency: Percentage of goods imported	Median number of shared species with other countries
Albania	3.6	4149	3	1.0	0.0	2.5	0.0	76.6[b]	53.3[b]	56[d]
Algeria	33.7	3520	5	24.2[f]	0.3	18.9[e]	0.6[f]	42.2	41.0	58[b]
Bosnia and Herzegovina	4.6	7274	3	2.3	0.0	4.9	0.0	46.1[f]	41.7	52
Croatia	4.5	8904	3[e]	5.9	0.1	9.6	0.1	51.5	33.8	57[c]
Cyprus	0.8	29,238[b]	6[b]	1.5	0.0	6.5	0.1	32.7	46.9[d]	48
Egypt	81.7[a]	3725	5[c]	11.5	0.5[f]	10.8	0.4	34.5	15.6	51
France	64.0[c]	22,223[c]	2[f]	142.3[b]	4.0[b]	145.9[a]	5.0[b]	24.5	21.1	56[d]
Gibraltar	0.03	56,425[a]	2[f]	0.1	0.0	2.8	0.0	31.1	32.0	56[d]
Greece	10.7	16,362	6[b]	10.3	0.6[e]	27.5	0.9[e]	36.5	28.8	58[b]
Israel	7.1	17,937	5[c]	10.1	0.3	8.4	0.3	11.9	11.9	49
Italy	58.1[d]	19,909[e]	12[a]	149.8[a]	8.1[a]	137.9[b]	8.3[a]	29.5	22.0	60[a]
Lebanon	3.9	4453	3[e]	0.9	0.0	5.5	0.1	26.1	28.7	48
Libya	6.1	2994	6[b]	35.6[d]	0.3	8.2	0.3	56.7[e]	45.3[e]	54[e]
Malta	0.4	20,497[d]	3[e]	3.7	0.1	4.4	0.1	22.5	43.5[f]	51
Montenegro	9.9	3620	3[e]	0.4	0.0	1.0	0.0	60.6[d]	33.2	56[d]
Morocco	34.3[f]	3465	4[d]	10.2	0.1	16.7[f]	0.5	47.4	40.0	57[c]
Palestinian Authority	4.1	2178	2[f]	0.0	0.0	0.1	0.0	90.5[a]	83.6[a]	No data
Slovenia	2.0	18,170	2[f]	9.1	0.1	11.3	0.2	35.1	33.5	53[f]
Spain	40.5[e]	19,706[f]	6[b]	92.3[c]	2.3[c]	111.8[c]	2.9[c]	35.0	26.0	58[b]
Syrian Arab Republic	19.7	8360	4[d]	4.1	0.1	4.4	0.1	43.2	24.8	45
Tunisia	10.4	6103	4[d]	12.1	0.1	13.4	0.3	64.6[c]	52.5[c]	56[d]
Turkey	75.8[b]	8066	3[e]	34.5[e]	2.2[d]	32.1[d]	1.5[d]	26.1	16.8	51

Note: The values are ranked in each column, from first to sixth (superscript a–f). The total number of *threatened* species analyzed was 77 (see supplemental appendix S2, available online at *http://dx.doi.org/10.1525/bio.2013.63.7.8*). For the export and important statistics, the *Providers* column represents the median share of imports in Mediterranean Basin countries from each exporting country (i.e., for this column, each country mentioned in the first column is an exporter, or *provider*). The *Users* column represents the median share of imports from Mediterranean Basin countries from each importing country (i.e., for this column, each country mentioned in the first column is an importer, or *user*).

population size), governance (democracy and corruption indices), economy (GDP, trade), tourism, politics (history of conflicts, international agreements), and the spatial extent of protected areas.

We used data on the occupancy of the native Mediterranean *threatened* and *near-threatened* marine vertebrate species compiled from the International Union for Conservation of Nature's (IUCN) Red List of Endangered Species (*www.iucnredlist.org/technical-documents/spatial-data*; appendix S2). These data comprised 63 fish species, 7 cetacean species, 5 seabird species, and 2 sea turtle species—altogether, 77 species (appendix S2). We overlaid the distribution ranges of each species and mapped its occupancy area within each country's Mediterranean EEZ. On the basis of these data, we derived a matrix of the number of shared species (ranging from 38 to 68) among the Mediterranean Basin countries. Our assumption here was that countries that share species may have a stronger incentive for collaboration in conservation.

To examine the existing set of MPAs in the study area, we combined information from the IUCN report by Abdulla and colleagues (2008) with country statistics of the percentage of each country's land covered by terrestrial protected areas or sea area covered by MPAs (WDPA 2010). We used terrestrial protected areas in our analysis because they may reflect a conservation-oriented tradition or conservation-related policy in that country.

To demonstrate how existing conservation plans and biodiversity-monitoring efforts are distributed within the Mediterranean Sea, we explored the following spatial layers: We digitized the map of existing and proposed MPAs for whales and dolphins in the Mediterranean and Black Seas from ACCOBAMS (the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area; *www.cetaceanhabitat.org*; Rais et al. 2006). We then evaluated the spatial distribution and extent of proposed MPAs over the EEZs of the Mediterranean Sea countries. We also mapped the location of underwater surveys conducted by Sala and colleagues (2012).

We used demographic data (human population size, from *www.ggdc.net/maddison/content.shtml*) for all of the Mediterranean countries (following Maddison 2007) for calculating the per capita values of trade and tourism factors. We used the Corruption Perceptions Index at the country level, derived from the World Resources Institute (*http://www.transparency.org/research/cpi/overview*), and the Democracy Index 2011, from the Economist Intelligence Unit (*www.eiu.com/public/topical_report.aspx?campaignid=DemocracyIndex2011*), to test whether these measures are correlated with a country's conservation efforts.

We collated data on the signatories of 27 major international agreements and policies related to conservation issues (appendix S1) and created a matrix showing the number of shared international conservation agreements between Mediterranean countries. To complement this and to represent any negative relationships between countries, we also collected information about military conflicts between the countries in the past 50 years (from 1963 onward; Themnér and Wallensteen 2011; Uppsala Conflict Data Program, *www.pcr.uu.se/research/UCDP*). This included information on the total number and duration of military conflicts among the Mediterranean countries (including conflicts between nongovernmental militia forces from one country acting against another country).

We collated the GDP statistics of all of the Mediterranean countries (from *www.ggdc.net/maddison/content.shtml*). We used the trade volume between countries to examine their economic interdependencies. We used trade statistics from Trade Map (*www.trademap.org*), which were based on statistics from the United Nations Commodity Trade Statistics Database (*http://comtrade.un.org*). We used trade data from 2008, because this was the most recent year for which trade data were available for all of the Mediterranean countries (except Monaco). Trade matrices between countries were constructed for all commodity types and for trade only in marine products (including fish, crustaceans, mollusks, aquatic invertebrates; also from Trade Map).

On the basis of these matrices, we then calculated the relative share of each country's import from and export to each other Mediterranean country, both in absolute numbers and relative to the country's total import and export. Using these data, we aimed to determine which of the Mediterranean countries are major providers of exported goods or users of imported goods. We used the import and export trade matrices to determine which countries were more dependent on other Mediterranean countries for their trade ties and to what degree they were trading with other Mediterranean countries.

We collected data on tourism from the UN World Tourism Organization (UNWTO 2013) for each Mediterranean country in the year 2010, showing the number of tourists arriving (inbound) from and departing (outbound) to each other country. We calculated both the proportion of tourists per capita and the percentage of incoming tourists from other Mediterranean countries out of the total number of incoming tourists.

Analyzing the collaboration data

To help the reader visualize the connections, we present the matrices spatially as networks and, therefore, visualize the spatial patterns of collaboration between Mediterranean countries as networks. For example, we show the trade and tourism connections depicted as lines connecting the capital cities of each country (using an equal-area Lambert projection; see Lenzen and colleagues [2012] for a similar approach). To standardize the different factors for comparison, we ranked the values in each of the matrices (of, e.g., trade, tourism, shared species, shared agreements) by their order from highest to lowest (e.g., the country that imported the most from another country was ranked first for the trade import variable). In order to summarize all the trade and tourism statistics for each country into a single composite number, we calculated the median rank of all 231 possible trade and tourism connections for each country. This resulted in a single trade score and a single tourism score for each country, representing its trade and tourism connections with each of the other countries.

We calculated monotonic relationships between the different factors at the country level, such that the demographic, economic, and political variables served as the independent variables, and the area protected for conservation (in square kilometers as well as in the percentage of a country's area) served as the dependent variable. The above relationships were calculated using Spearman's rank correlation. We also performed a hierarchical cluster analysis at the country level, using several clustering methods (average, ward, and centroid) for measuring the distance between the countries using JMP7 statistical discovery software (SAS Institute; *www.jmp.com*). This was done for the following variables: population size, GDP, protected areas (area, number, and proportion), trade, tourism, shared legislation, shared species, and democracy and corruption indices.

Spatial prioritization of protected areas. In order to demonstrate the effects of collaboration between countries on the spatial prioritization of protected areas, we used the conservation-planning software Marxan (University of Queensland; *www.uq.edu.au/marxan*). Marxan is a decision support tool for conservation planning (Moilanen et al. 2009) and finds efficient solutions to the problem of selecting a least-cost system of spatially cohesive areas that meet a suite of biodiversity targets (Possingham et al. 2000). The proportion of times a spatial planning unit is included in the selected set of protected areas (selection frequency) can be used to determine its priority (irreplaceability) for conservation and to compare different scenarios (Leslie et al. 2003). We also used Marxan (Possingham et al. 2000) to demonstrate how information about collaboration between countries can be integrated into a systematic conservation-planning tool. We used square planning units of 100 km^2, corresponding with the spatial scale and accuracy of the species distribution data and following a study in the terrestrial Mediterranean Basin (Kark et al. 2009).

Comparing collaboration scenarios. In the conservation-planning analysis, we set biodiversity targets to be 30% of the distribution area for each of the 77 threatened marine species. We then compared how these targets could be achieved using (a) a scenario with no collaboration and (b) a scenario in which collaboration between neighboring countries was incorporated. In the no-collaboration scenario, the costs of all planning units were uniform. In the full-collaboration scenario, we used the median trade rank between neighboring countries as a surrogate for cost, assuming that collaboration in trade facilitates collaboration in conservation. Therefore, a high trade ranking between a pair of countries signifies lower costs for collaboration. This resulted in a higher prioritization of planning units between country pairs that have strong trade ties than of planning units between country pairs with weaker ties. We assumed in this scenario that collaboration in conservation can occur across a shared EEZ boundary. Although additional variables may also be included, we chose to use trade both because we hypothesized that it can serve as a surrogate for the political feasibility of collaboration between countries and as a demonstration of our methodological approach (see the section entitled "The implications of between-country collaboration for conservation in the Mediterranean" below).

We used the EEZ boundaries to create a layer of Thiessen polygons (Thiessen 1911), using the ALLOCATE algorithm within Idrisi Selva geographic information system software (version 17.0; Clark Labs; *http://clarklabs.org*). Thiessen polygons define individual areas of influence around a given set of points (in our case, these sets of points are defined by the EEZ boundaries). The Thiessen polygon boundaries then define the area that is nearest to each point relative to all other points. Mathematically, they are defined by the perpendicular bisectors of the lines between each point and every other point (see supplemental figure S1). Using the Thiessen polygon layer, we allocated each 100 km^2 planning unit to its nearest EEZ boundary. We then assigned the median ranking of the trade connections of a country pair as the *cost* to all the planning units allocated to the EEZ boundary of the country pair defined by the Thiessen polygons. We ran Marxan 1000 times for each collaboration scenario, with a boundary length modifier value of 2 in both scenarios (determined using a sensitivity analysis following Ardron and colleagues [2010]). We compared the selection frequency of the planning units in the two scenarios and calculated the change in the selection frequency of the planning units when trade connections were considered.

Spatial trends in socioeconomic and political factors

We discovered a clear distinction in most of the factors tested here between the EU Mediterranean countries of Italy, France, and Spain and all other Mediterranean countries. These three countries were also three of the six most-populated Mediterranean countries (France, Italy, and Spain had a combined population of 162 million people in 2008). The three other most-populated countries were all non-EU countries: Egypt, Turkey, and Morocco, which had a combined population of 192 million people in 2008 (table 1). The six highest-ranking countries in terms of GDP (with a per capita GDP above $18,000) all belonged to the European Union and also included France, Italy, and Spain (table 1). Of the 22 Mediterranean countries examined, Italy had by far the highest number of shared EEZ borders with other Mediterranean countries (sharing boundaries with 12 other countries because of its central location; figure 2), followed by Spain, Cyprus, and Libya (which had five shared EEZ borders each; table 1).

The countries that had signed the largest number of international conservation agreements included Italy (23 agreements), France (21), Spain (20), and Morocco (20),

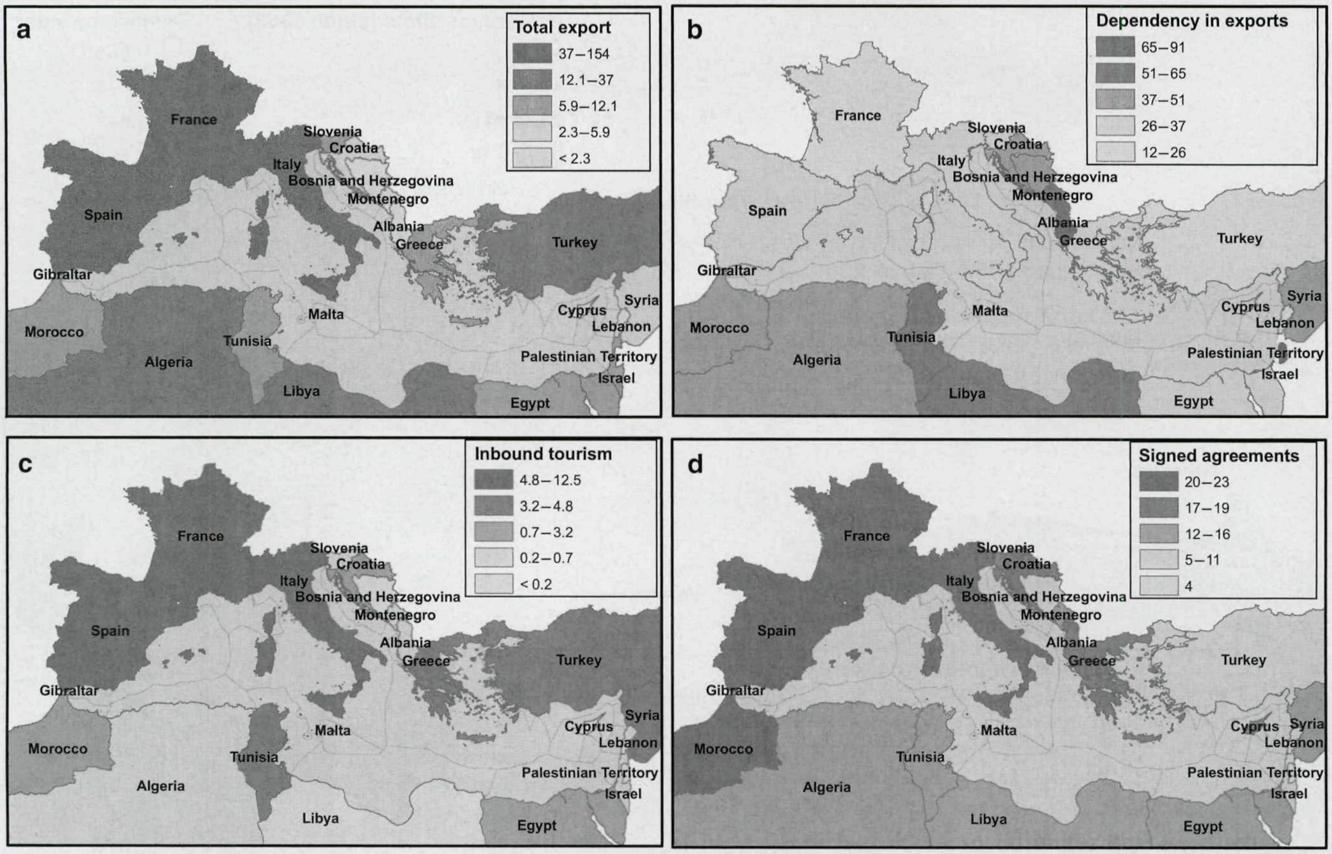


Figure 2. The distribution of the major socioeconomic and political factors at the country level. (a) Total export to other Mediterranean countries (in billions of US dollars). (b) Dependency in exports calculated as the percentage of total exports sent to other Mediterranean countries. (c) Inbound tourism from other Mediterranean countries (in millions of people). (d) The number of signed international agreements related to conservation and environmental issues. Only Mediterranean countries are shown on these maps.

and those with the fewest signed agreements were Bosnia and Herzogovina (9) and the Palestinian Authority (4) (figure 2d). Overall, on the basis of the 2011 Democracy Index, northern Mediterranean Sea countries were more democratic than those in the eastern and southern Mediterranean (figure 3).

In terms of the volume of trade with other Mediterranean countries, Italy, France, and Spain were again the top three Mediterranean countries in both their total import and total export volumes (table 1, figure 2a). When we calculated the proportion of trade between each country and the other Mediterranean Basin countries by their total trade volume (with all other countries), Italy was the leading exporter to other Mediterranean countries and provided the greatest proportion (8.1%, median value, of their total imports worldwide) of exports to other Mediterranean Basin countries and imported 8.3% (median value) of its total imports from other Mediterranean Basin countries (table 1, appendix S3). The major importer and exporter countries after Italy were France, Spain, and Turkey (table 1). When we examined the trade of marine products alone (e.g., fish), we found that Italy provided the greatest proportion of marine exports to other Mediterranean Basin countries (13.1%, median value), followed by Spain (4.9%, median value). Israel (0.3%, median value) and the Palestinian Authority (less than 0.1%, median value) had the weakest trade ties with other Mediterranean countries (table 1, appendix S3). The average share of a country in import (or export) with other Mediterranean countries was positively correlated both with the total value of its own import (or export; $r = .87$, $p < .001$) and with the number of its shared boundaries ($r = .64$, $p < .01$).

France, Spain, and Italy had the highest number of inbound tourists from other Mediterranean Basin countries (12.4 million, 11.8 million, and 9.3 million, respectively) and outbound tourists (19.8 million, 9.1 million, and 15.7 million, respectively, in 2010) to other Mediterranean Basin countries (figure 2c).

The factors most strongly and significantly correlated with the percentage of terrestrial area set aside as protected area included the democracy index ($r = .73$, $p < .001$), the per capita GDP ($r = .54$, $p < .01$), and the number of inbound

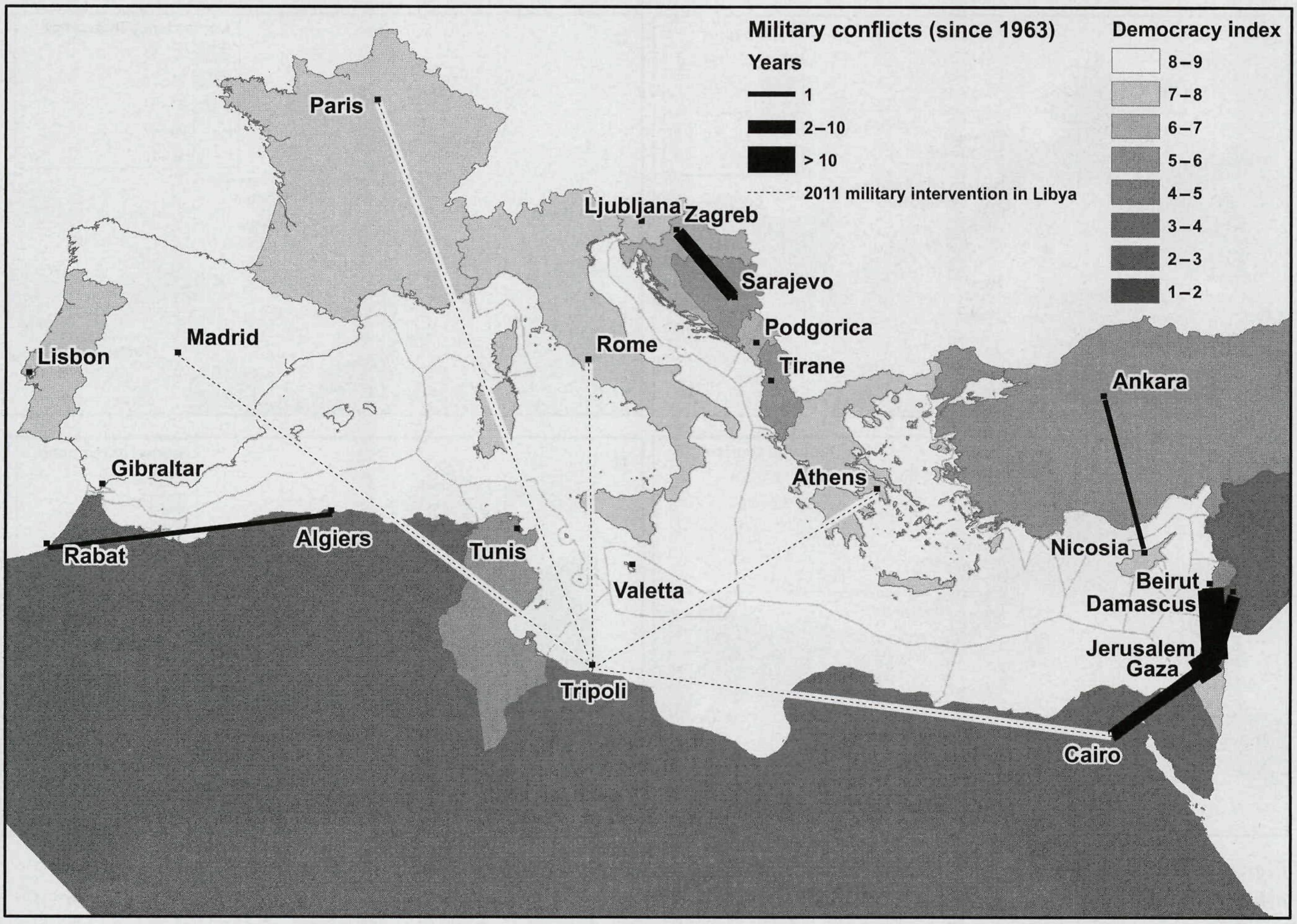


Figure 3. The number in years of military conflicts between the different Mediterranean countries since 1963, based on Themnér and Wallensteen (2011) and the democracy index of the Mediterranean countries (based on the Economist Intelligence Unit's Democracy Index 2011; see the "Mapping and quantifying collaboration" section). The dashed lines show the North Atlantic Treaty Organization intervention in Libya during 2011.

tourists per capita originating from other Mediterranean countries ($r = .52$, $p < .05$; table 2). The variables that were most strongly correlated with the percentage of marine area set aside as MPAs (within the territorial waters) and with the total area of MPAs within a country's EEZ included the total number of inbound tourists (r_s = .59 and .73, respectively), the total exports of marine products to other Mediterranean countries (r_s = .45 and .78, respectively), and the total imports from other Mediterranean countries (r_s = .53 and .75, respectively; table 2).

A significant positive correlation was found between the size of the MPAs per country and the number of international conservation agreements to which a country was a signatory ($r = .48$, $p < .05$; table 2). The distinction between Mediterranean countries in their economic, political, and demographic variables was confirmed by a cluster analysis performed at the country level (supplemental figure S2). In all three dendrograms, Italy, Spain, and France were always separate from the other Mediterranean countries, regardless of the clustering method used (figure S2).

Socioeconomic and political connections between countries

In all of the factors that we analyzed, the strongest socioeconomic and political ties between countries were found in the northwestern part of the Mediterranean Basin, with the triangle of the strongest ties among Italy, France, and Spain appearing in the networks of trade and tourism, as well as in their shared species and shared international agreements (figure 4). More specifically, the connection between Italy and France was always ranked either first or second out of all of the 231 possible connections between Mediterranean countries for the following four variables: total import, total export, inbound and outbound tourism, and the number of shared agreements. In general, the connections were stronger among European Mediterranean countries than among non-European Mediterranean countries. The least connected countries were located in the southeastern region of the Mediterranean Basin. The eastern Mediterranean region had the highest number of military conflicts between Mediterranean countries in the past 50 years (figure 3).

Table 2. Socioeconomic and political variables correlated with the percentage of a country's total area that is set aside as terrestrial and marine protected areas (Spearman's rank correlation coefficient), the absolute area of marine protected areas in that country, and the number of conservation agreements signed by that country.

	Percentage of a country as terrestrial protected areas	Percentage of a country as marine protected areas	Absolute area of marine protected areas	Number of signed international conservation agreements
Gross domestic product per capita	.54	.34	.33	.42
Democracy index	**.73**	.48	.24	.48
Median percentage of imports from Mediterranean Sea countries	.19	.53	**.75**	.53
Total exports of marine products to Mediterranean Sea countries	.04	.45	**.78**	.64
Number of signed international environmental agreements	.41	.33	.48	–
Number of inbound tourists per capita	.52	.42	.45	.64
Total inbound tourism	.03	.59	**.73**	.60

Note: Correlations greater than .7 are shown in bold.

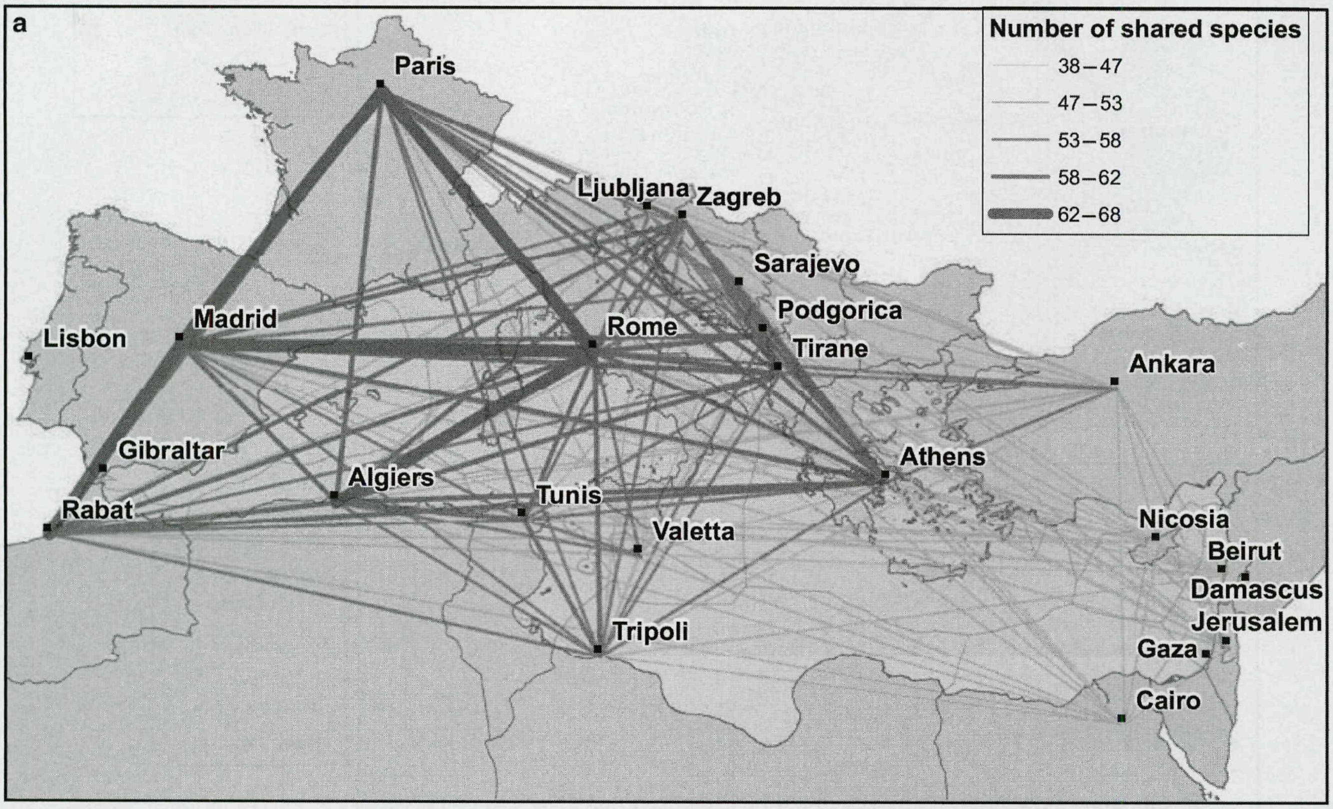


Figure 4. The spatial patterns of socioeconomic and political interactions between each pair of Mediterranean countries presented as a network. Between-country connections are depicted as lines linking the countries, and the line width represents the strength of the relationship. (a) The number of shared species between each pair of Mediterranean countries, calculated from the 77 threatened vertebrate species included in the study. (b) The median rank of all the variables used to calculate trade connections between Mediterranean countries. (c) The median rank of all the variables used to calculate tourism (inbound and outbound) connections between Mediterranean countries. (d) The number of shared international environmental agreements between country pairs. Low values represent a high ranking in (b) and (c).

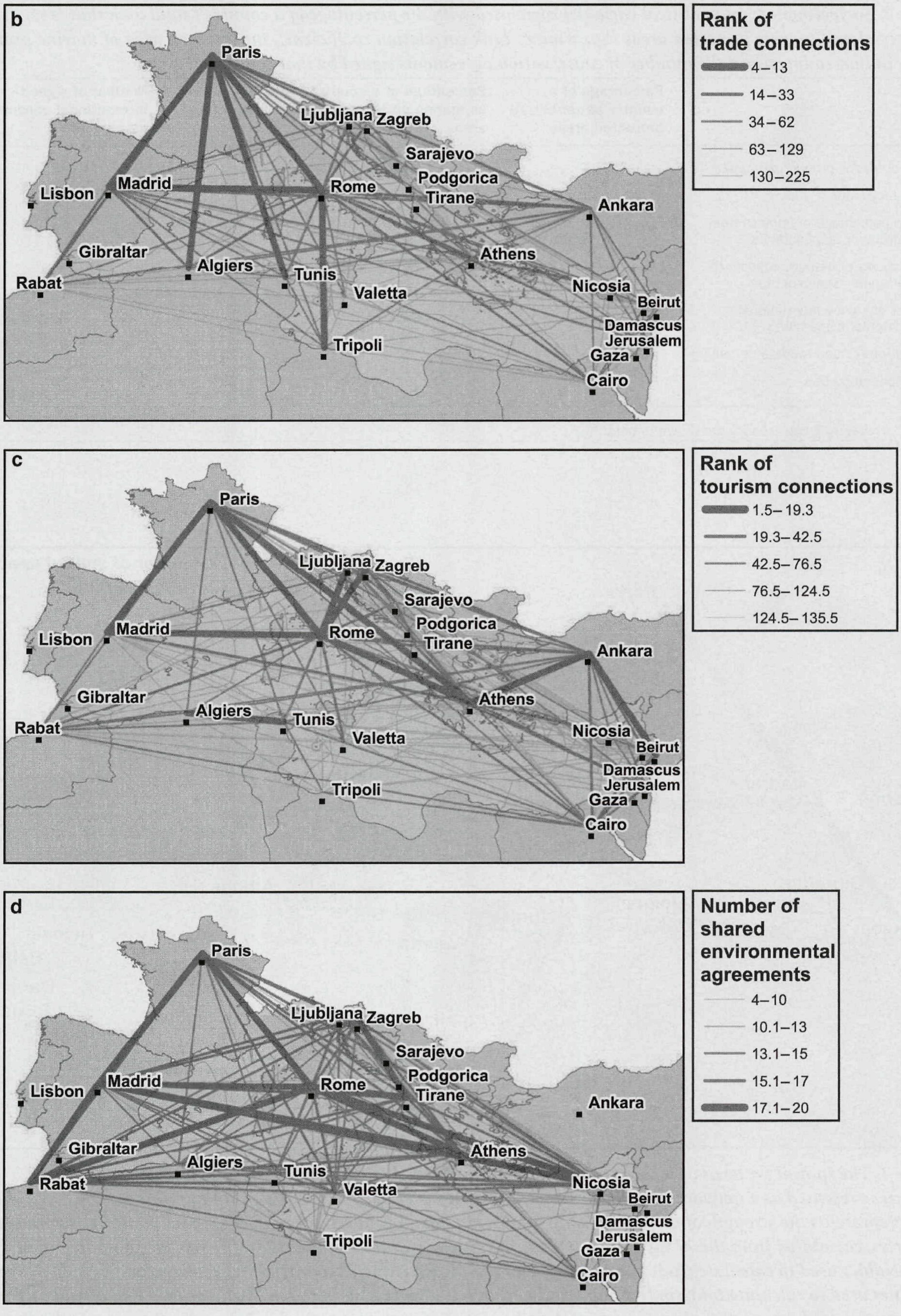


Figure 4. (Continued)

Interestingly, the geographical distance between pairs of Mediterranean countries was not significant in explaining their between-country trade or tourism connections.

Conservation prioritization outcomes when collaboration is considered

When uniform costs were used in the Marxan scenario of no collaboration among Mediterranean countries, the spatial pattern of the resulting selection frequency was driven by biodiversity patterns of the threatened species and species spatial aggregation, showing higher selection frequency (the number of times each grid cell is selected in the 1000 Marxan runs) and therefore higher conservation priority near the coast (figure 5b). However, there was no clear difference in selection frequency of the northern, southern, eastern, and western parts of the Mediterranean Sea.

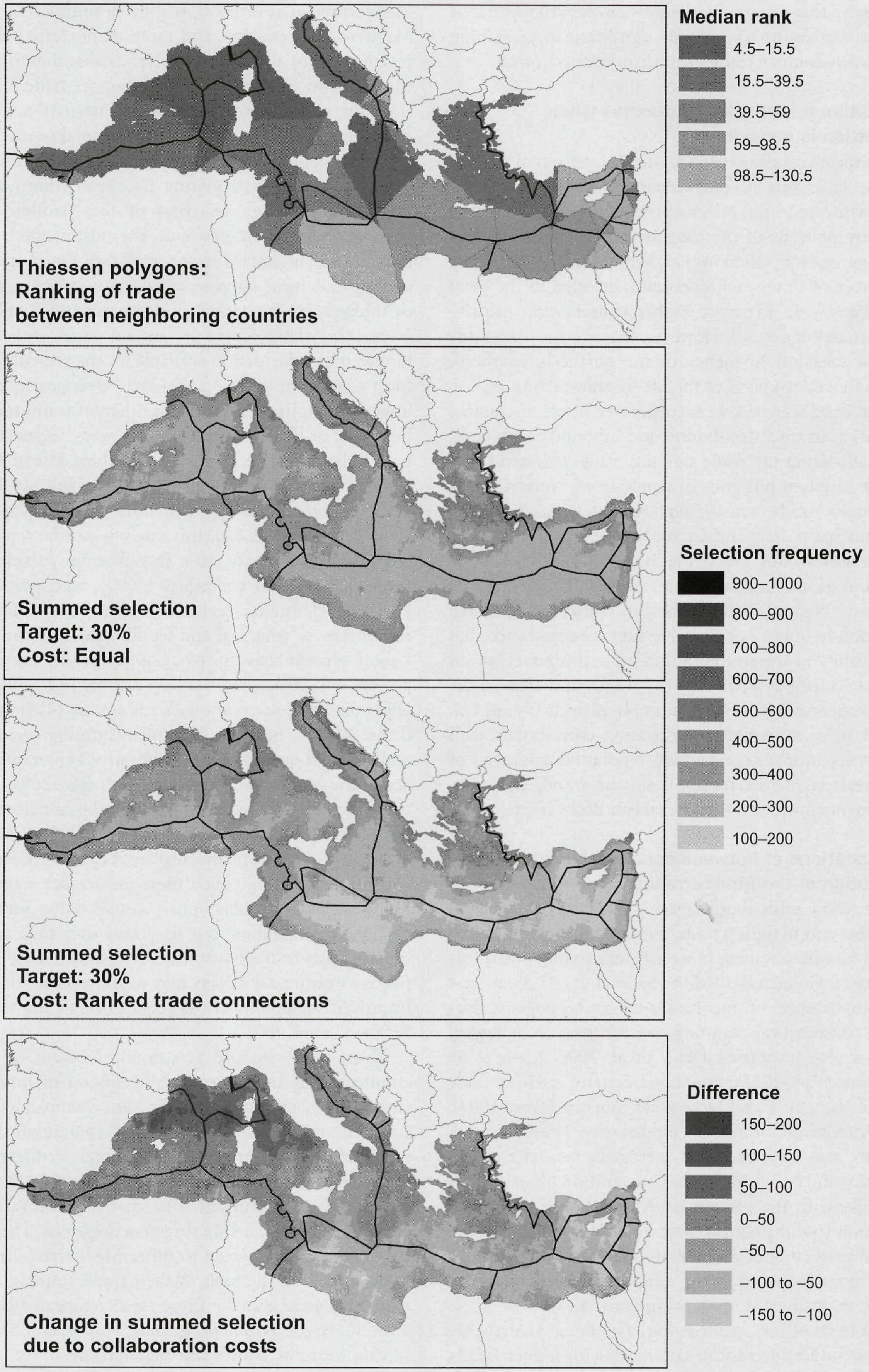
In the second scenario, we incorporated between-country collaboration in trade (outbound and inbound combined), spatially allocating the trade ranking using Thiessen polygons. The Thiessen polygons of neighboring countries that had strongest trade connections (e.g., Italy and France, France and Spain, Italy and Greece) are shown in figure 5a. When we used in our Marxan runs the median ranking of trade connections as a surrogate for higher feasibility of collaborative conservation efforts (low conservation costs), the selection frequency of planning units changed such that planning units in the southern and eastern Mediterranean Sea were selected less frequently (figure 5c) and areas in the northwestern area were selected more frequently (figure 5d). This shift in conservation prioritization corresponds with the difference in trade connections among the countries of the southeastern Mediterranean Basin and among the countries of the northwestern Mediterranean Basin (figure 5a).

The implications of between-country collaboration for conservation in the Mediterranean

In recent years, with the increasing availability of spatial quantitative and mapping tools, conservation planning has advanced rapidly, allowing more efficient spatial prioritization at large regional scales (Moilanen et al. 2009). Awareness of the importance of incorporating anthropogenic factors into conservation planning—in addition to biological factors—is also increasing (Kark et al. 2009, Klein et al. 2010, Bryan et al. 2011). Economic activity, such as trade (Lenzen et al. 2012) and large-scale tourism (Gray 1997), is often viewed as a threat to biodiversity. However, such factors can also serve as useful surrogates for determining where successful collaboration in conservation interventions is more likely. In the present study, we showed how such socioeconomic and political factors could potentially serve as helpful predictors of conservation efforts at the country scale and provided an example of how they can be incorporated into the conservation-planning process.

On the basis of our socioeconomic–political analysis, we found that in Mediterranean countries with higher GDPs, a larger volume of outgoing and ingoing trade (with other Mediterranean countries), a greater number of incoming Mediterranean tourists, and more-democratic political systems tended to allocate more terrestrial and marine area for conservation (i.e., in protected areas; see table 2) and were signatories to a larger number of international conservation agreements. We also found that collaborative potential (evident in a wide range of socioeconomic and political factors) was strongest among European countries situated along the northwestern coast of the Mediterranean Sea (figures 4 and 5). Interestingly, the northwestern countries also shared the largest number of threatened species, suggesting that these countries may have strong potential for defining common conservation targets and for collaborating in reaching them. There are several issues with the IUCN biodiversity information available for the present study, with most significant biases in the data being potentially due to unequal sampling efforts across different taxonomic groups, locations, or times and the use of species ranges rather than probabilities of occurrence. We used these data in the current study because of their availability at the full Mediterranean Sea scale, but as better information about species distributions becomes available, this analysis can be repeated with improved biodiversity data. Our findings correspond with those of Kark and colleagues (2009), who pointed to the European Union as a region in which conservation collaboration may be practical and feasible. Because the European Union already has in place a range of environmental agreements, efforts, and collaborations (e.g., EU 1992; see appendix S1), conservation efforts among EU countries may be an effective first step toward integrating socioeconomic and political factors into collaborative conservation efforts across the Mediterranean Basin (Kark et al. 2009). However, more area may be required to reach the same conservation targets if conservation is focused only on EU countries (Kark et al. 2009). Therefore, the next steps could involve countries and regions among which there are weaker economic and political ties, and collaborative conservation may be more challenging to initiate but may lead over time to effective impacts. Interestingly, it has been shown that collaborative environmental efforts may also, in some cases, lead to improved sociopolitical ties (e.g., through peace parks; see Sandwith et al. 2001).

Clearly, the size and geographic location of particular countries may influence their likelihood of implementing successful collaborative activities. For example, Italy, Greece, Libya, and Spain have the largest (potential) EEZ areas in the Mediterranean (65% of the total Mediterranean Sea marine area; supplemental appendix S4) and, therefore, will probably have important roles in the conservation of the sea's biodiversity and its threatened species. The countries most strongly connected to other Mediterranean countries (determined on the basis of their trade, tourism, and other variables) were also the three Mediterranean EU countries with the largest populations: Italy, France, and Spain. Italy's central location within the Mediterranean Sea appears to play a major role in determining its strong economic ties


a
Thiessen polygons:
Ranking of trade
between neighboring countries
Median rank
4.5–15.5
15.5–39.5
39.5–59
59–98.5
98.5–130.5
b
Summed selection
Target: 30%
Cost: Equal
Selection frequency
900–1000
800–900
700–800
600–700
500–600
400–500
300–400
200–300
100–200
c
Summed selection
Target: 30%
Cost: Ranked trade connections
d
Change in summed selection
due to collaboration costs
Difference
150–200
100–150
50–100
0–50
–50–0
–100 to –50
–150 to –100

with other Mediterranean countries and also played an important role historically with the expansion of the Roman Empire 2000 years ago. Italy emerged in our analysis as a pivotal Mediterranean country, being a key importer from and exporter to other Mediterranean countries. Italy also has the highest number of shared marine boundaries with other Mediterranean countries—more than double the number of any other Mediterranean country. In addition, Italy has the largest-size EEZ (covering 21.3% of the whole Mediterranean Sea) and the largest number of threatened marine species shared with other Mediterranean countries (a median of 60; table 1). In contrast, some countries were found to be relatively isolated from other Mediterranean countries, with relatively weak economic ties to other Mediterranean countries (e.g., Israel). When evaluating the potential for collaboration between stakeholders, especially between nations, we also need to take into account historical and political factors such as governance instabilities and changing economic situations and crises. Given the history of armed conflicts between countries in the southeastern Mediterranean, new developments such as the recent findings of natural gas and oil in the deep sea will pose new challenges for marine conservation in the southeastern Mediterranean (Shaffer 2011, Khadduri 2012).

A unique example of potential Mediterranean collaboration in conservation is that of the only international MPA in the Mediterranean Basin, the Pelagos Sanctuary (Notarbartolo di Sciara et al. 2008; figure 6). Three other cross-boundary MPAs for marine mammals have been proposed by ACCOBAMS (see figure 6), which, if they are approved, will be shared among Spain, Morocco, and Algeria; between Italy and Malta; and between Greece and Turkey (Rais et al. 2006), all involving at least one country from the northern part of the Mediterranean Sea (figure 6). Collaboration to achieve conservation benefits already exists between some Mediterranean countries. An example for collaborative research is the set of marine surveys by Sala and colleagues (2012), which were conducted in the four countries with the most sites in the northern Mediterranean Sea: Spain (59 survey sites), Italy (52), Greece (30), and Morocco (6) (figure 6).

A clear link between the state and history of peace within a country and between countries and factors such as governance, economics, environmental awareness, and conservation has been demonstrated both in earlier studies (e.g., Neumayer 2002) and here (table 2). Democracy and a higher income were found to be favorable for promoting internal peace in various countries (Collier and Rohner 2008). It is also known that democratization reduces the risk of war (Gleditsch and Ward 2000). Trade has also been shown to promote peace between countries, because of the negative costs associated with violence that might deter countries from engaging in war (Hegre et al. 2010). These trends reinforce our suggestion that trade connections and the level of democracy can be used as surrogates for the potential success in conservation collaboration. Previous studies have mostly emphasized the negative impacts of economic activity on biodiversity, such as the increased density of invasive plants with trade imports in the Mediterranean (Vilà and Pujadas 2001) and the high risk of biological invasions resulting from the complex global network of cargo ship routes (Drake and Lodge 2004, Molnar et al. 2008, Kaluza et al. 2010). However, in our view, strong trade relations may also facilitate collaboration in other fields that may benefit conservation. In addition, trade may drive better environmental outcomes through multinational enterprises—for example, when multinational firms implement advanced environmental standards in developing countries (Rondinelli and Berry 2000). A lack of prior knowledge and the disregard of socioeconomic and political factors may be the cause of some conservation failures (Brechin et al. 2002, Bunnefeld et al. 2011, Fulton et al. 2011). Theory and tools are currently being developed to help better balance socioeconomic and conservation trade-offs in spatial conservation planning (Klein et al. 2010).

The proxies used here for predicting collaborative potential in conservation provide information that planners and decisionmakers can incorporate to account for political feasibility when setting up international marine conservation projects. Most previous studies have not accounted for this in the prioritization of conservation actions. In the example presented here, we showed how trade can be incorporated into a systematic conservation site selection tool as a surrogate of collaborative potential. In our analysis, using Marxan, we changed the selection likelihood of planning units by increasing or decreasing their cost, using the trade variable as a surrogate for the level of collaboration. We assumed that collaboration in conservation would be easier (i.e., the cost would be lower) between countries that also collaborate in other realms. Our collaboration scenario showed how the selection frequency for marine conservation shifts from the southern and eastern parts of the Mediterranean toward the northern and western parts of the Mediterranean

Figure 5. Results of the two Marxan prioritization scenarios aiming to conserve 30% of the occupancy area of 77 threatened species in the Mediterranean Sea while either ignoring collaborative potential or including it as a cost (see the "Mapping and quantifying collaboration" section). (a) Thiessen polygons dividing the Mediterranean Basin area, based on the nearest exclusive economic zone boundary (shown in thick black lines). Planning units within each Thiessen polygon were assigned a cost on the basis of the median value of the ranked trade variables between each pair of neighboring countries. (b) The selection frequency of planning units when no costs are included. (c) The selection frequency of planning units when costs were based on trade connections between countries. (d) The difference in the selection frequency between the two collaboration scenarios.

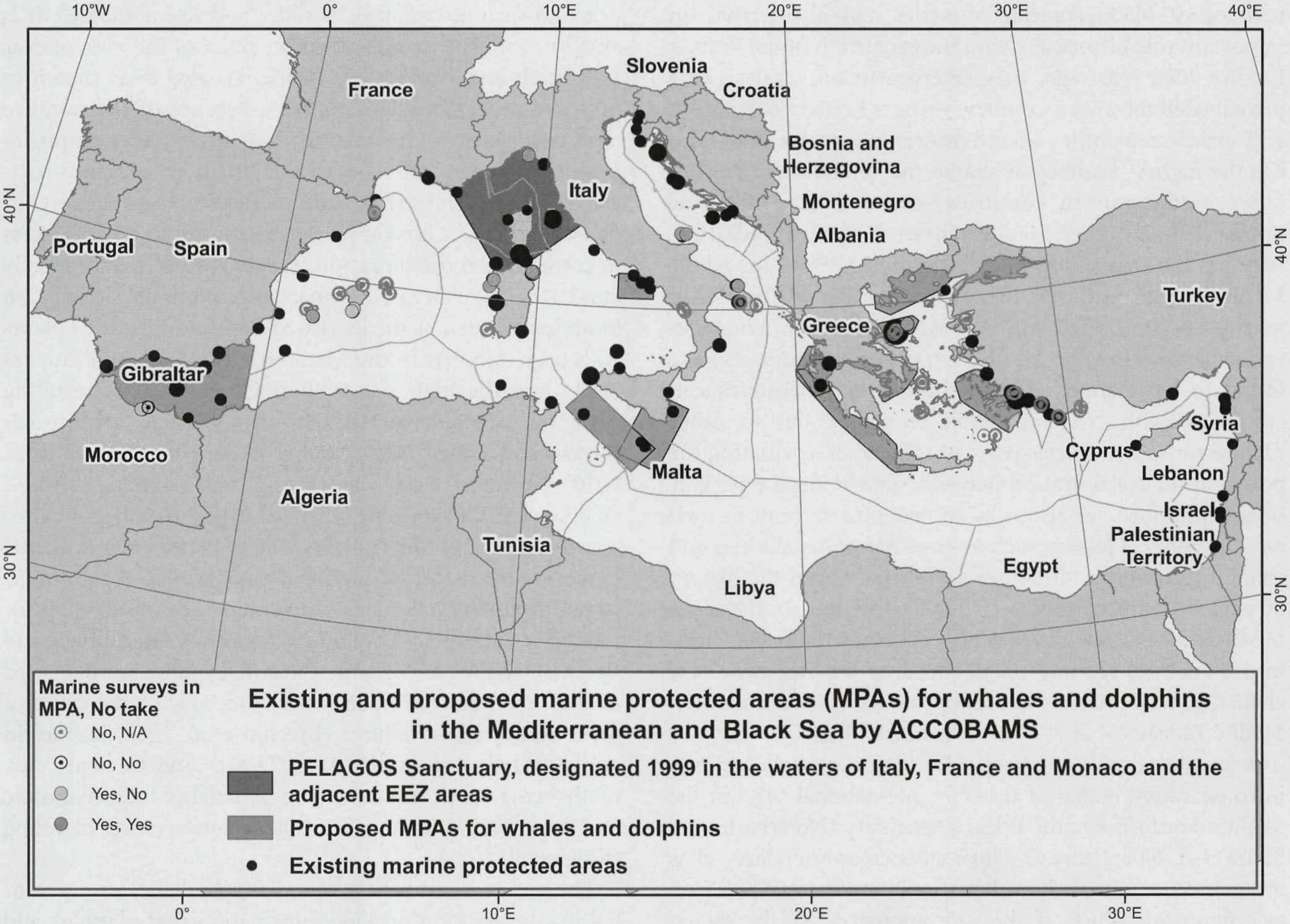


Figure 6. Current and proposed marine conservation activities in the Mediterranean Sea. The lines in the sea depict exclusive economic zones. Existing marine protected areas (from Abdulla et al. 2008) are shown with dots. The polygons show existing (the dark gray in the legend) and proposed (the lighter gray in the legend) large protected areas for marine mammals. The locations in which marine surveys were conducted by Sala and colleagues (2012) are shown with four different point symbols based on the level of protection of the site. No take *refers to no-take marine protected areas.*

(figure 5d) when proxies for collaboration were taken into account. This spatial bias in current conservation efforts in the Mediterranean Sea is also reflected by the present spatial distribution of proposed conservation areas across the region (figure 6; Abdulla et al. 2008).

Conclusions

Transboundary conservation programs are increasing globally in both the terrestrial (Halpern et al. 2005) and marine (Mackelworth et al. 2012) realms, and new approaches are required for estimating the potential for collaboration success between stakeholders when taking conservation action. We have demonstrated one approach at a multinational level, and similar analyses accounting for different aspects of uncertainty and socioeconomic information are possible at smaller scales—for example, using bioeconomic modeling (Stewart and Possingham 2005), applying more complex models predicting probability of collaboration success, and including the growing literature on opportunity costs in conservation planning (Adams et al. 2011). The example of marine conservation in the Mediterranean Sea presented here can be used as a framework for incorporating a range of socioeconomic factors into conservation planning in other complex regions. Unraveling these socioeconomic factors into meaningful collaborative ties for conservation can help facilitate successful international collaboration and can ultimately help achieve more cost-effective conservation outcomes.

In the conservation-planning case study analyzed here, we used trade as our surrogate for collaborative potential between countries. Additional factors worth exploring in future studies include countries that are not immediate neighbors and how decisions might change using other proxies that might reduce the estimated costs of collaboration in conservation. These other proxies include tourism, shared international agreements, or the history of conflicts between countries. The cost of conservation could also be adjusted in accordance with the difficulty of implementing conservation actions—for example, the willingness of an actor (in the present study, a country) to take an environmental action (e.g., Knight et al. 2010). Proxies such as the degree of democracy and governance or the percentage of a country set aside for terrestrial protected areas might be useful for assessing this, although the causal link between effectiveness of environmental actions and governance has not yet been clearly demonstrated (Bäckstrand 2006). Finally, costs can be modeled using weighted distance functions (Levin et al. 2007), which are inversely related to the distance from the coastline (assuming that negative impacts of terrestrial activity on marine systems mostly originate from the coast).

In summary, in the present study, we present a framework for integrating collaborative potential into systematic conservation planning. Our analysis shows that taking surrogates for collaborative potential into account can alter our spatial priorities. Within the Mediterranean Sea, where collaboration between countries is essential for protecting its unique biodiversity, the approach proposed here can help identify areas in which future transboundary MPAs and collaborative initiatives for marine conservation may be more likely to succeed (or less costly). The approach can also be a guideline for international nongovernmental organizations (NGOs) to determine where their funding allocations may be more successful. Alternatively, these results can be used to indicate areas in which extra resources and time are required to facilitate collaborative conservation planning and management.

Existing sociopolitical and economic ties between northwestern European countries may enhance the potential of future conservation efforts among these countries. Because, as was discussed above, the European Union already has in place many of the institutions required for building these collaborations, concrete actions might be put into place in the very near future without much outside international facilitation. Other parts of the Mediterranean Basin may require more international support (e.g., of international conservation NGOs) in order to facilitate potential collaborative conservation efforts. One of the first steps that should be taken in order to advance cross-boundary conservation planning and the establishment of large cross-boundary MPAs in the Mediterranean would be the mutual agreement between countries of their EEZs. The framework developed in the present study for the Mediterranean Sea can be further applied to other complex marine and terrestrial regions in which multiple countries share ecosystems, conservation targets, and other environmental resources, such as in the Coral Triangle, the Caribbean Sea, and the Black Sea.

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