Territorializing the sea: equilibrium, seaward projection, and seaward exposure of world countries

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According to the International Court of Justice, "the land rules the sea". This legal principle reflects a more general conceptual asymmetry: concepts to describe marine entities are molded on land–based concepts. In this paper we consider the notion of Exclusive Economic Zones (EEZ), and we carry to the extreme consequences the idea that EEZs are full–blown territories. We define several indexes based on a territorial reading of EEZ (land–sea *Equilibrium*, *Marine Population Density*, marine *Projection* and marine *Exposure*) to investigate different imbalances between world countries. The main results are that these imbalances, whenever present, are due to a complex of historical contingencies, geographic contingencies, and the features of the basic algorithm for calculating EEZs' shapes and extents. These factors bring about the fact that the imbalances under study do not in general track existing power imbalances.

1. The territorialization of the sea

Land and sea are in opposition and in balance, conceptually and geographically. From Ptolemy to Mercator to Darlymple, it was argued that there should be a southern continent to re–balance the relationship between land and sea between the hemispheres. The physical characteristics of the land are dual to those of the sea (Casati, 2022): the seascape is the mirror image of the terrestrial landscape – unstable, without shelter from wind and sun, filled with an undrinkable liquid, devoid of navigational landmarks; as Grotius noted (a point relevant to our topic), its liquidity means that no boundaries can be physically drawn in the sea. The cartography of the sea is different from that of the land; the seabed at present and for the most part mapped at a very weak resolution, so that elements smaller than 5 km are not visible. The inhabitants of the sea have always been considered aliens, in art and literature. Sea space itself is not only as hostile as a desert can be, but it is an alien space, conceptually more distant from that of Earth than that of a planet like Mars. There are no "sea people": even if it is heavily colonized, the ocean is uninhabitable. Some marine areas, such as the mesopelagic zone, have only recently, and partially, been explored (Widder, 2021). We depend on the sea in many ways. Without the ocean, the planet would be overheated and uninhabitable (and the ocean has absorbed most of the anthropogenic warming and carbon), there would be no life on land, the atmosphere would not be breathable, and the food chain would not have its base (Speich, 2019), (Falkowski, 2012). The sea–land duality also has physical aspects. The coastline changes as the water level rises or falls. The melting of land ice on the one hand increases the volume of water, on the other hand, it releases continental masses which, as they rise, cause other masses to submerge, thus threatening coastal communities (Labeyrie, 2015).

The complexity and radical otherness of the marine space constitute a challenge for *nomos*, to the point of configuring paradoxical tensions. On the one hand, it quickly became apparent that what is true for the land is not true for the sea; the negotiations that are enacted to resolve land issues are not directly translatable into the resolution of sea issues, precisely because of the radical difference of the environment and the way in which humans can intervene on it; in particular, the sea itself does not and cannot preserve traces (delimitations, transformations) of the outcome of these negotiations in the form of *physical boundaries*. On the other hand, "terrestrial concepts" have a very strong inertia and seem to be the only resource available to deal with marine issues, or at least they are our first recourse, with which subsequent negotiations have to deal. The tension, which emerged overbearingly in the European colonial era, is particularly evident in the use of territorial notions for sea management ("sea management" here encompasses the regulation of a range of activities involving the sea, from navigation to fishing, from recreation to use as a dumping ground, to coastal care, to warfare, to sea rescue, to environmental protection). (Steinberg, 2001) showed how some major conceptualizations of the sea were explored in the wake of the disputes over ownership of the sea that centered ont the Treaty of Tordesillas (1494) – the drawing of a meridian line in the Atlantic to divide Portuguese and Spanish zones of influence – and the conflict of influence between the Netherlands and Portugal in the East Indies. In *Mare Liberum* (1608) Grotius, expressing the position of the Dutch East India Company, rejects the possibility of enclosing the sea within a territorialist framework, on the basis of two arguments: firstly, territorial boundaries are not traceable/permanent on the water (insufficiency of territorialization) and, secondly, the sea is inexhaustible, so that whoever draws on its resources does not harm others (non–—necessity of territorialization). territorialization would therefore be both technically unfeasible and useless. territorializt answers came from two authors belonging to maritime powers in conflict with the Low Countries, the Portuguese Serafim de Freitas (1625: *De iusto imperio lusitanorum asiatico*) and the English John Selden (1617, 1635: *Mare clausum*). Both are opposed to Grotius, but while the former defends the possibility of limited control over some (mainly) coastal waters, the latter is an advocate of a genuine territorialization of the sea, in parallel with the establishment of land *enclosures*. Selden's arguments are interesting and foreshadow the contemporary situation. *Contra* Grotius, the tracing of borders would not be an insurmountable obstacle. It is true that one cannot leave traces in the sea, but with the advent of precision cartographic instruments it will be possible to determine, for a given point in the sea, whether this point belongs to one or the other maritime power, provided that it has been established, on a map, to whom this point belongs in the abstract. The territorialization of the sea then shifts towards the *representation of* this very same territorialization; the representation grounds and justifies the territorialization. It is the *lines* drawn on maps (Smith, 1995), and not those in the environment, that create *textual precedents*. Reference to text, however, relies on *verification*, which depends in turn on the development of technologies to determine ones' position (Giudici, 2016) (Sobel, 2013). Equally dependent on technology is Selden's second counter–argument: the sea *appears* inexhaustible to us, but the development of fishing techniques will undo this illusion. (And technology is also part of the equation with regard to the delimitation of "sea territories"; for a long time the extent of territorial waters was defined by the range of coastal guns.)

As has been repeatedly noted (Steinberg, 2001), (Steinberg, 2017), (Armstrong, 2022), the two opposing philosophies conceptually preside over the current status of the sea. We can put forward a true territorial paradox of the sea. Given its spatial nature, it comes natural to conceive of the ocean as a territory (territorial bias). But as a territory, the sea is recalcitrant to human management (intervention, colonization, control). Selden proposes to fully accept the territorialization of the sea, and then calls for the development of technologies that make it viable. But other avenues are possible, in particular one can work on the first horn of the dilemma and *deconstruct* the territorial bias (reinforced precisely by the pervasive use of maps), or work on the second horn and renounce purely *spatial* management, seeking alternatives to the latter. Historically, Selden won (though the tension with the need for freedom of navigation remained unresolved). President Truman's unilateral proclamation in 1947, by which the United States claimed rights to the continental shelf far beyond territorial waters (Truman, 1947), triggered a geopolitical and legal chain reaction of similar claims by other states, leading to the opening in 1973 of international negotiating rounds that resulted in 1982 in the United Nations Convention on the Law of the Sea (United Nations, 1982). UNCLOS entered into force in 1994 and its main achievement, for the purposes of the present argument, is the creation of an Exclusive Economic Zone (EEZ) status, defined in Part V, Articles 55–75, which paved the way for completing the tendency to the territorialization of the sea that began with the colonial era (Kwiatkowska, 1989), (Rothwell et al., 2017). Although the status of full–blown marine *territories* is only to be attributed to territorial waters up to 12 nautical miles from the coast, the powers of states over Exclusive Economic Zones, which extend up to two hundred nautical miles (=370.4 km) from the baseline for calculating territorial waters (United Nations, 2000), increasingly push for these areas to be considered territories. Indeed, while EEZs are not territories per se, they are typically the subject of territorial disputes, as evidenced, for example, by the Turkish rhetoric of the 'blue homeland', which would redraw the boundary of the Turkish EEZ in the middle of the Aegean Sea (Turkey did not sign the UNCLOS treaty precisely because of the perceived territorial disadvantage) or by the Chinese claims on the South China Sea.

In the wake of this watery conceptual extension of the notion of territory, the maps of the world we should consult will not be just land maps; sea boundaries may be impossible to draw in the sea, but on paper they are sharp and clear and catalyze immense issues of power, wealth, management and strategic control (Fig. 1.1).

Fig. 1.1 Spatial map of the world, 2013 By Rafi Segal and Yonatan Cohen. The map is a work in progress and should not be understood as supporting territorial claims or as a tool to settle disputes. It offers a glimpse of what the geopolitical world looks like if one abstracts from the difference between land and sea territories. The land/sea asymmetries are preserved in the jagged shape of purely terrestrial borders, the alignment of coastal cities, and the almost perfect round territories generated by small "isolated islands". Note the "disappearance" of the Mediterranean. 2/3 of the oceans are outside territorial jurisdiction.

2. The sea as territory

In the present study we deal with the *territorial interpretation* of *EEZs*, in order to highlight the points of balance and imbalance in the territorial distribution on a planetary scale. The research cluster that motivates us is the following conditional hypothesis: *if the sea is* considered as a territory, how do marine territorial divisions track power structures related to terrestrial territorial divisions? What are the balances and imbalances between sea and land? What does it mean to be a maritime power? How does control of marine extension change the balance?

The basic data we take into consideration are the land area (non–maritime) of a State, its maritime area expressed in terms of EEZ, its population, and the length of its coastline. These data allow us to define some indices on the basis of which we can organize the various forms of expression of "territorial power" (terrestrial or maritime) and highlight the imbalances.

The derivative indices in question are:
1. the *land/sea equilibrium*, i.e., the area of the EEZ that corresponds to one unit of land area; some states are more imbalanced towards the sea than others; the index measures a state's "seaworthiness" or, conversely, "land rootedness".
2. the *marine population density*, i.e. the area of EEZ per capita enjoyed (theoretically) by an inhabitant of a given State.

To explore the land/sea relationship in more depth, we also chose to consider the role played by the geographical factor of the *coast*. This outlines two other indices:
3. *marine exposure*, i.e. the ratio of the land area of a state to the length of its coastline; this could be defined as an index of *insularity* (or of “peninsularity”), i.e. as an indication of how much "effort" a the land territory of a state makes to access the sea.
4. *marine projection, which* is the ratio of the area of a state's EEZ to the length of its coastline; an indication of a state's "maritime fortune" or "sea capital".

2.1 Methodological note: Data selection and conceptual issues

The database for our study includes 198 countries. It is the result of merging the *CIA Factbook* (https://www.cia.gov/the–world–factbook/), which lists 258 countries, and the marineregions.org database (including 158 countries that have an EEZ of at least 1 km^2: 44 landlocked countries are not in the marineregions.org database). 13 countries that had different names in the two databases were renamed according to the marineregions.org database. Western Sahara is in the marineregions.org database but not in the CIA database and was not maintained. We excluded Antarctica, which was part of both databases, because of the special status of Antarctic spaces.

Since the status of the Caspian Sea (as a large lake or as a sea) remains undecided, the countries bordering only the Caspian Sea (Kazakhstan, Azerbaijan, and Turkmenistan; Russia also accesses other seas) were considered landlocked by the CIA Factbook database; however, they were assigned both EEZ area values from the marineregions.org database, and a coastline length from the CIA database: in this case we opt for a broad interpretation and include both values in our base.

The CIA database treats Denmark and Greenland as two different territories, while the marineregions.org database treats the Greenland EEZ area as part of Denmark. In our database, we have merged Greenland's area, coastline and EEZ with those of Denmark to display them as a single entity.

Part of our argument depends on measuring the length of the coastline. Measuring the lengths of geographic curves (especially coastal curves) is notoriously not easy. A fjord may contain a bay, and when you "zoom in" on the bay you may discover further small inlets. If a geographer tries to measure the finer details of curves, using a shorter ruler, they will end up with a larger number than the geographer who used a longer ruler. As the length of the ruler approaches zero, the coastline measurement approaches infinity. This problem is known as the Coast Paradox, first described by L.F. Richardson and later elaborated by (Mandelbrot, 1967), who showed that the measured length of a coastline is inversely related to the length of the unit of measurement used. Mandelbrot argued that coastlines are *fractal* lines: for coastlines the notion of "length" is always only an approximation and does not account for the complexity of the shape. He proposed to use the notion of fractal dimension to capture the complexity of the coast.

The fractal number that measures the complexity of a coastline is the value of D in the following equation:

$$N=\varepsilon^{-D}$$

where N is the number of rulers of a given length used to measure the coastline and ε is the scale factor. For example, consider a straight shoreline: if using only one ruler the length of the shoreline is 1, using rulers measuring 1/3 of the first the length would be 3. So with a scaling factor of 1/3 you get $3=1/3^{-1}$ and D=1. For an indented coast, the scale factor with rulers measuring 1/3 of the original can yield a value of, say, 4, and since $4=1/3^{-1,2619}$, the fractal dimension will be 1.2619.

The Australian coastline has a fractal dimension of 1.13, the British coastline (which looks much shorter than the Australian coastline, but is actually only half of the latter) has a fractal dimension of 1.25, while the Italian coastline has a fractal dimension of 1.06 (D'Alessandro et al., 2006). A high value of fractal dimension indicates a higher complexity of the coastline. For example, Great Britain's fractal dimension, which is larger than Italy's, tells us that if we used a smaller ruler to measure the coastlines of both countries, Great Britain's coastline would be much longer than Italy's. An argument could be made to the effect that the length of a coastline is an illegitimate theoretical posit, as its operationalization cannot yield a unique measure; thus no index could be made dependent on it. Given two countries A, B, their respective fractal numbers f(A) and f(B), and two rulers R and r, R>r, it could turn out that $f_R(A)>f_R(B)$, but that $f_r(A)<f_r(B)$. The anfractuosity of A could be visible at a larger scale than the anfractuosity of B. From close up, the coast of B could be straight, the coast of A anfractuous, and conversely.

Accepting that coastline cannot be measured is however not without problematic consequences, first and foremost among them the non drawability of coastlines. Fractality indifferently affects measuring and drawing, but sure enough we accept that maps distinguish land from sea. Equally problematic is the consequence that absent knowledge of a ruler, we could not determine whether we are at sea or on land. (A side issue is why we trace coastline approximation on the sea, and not inland.)

Here our claim is conditional: given the choice of a certain ruler (say, 1km long), it is legitimate to compare coastline lengths across countries; accepting that the choice of the ruler can be dictated by non–morphological reasons. As a matter of fact, the length of a coastline is a relevant measure for its practical utility in military and commercial applications, and appears in several geographical databases. However, the Coastal Paradox comes to the fore here, as coastline length values vary from database to database, so that the coast of Norway has been assigned values ranging from 2650 km (Strøm, 1959) to 83281 km (Nesje, 2009). Since one of the objectives of the present work is to compare values across countries, it is important to use a consistent measurement tool, as this ensures that the ratios of coastal lengths of the respective countries remain constant. We chose to use the CIA Factbook database to obtain coastline values (https://www.cia.gov/the–world–factbook/field/coastline) because it is the most widely used database but in particular because it appears to consistently use a ruler of fixed length (1km) for measuring coastlines in different countries. We also adopted the CIA Factbook to obtain countries' population and land area data.

To discuss the EEZ areas, we instead relied on the public database marineregions.org. The database combines the EEZ area of all territories belonging to a country. The EEZ area is calculated as a function of the distance of 200 nautical miles from the baseline of each state. These baselines are a "combination of a coastline as a proxy for the low tide line and straight or archipelagic baselines." Marineregions.org in turn refers to the 2014 ESRI database (https://esri.maps.arcgis.com/) for the definition of baselines. Because the potential overlap of EEZs is a frequent occurrence, there are many unresolved claims for marine territories. Marineregions.org addresses these issues by indicating all claims for each territory. Areas are expressed in square kilometers.

The dataset is presented in the Appendix, along with indications on how to navigate it.

2.1 Land/sea balance: marine vs. terrestrial powers

If EEZs are assumed to be full blown territories, states can be ranked according to their *cumulative* territorial assets. What are then the *largest* countries, *cumulatively*?

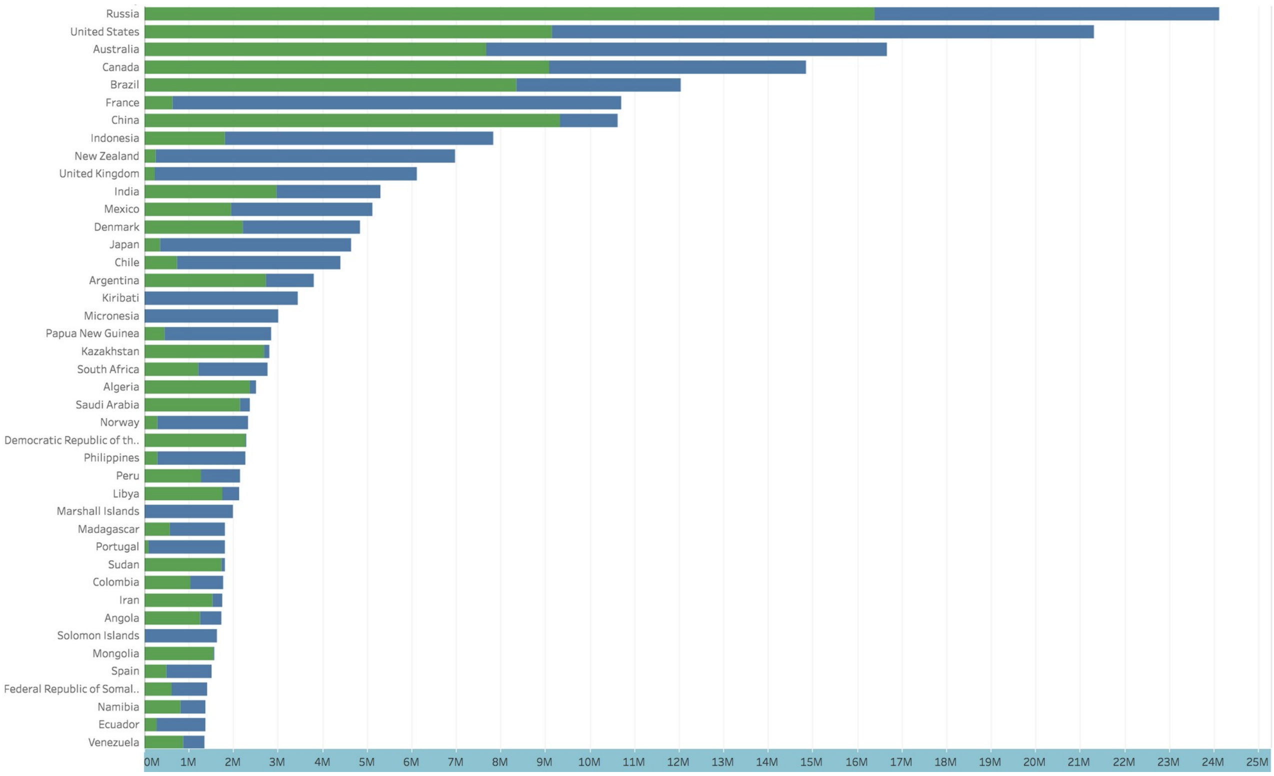


Fig. 2.1.1 The largest cumulative territorial extents. Green: terrestrial territory. Blue: EEZs. Areas are expressed in millions of km^2. Only states with a cumulative area of > 1.5 million km are represented^2. France has approximately the same cumulative area as China. The UK is larger than India. Iran is cumulatively smaller than Portugal. Mongolia is the first landlocked state to figure in the top 42 largest states – still, in position 37.

Fig. 2.1.1. shows the distribution of the largest territorial extensions considering both land and sea. Russia, the United States, Canada and Australia, with large territories both by land and sea, occupy the first positions together with France and China, which instead obtain their territorial contribution from different sources, respectively from sea and land, and are found to have the same total area. Looking at the smaller states, we see that the pattern repeats itself: alongside "balanced" states, we find some imbalances towards the sea or land respectively. All the archipelagos of small islands in the Pacific have a territorial existence that is almost exclusively marine (Fig. 2.1.2). France, Indonesia, the United Kingdom, Japan, New Zealand, Chile, Norway, the Philippines, Portugal, Madagascar, and Spain obtain a significant territorial premium from their marine regions. Brazil, Argentina, Kazakhstan (which accesses the Caspian Sea), Sudan, Algeria, the Democratic Republic of Congo, Saudi Arabia, Libya, Iran, Angola, are "more land–based" than "sea–oriented". Landlocked countries, of course, are examples of purely land–based powers. It is interesting that among landlocked states, only Mongolia (more than 1.5

million km^2) appears in the upper part of the ranking, indicating that marine territorial gains are generally advantageous.

Fig. 2.12 shows that some insular/archipelagic states obtain considerable territorial gains, their cumulative territories being constituted predominantly by their respective EEZs. Only two European countries figure in the list, Malta and Monaco.

Country	EEZ Area	Land Area	EEZ as Percentage of Lan..
Tuvalu	753,133	26	2,896,665
Nauru	309,261	21	1,472,671
Marshall Islands	2,001,566	181	1,105,838
Micronesia	3,010,644	702	428,867
Kiribati	3,440,220	811	424,195
Maldives	920,739	298	308,973
Seychelles	1,341,504	455	294,836
Palau	614,807	459	133,945
Tonga	666,052	717	92,894
Republic of Mauritius	1,278,182	2,030	62,965
Barbados	185,074	430	43,040
Antigua and Barbuda	111,568	443	25,185
Cape Verde	801,936	4,033	19,884
Sao Tome and Principe	165,378	964	17,155
Malta	52,923	316	16,748
Monaco	288	2	14,400
Saint Vincent and the Gre..	36,244	389	9,317
Grenada	25,571	344	7,433
Comores	164,476	2,235	7,359
Fiji	1,289,978	18,274	7,059

Figure 2.1.2: EEZ area compared to land area, top values. The last column shows the EEZ area as percentage of Land area. Small island states or archipelagos receive significant territorial gains (up to almost three million percent).

Fig. 2.1.3 shows the largest marine territories. Strikingly, seven Western/Northern countries are among the top ten largest marine extensions: France, The US, Australia, the UK, Russia, Canada, New Zealand, the first five being also the top largest marine extensions. (Different aggregations would put the pre–and post–Brexit EU and the Commonwealth at the top positions).

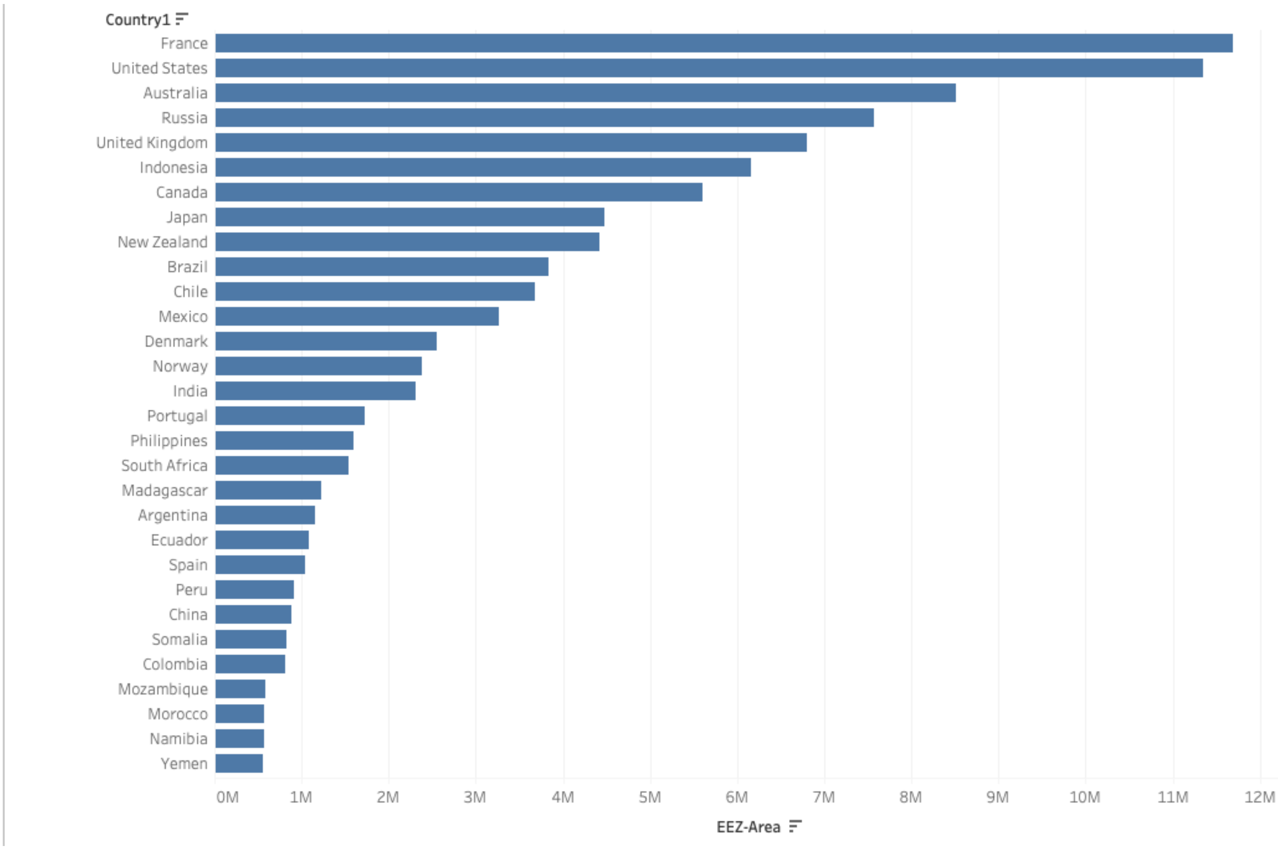


Figure 2.1.3 : EEZ Areas. In absolute values, some Western/Northern powers are also the largest marine powers.

We find an equilibrium point for countries whose EEZ has the same surface area as the land area, and calculate an Equilibrium Index (denoted as Eql),

$$Eql = 50 - (100 \times area\_land/(area\_ZEE+area\_land)$$

The Eql is obtained by subtracting the percentage of land area from the total (EEZ + land area) from 50. The formula yields 0 for states whose area is equally divided between 50% land and 50% EEZ. (For instance, for 60% land area and 40% EEZ area, the value of the balance is –10; for 5% land area and 95% EEZ area, the value of the balance is +45).
We can stipulate that states with a positive Eql value are the "big winners" in the territorial game (Fig. 2.1.4), as they more than double their cumulative territory with the addition of an EEZ, while states with a negative value are "moderate winners". Landlocked states are obviously indifferent.

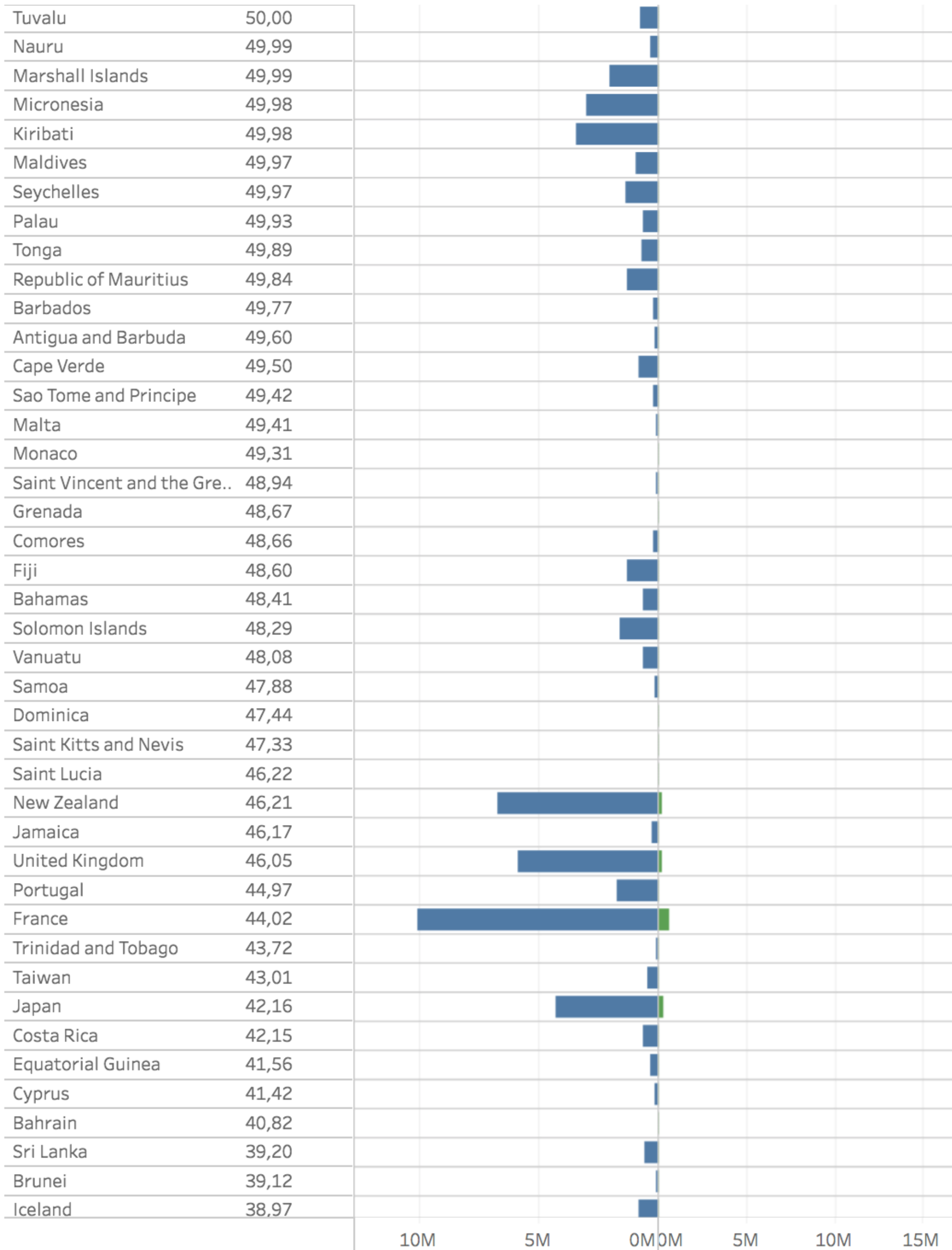


Fig. 2.1.4. "Big winners" are the states that have acquired a large or imbalanced sea area relative to land area, with a high Eql value (middle column). Areas are in millions of km^2. For some countries, land surface is so small compared to EEZ that it is not visible at the scale of the infographics.

In particular, independent oceanic islands and archipelagos are among the big winners in terms of EEZ territorial gains. The United Kingdom, France, Portugal, New Zealand, Bahrain and

Japan all have Eql>40, being amply rewarded by the expanse of their EEZ. Although France's EEZ is larger than the UK's, the latter gets more marine territory per unit of land territory than the former. For one km^2 of land–area UK gains 27.8 km^2 of EEZ, whereas France gains 21.7 km^2.

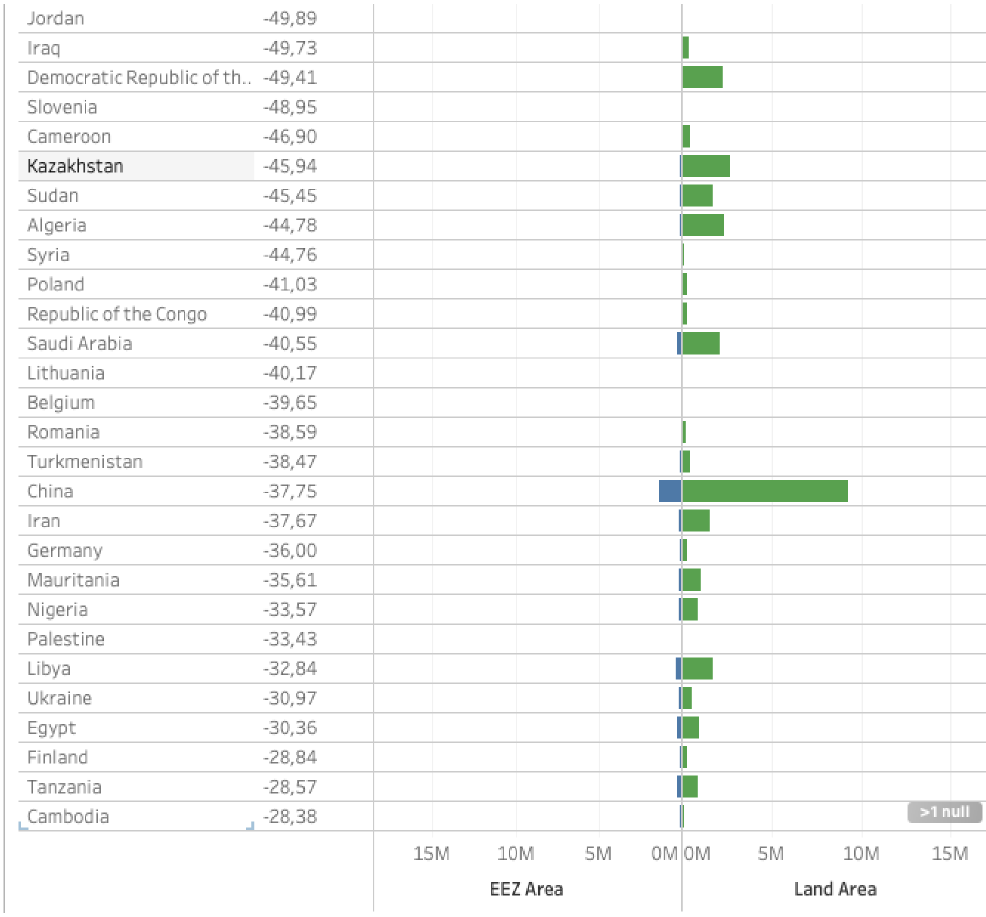


Figure 2.1.5: Eql index. The graph shows countries that have a comparatively small EEZ Area compared to their land area ("moderate winners", Eql<–28).

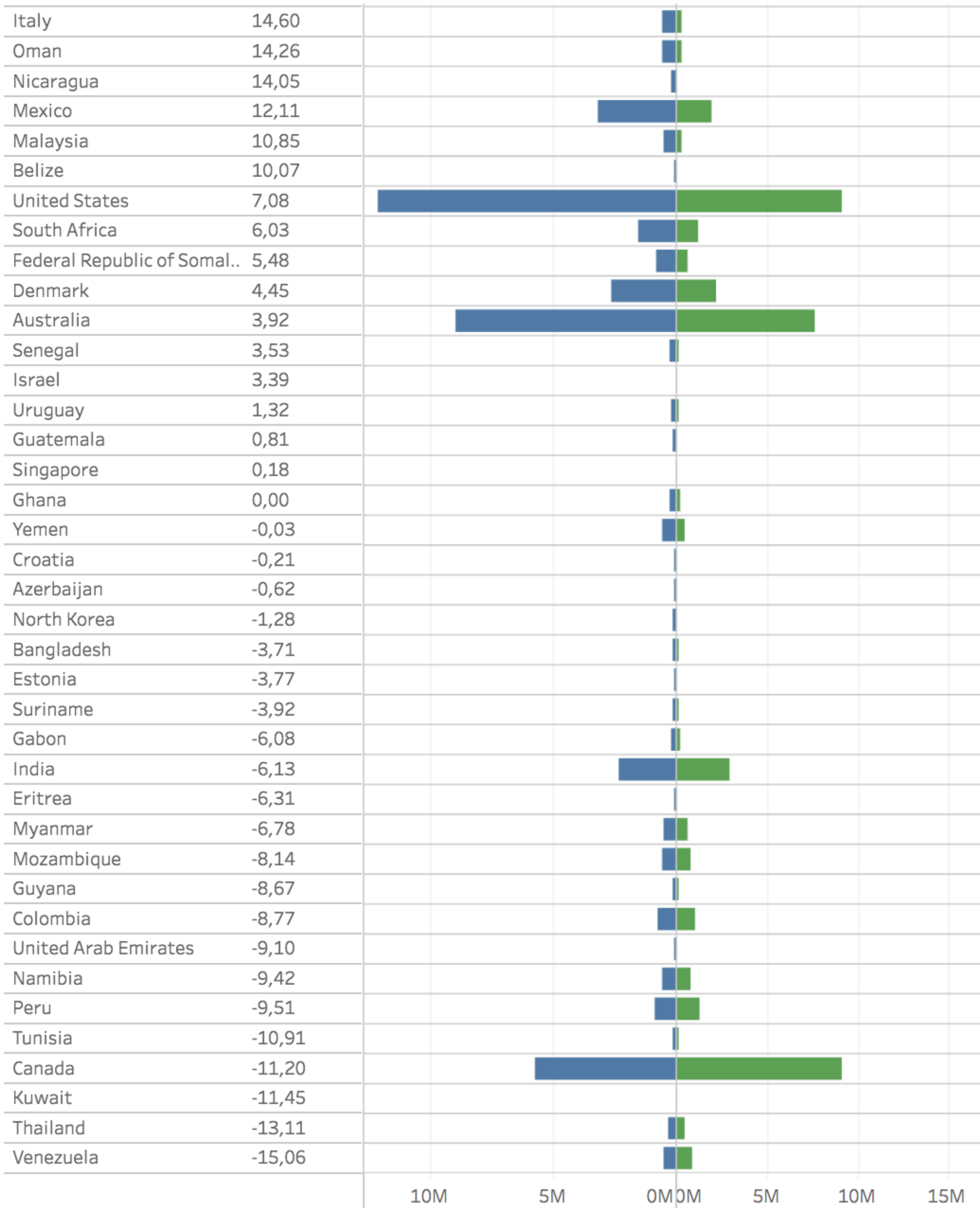


Fig. 2.1.6 The states that are most balanced between land and sea, ordered by Eql value (–15<Eql<15). Ghana turns out to be the most balanced country. Eql is orthogonal to size.

Among the very moderate winners, with Eql< –40, Iran, Romania, Poland, China, Republic of Congo, Syria, Algeria, Cameroon, Sudan, Slovenia, Jordan, Iraq, Bosnia and Herzegovina, and the Democratic Republic of Congo get very little proportional gain from expanding their EEZs (2.1.5). The top "balanced" states, with an Eql between 10 and –10, include India, the United States, Morocco, Australia, Myanmar, Namibia, and Denmark (which includes the territory of Greenland) (Fig. 2.1.6).

2.2. Marine population density

Being an alien place (Casati, 2022), the sea is not *inhabited by* humans and probably never will be. At the same time, the territorialization of the sea gives each citizen of a state a set of resources, the per capita amount of which is a function of the extent of the EEZ and the number of inhabitants. This makes it possible to define a virtual marine population "density" index (Mpd):

Mpd=ZEE_area/population

Figure 2.2.1 highlights those states whose citizens have a large (virtual) per capita access to marine resources, expressed in area of EEZ available per thousand inhabitants. The lower part of the distribution is best represented (Fig. 2.2.2.) directly in terms of Marine Population Density, i.e. the number of inhabitants that a single square km of EEZ must support.

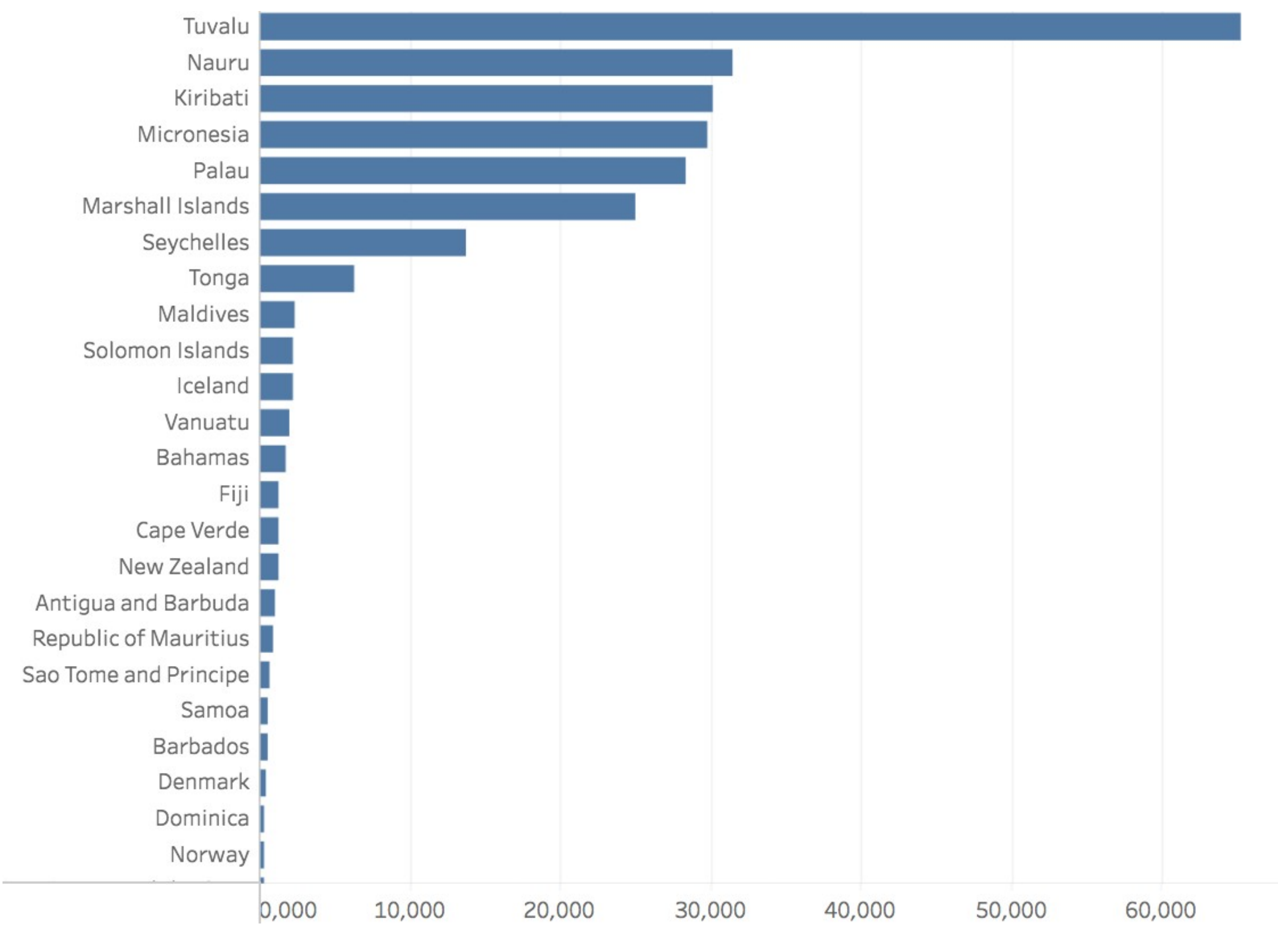


Fig. 2.2.1. Marine population density. How much marine territory is entitled to one thousand inhabitants of a state? Data in km^2. Small pacific islands are outliers.

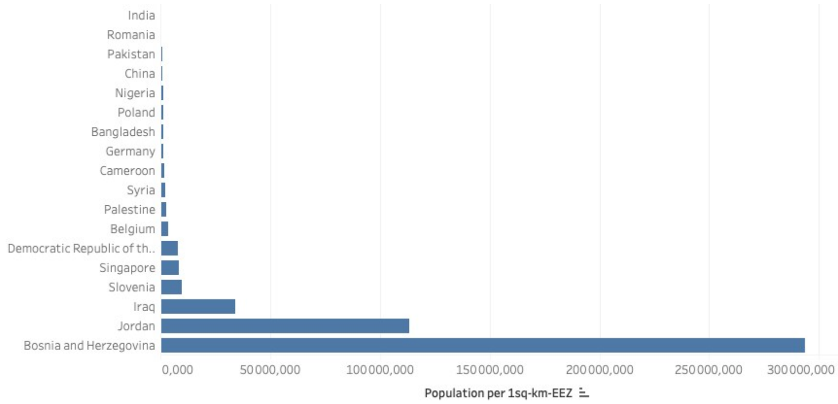


Fig. 2.2.2. Marine population density. How many people share 1 km² of EEZs? The lower part of the distribution shows the "virtual crowding" of some EEZs. Countries with very short and constrained coastlines are outliers.

As seen in fig 2.2.2 , Countries with small EEZs, such as Germany or Jordan, can have a high, if not very high, Mpd. The same goes for countries that have access to large EEZs, but have large populations as well, like China. On the contrary, being a citizen of some Pacific islands that are scarcely populated and with vast EEZs confers many km^2 of marine resources, to the point of embodying outliers (Tuvalu, Nauru, Kiribati, Marshall Islands, Micronesia). At the opposite extreme, the States that do not have access to the sea have an "infinite" Mpd (obviously this is a borderline case with purely mathematical meaning). Bosnia and Herzegovina, Jordan, the Democratic Republic of Congo, and Iraq have a minimal EEZ, making them anomalous in terms of Mpd. Most countries have a marine density above 20 people per km^2; Italy, for example, has a Mpd of 115; with a comparable population, France's Mpd is only about 6 (persons per marine km^2). Fig. 2.2.3 shows the geographic distribution of Mpds (with dark green corresponding to landlocked states.)

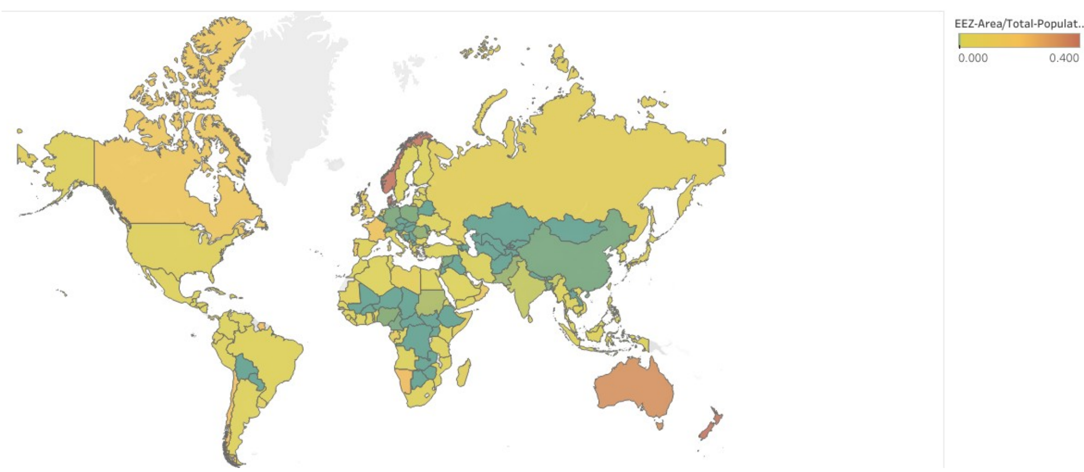


Figure 2.2.3: The geographic distribution of Mpd.

It goes without saying that the exact quantification of marine resources per capita goes beyond purely spatial data and depends on the physical, geological and biological content of the various

EEZs, which may vary in terms of resources of the seabed and the water column, up to and including the benefits of climate regulation or the energy of currents and tides; or, on the contrary, it incurs the costs arising from the action of the sea on the coast, or from the transport/transit of pollutants. To a first approximation, however, spatial imbalance is a good indicator of resource imbalance. The lack of access to the sea deprives a country of marine resources; the possession of a large EEZ makes the presence of resources associated with the seabed and the water column more likely; in addition, of course, to the important resource constituted by the very possibility of accessing the sea.

2.3 Exposure to the sea: terrestrial projection

The land–sea balance index (Eql) and the marine population density index (Mpd) provide an initial heuristic for assessing equilibria and imbalances; but the mechanics of imbalances appear to depend not only on the extent of a state's land and sea areas, or a state's land population density, but also on how a state's land territory *interfaces* with its sea territory. Coastal characteristics are here the factor to be explored. We define two indices, an *exposure* index (Exp) and a *projection* index (Prj), which account for some of these differences in detail. If other things being equal, some imbalances are due to the properties of the coast, the indices account for those properties. This section deals with Exp; the next with Prj.

The Exp index (Fig. 2.3.1.) provides information on the sea exposure of a territory. It is obtained by dividing the length of the coastline by the land area of a state.

Exp= Land_area/Coast_length

Exp is obviously non available for States without access to the sea. At the top of the distribution we find many island or archipelagic states, and/or states that include a considerable number of islands, such as Estonia or Greece.

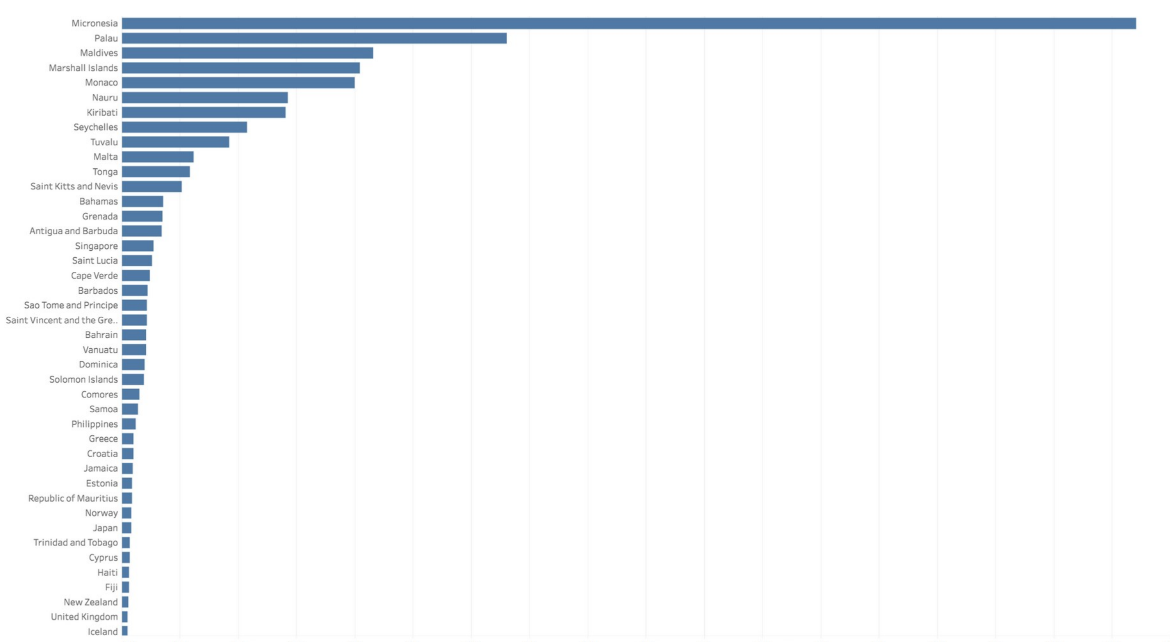


Fig. 2.3.1 How exposed is a country to the sea? Data refer to km of coastline corresponding to 1 km^2 of land. In Singapore, for example, 1 km^2 of land is exposed to an average of 278 m of coastline.

Italy is in the medium–high part of the ranking both for the presence of islands and for its markedly peninsular structure, which imbalances the relationship between the length of its coasts and land territory. On the other hand, the index does not allow for subtler distinctions, for example between countries like Italy, which has few islands but a long peninsular coastline, and Sweden, which has tens of thousands of islands. In Italy, the average coastal exposure of 1 km^2 of land is 25 m. In the case of France, the fact that it does not appear at the top of the list (France has 8m for each km^2 of land) indicates that its metropolitan territory is larger than the surface area of its island territories, which are thus the main contributors to the surface area of its EEZ. In a sense, France could be rethought as a Pacific country with a large territorial *dépendance* in Europe. Fig. 2.3.2. amplifies this point comparing some territorial indicators for large world players (aggregating data for the EU). This brings us to the discussion of Seaward Projection.

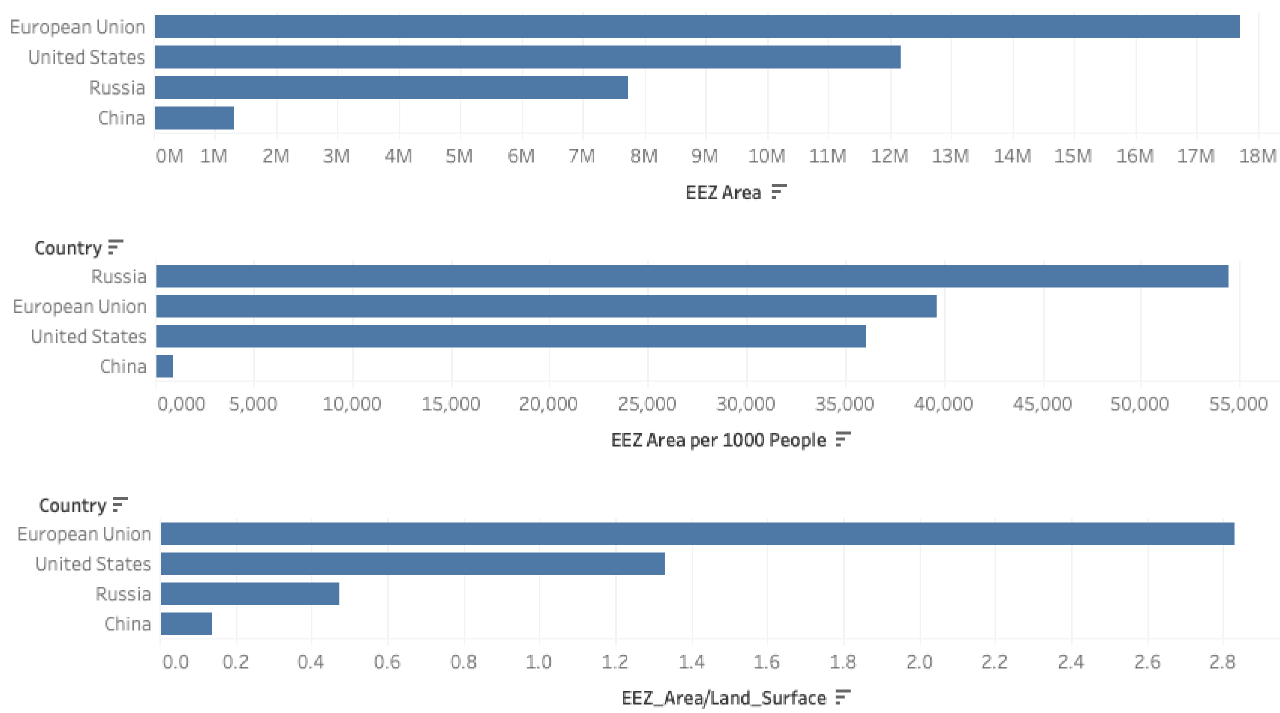


Fig. 2.3.2 A comparison of EEZ area, marine population density MPD, and EEZ/Land surface ratio, aggregating countries of EU. A further study should consider the historical variation of the indexes (e.g. the contribution of the UK to the evolution of data for the EU, before and after Brexit).

2.4 Seaward Projection

Seaward Projection is defined as the ratio of the surface of a state's EEZ to the length of its coastline.

Prj=EEZ_area/Coast_length

The larger the area relative to the coastline, the higher the Prj. Island and oceanic states, once more clear outliers, figure at the top of the ranking (Fig. 2.4.2).

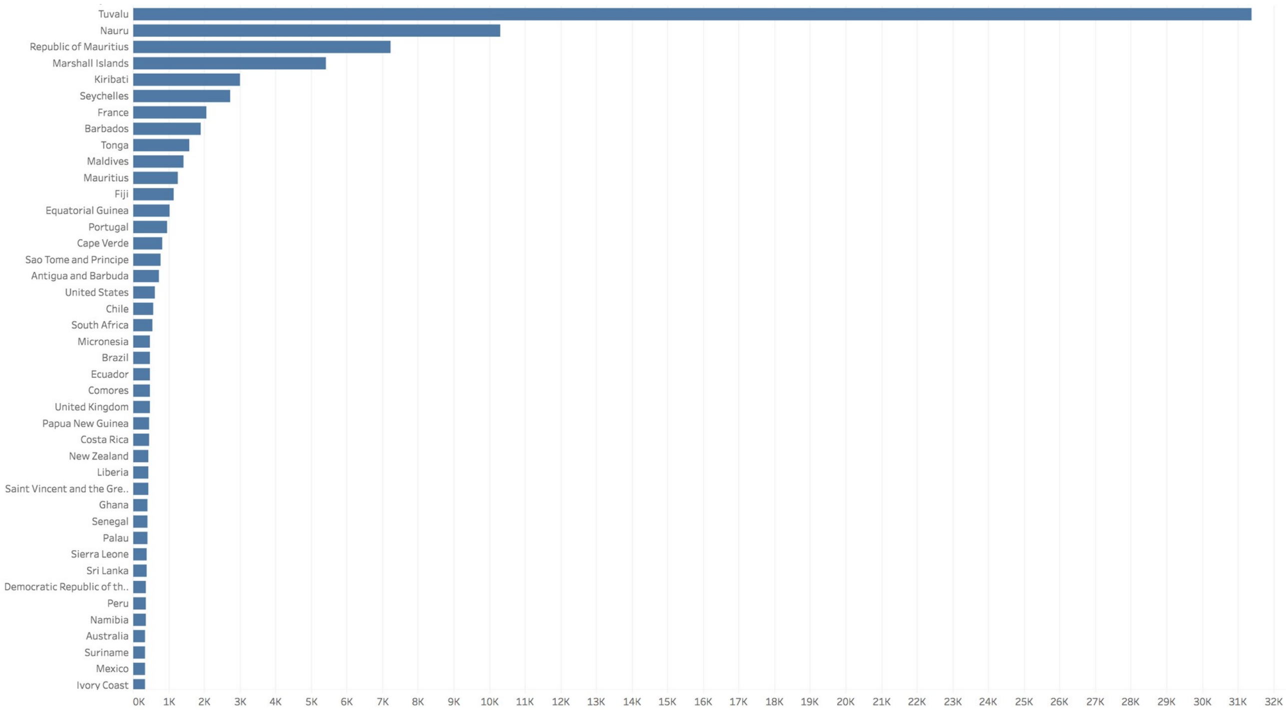


Fig. 2.4.1 Seaward Projection: how many km^2 of EEZ gives one km of coastline? (Data in thousands of km^2)

Among the Northern/Western countries, France is the most striking case (Fig. 2.4.1). One km of French coastline projects 2075 km^2 of EEZ; for Portugal, the next most seaward projected European state, the value is 964 km^2; and 611 and 474 km^2 for the US and UK respectively. Former colonial states that have been able to retain some form of sovereignty over remote islands have derived a clear advantage. States with long coastlines may not be very projective, either because of the convexities of the coast (e.g. Russia, with "only" 205 km^2 of EEZ per km of coastline), or because nearby coastal states project EEZs that limit their EEZ (as is the case for Italy, with 71 km^2 of EEZ per km of coastline).

Fig. 2.4.2. The middle part of the Projection Index distribution shows that long coasts (e.g. Italy, Norway, Philippines) do not automatically confer projective advantages. Abscissa: Square kilometers.

To visualize the imbalances, we can group together countries with coasts of similar length (Fig. 2.4.3). In this case, we choose figures clustered around some threshold values and see that coastline length is not well correlated with EEZ area. For example, Portugal’s coastline is 14.5% longer than Taiwan's, but the former's EEZ is more than 3 times larger than the latter's.

Coastline Coverage Group (km)	Country	EEZ-Area	Coastline Coverage
1K	Angola	518433	1600
	Dominican Republic	255898	1288
	Finland	87171	1250
	Ireland	410310	1448
	Libya	351589	1770
	Morocco	575230	1835
	Myanmar	532775	1930
	Namibia	564748	1572
	Pakistan	290000	1046
	Portugal	1727408	1793
	Sri Lanka	532619	1340
	Taiwan	83231	1566
	Tanzania	241888	1424
	Tunisia	101857	1148
	Turkmenistan	0	1768
	United Arab Emirates	58218	1318
	Yemen	552669	1906
2K	Ecuador	1077231	2237
	Egypt	263451	2450
	Eritrea	77728	2234
	Germany	57485	2389
	Iran	168718	2440
	Mozambique	578986	2470
	North Korea	113888	2495
	Oman	533180	2092
	Panama	335646	2490
	Peru	906454	2414
	Saudi Arabia	228633	2640
	South Africa	1535538	2798
	South Korea	475469	2413
	Ukraine	147318	2782
	Venezuela	471507	2800
3K	Colombia	808158	3208
	Cuba	350751	3735
	Somalia	825052	3025
	Sweden	160885	3218
	Thailand	299397	3219
	Vietnam	417663	3444
4K	Argentina	1159063	4989
	France	11691000	4853
	Madagascar	1225259	4828
	Malaysia	334671	4675
	Spain	1039233	4964
7K	Brazil	3830955	7491
	Denmark	2551238	7314
	India	2305143	7000
	Italy	541915	7600
	Turkey	462000	7200

Fig. 2.4.3 Countries grouped by similar coastline length may have very different EEZ extents, corresponding to different projection indices Prj.

Prj defines a kind of "coastline usefulness". Both the EEZ area and the coastline are affected by the geometric complexity of the coastline. A simpler coastline (with a lower fractal number) will create a higher projection than a more complicated coastline. Liberia and Tanzania (Fig. 2.4.4) have comparable EEZ areas (~249000 km2 and ~241000 km2, respectively), but Liberia's shorter, more linear coastlines project much more (Prj=435) than Tanzania's longer, more fractional coastlines (Prj=170). We will examine this factor in the next section.

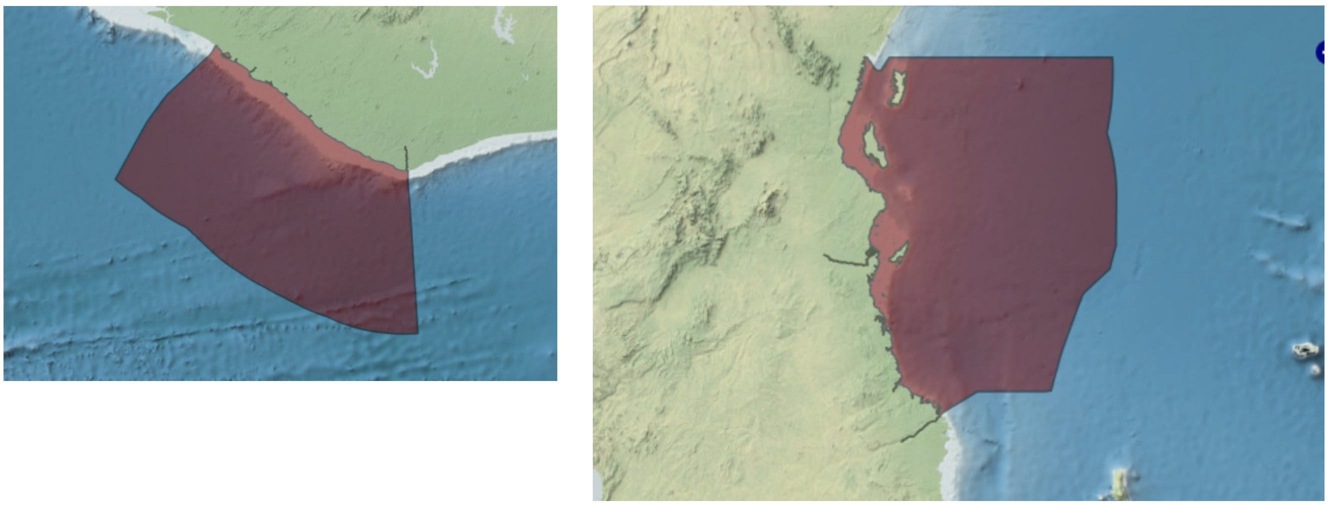
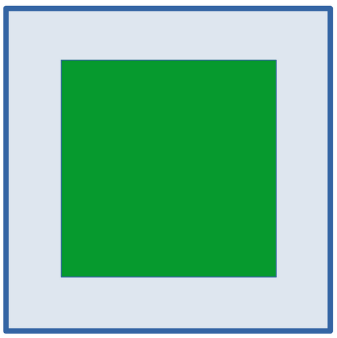


Fig. 2.4.4. Liberia (left) and Tanzania (right) have EEZ of comparable extension, but marine projections Prj of significantly different values (435 vs 170 respectively). One km of Tanzania's coast is 2,55 times more "useful" in generating EEZ than one km of Liberian coast. (Source: Marineregions.org)

3. The mechanics of Projection: an idealized model to understand the relationship between land and sea

To understand how geography affects the distribution of EEZs, we can consider an idealized model, in which, for simplicity, areas are computed on a pixellated map, i.e., one constructed with a grid of non–decomposable square atomic units whose sides measure 200 nautical miles, the unit of measure *u* for EEZs (*u=200nm*).

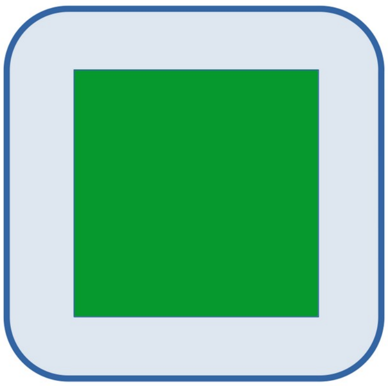
In Fig. 3.1, we see how a land area of 16u, in the case of a square island of side 4u (the "Paradigmatic Island"), creates an EEZ of $20u^2$, with a projection ratio of 24/25u between shoreline length and EEZ area (a *u* of shoreline generates $25/24u^2$ or slightly more than one u^2 of EEZ).



Surface land area=$16u^2$
Coast=16u
EEZ=$20u^2$

Exp (S/C)= $16u^2/16u=1u$
S/EEZ=$16u^2 / 20u^2 = 4/5$
Prj (EEZ/C)=$20u^2 / 16u = 5/4u$

Fig. 3.1. The paradigmatic case of a square island with side of 4u surrounded by a "pixilated" EEZ with pixel side of 1u=200nm, corresponding to the extent of the EEZ. In this and the following figures, each country has a fixed total coastline of 16u. The boxes display measurements for the situation and calculate indexes (here for instance Exposure (Exp): 1 square unit of territory accesses 1linear unit of coastline; Projection (Prj): 1 linear unit of coastline projects to 5/4 of square units of EEZ).



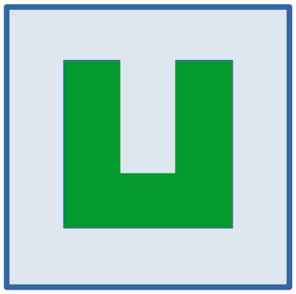
Surface land
area=$16u^2$
Coast=16u
ZEE=$(16+\pi)u^2$
$\approx 19{,}14u^2$

Fig. 3.2 A more realistic image of the paradigmatic island EEZ. Its surface area is smaller than that of the pixilated EEZ.

Note that the use of the *pixel* area u^2 (=40000nm^2) is an idealization and does not correspond to the actual calculation of the area of an EEZ. In particular, the "corners" of the EEZ, in the case of a square island, are not "rounded" as they should be in reality. Comparing the more "realistic" situation in Fig. 3.2 with the idealization in Fig. 3.1, we see that the idealized situation in Fig. 3.1 results in an increase of about 4.5% in the area of the EEZ compared to the more realistic situation.

Keeping constant the length of the coastline (=16u), we can consider other island situations whose shape creates EEZs of very different areas.

Concavities obviously produce *spatial disadvantages* when the facing coasts are at distances <2u.



Surface land area=$7u^2$
Coast=16u
EEZ=$18u^2$

Prj(S/C)= $7u^2$ /16u=7/16
S/EEZ=$7u^2$ /$18u^2$ =7/18
Prj(EEZ/C)=$18u^2$/16u =9/8

Fig. 3.3. An island with a fjord. Compared to the paradigmatic island of Fig. 3.1, almost the double of the U–shaped island is exposed to the sea (Exp=7/16), but less ZEE is generated by a unit of coastline (Prj=9/8).

For the same length of coastline, a jagged coastline (e.g., with a narrow fjord, as in Fig. 3.3) inevitably cancels out projective EEZ gains. In Fig. 3.3, one *u of* coastline "generates" little more than one u^2 of EEZ, with a loss of EEZ area of 10% relative to the Paradigmatic Island in Fig. 3.1. This explains how countries with very long but jagged coastlines, such as Russia, can have relatively low projective indices. On the other hand, almost twice as much land has access to the sea per unit of coastline (Exp= 7/16, compared to Exp=1 for the Paradimatic Island).

Not only "isolated" islands, but also archipelagos (Pacific islands, Greece, Latvia...) are harbingers of advantageous EEZ areas. Of course, as with fjords, the distance between the component islands is a key factor.

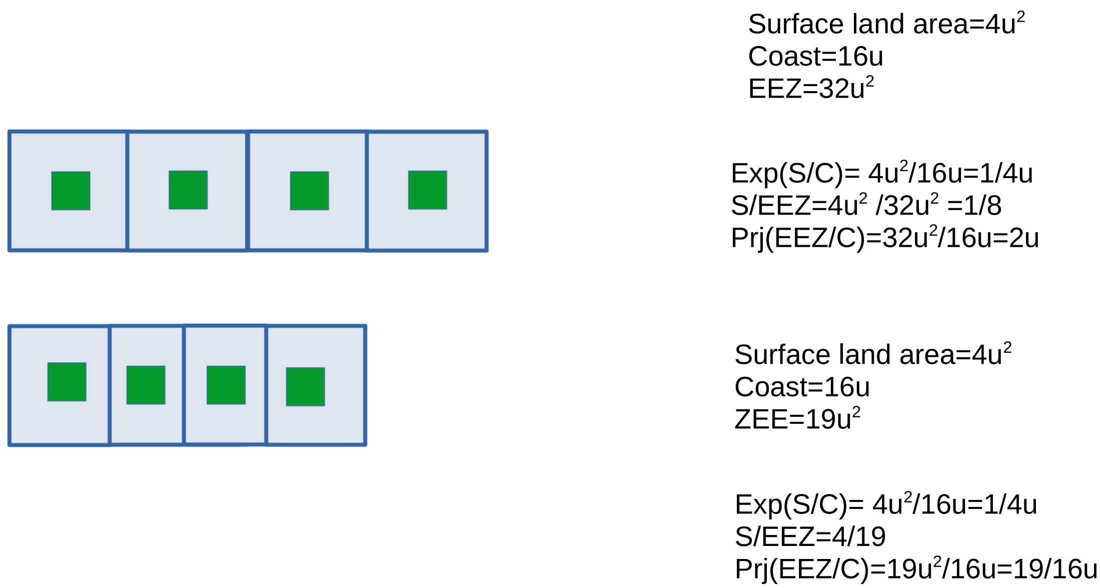


Fig. 3.4. For the same length and land area, different distances between islands result in EEZs of different area.

Fig. 3.4 compares two archipelagos whose individual islands have identical shape, area, and coastal length, but are located at different distances from each other in each respective archipelago. In the pixellated world of our simulation the Projection advantage accrues to the archipelago that maintains a distance between islands ≥2*u*; compared to the archipelago with distance between islands ≤*u*, the advantage in terms of EEZ is almost 40%; compared to the paradigmatic island in Figure 3.1, the advantage is 60%, and compared to the island with fjord in Figure 3.3, it is almost 78%. It is clearly convenient for a state to possess scattered archipelagos and convex coastlines, which confer significant, sometimes enormous marine Projection. The contrast becomes particularly stark when one considers that insularity *per se*, partially captured by the Exposure Index, confers a marine Projection: the total land area of the four islands in each of the two archipelagos is 1/4 that of the paradigmatic island in Fig. 4.1, so if a land unit in the paradigmatic island projects 1.25 marine units, the same unit in the archipelago projects 6 to 8 marine units, shifting the land/sea balance considerably. In maps of the world representing actual EEZs (Fig. 1.1.), we see the Projective force at work in the form of *geographic structures approximating circles*. Whenever we find a circle–shaped EEZ on the world map, we know that it is generated by a small island (or a cohesive group of islands not far apart) at its center. An example is Clipperton Island 10° 18′ 14″ N, 109° 13′ 04″ W, a French possession in the North Pacific off the coast of Mexico (Fig. 3.5). This closed atoll of only 9 km², biologically extraordinary for the presence of a freshwater lagoon, generates an EEZ of 435612 km^2, equal to ~80% of the territory of metropolitan France (543940 km^2).

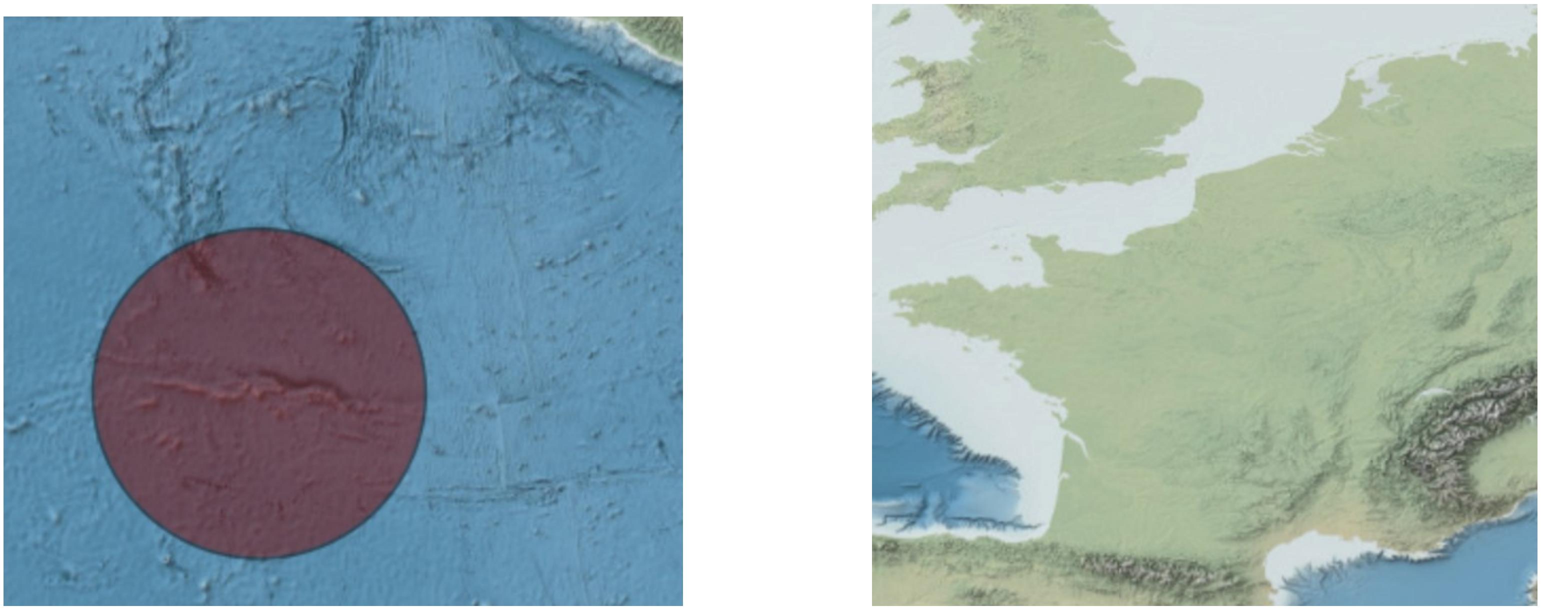


Fig. 3.5. Comparison the relative sizes of Clipperton's EEZ and of metropolitan France. (Image source: marineregions.org).

Fig. 3.6 illustrates two other idealized situations. Fractioning is advantageous: the two islands, while disadvantaged from the projection point of view with respect to the four smaller islands at the top in Fig. 3.4 (–25%), are decidedly advantaged with respect to the paradigmatic island in Fig. 3.1 (16.6%), especially since their total area is half that of the paradigmatic island. The elongated shape also counts, as in the oblong island, which has the same EEZ as the Paradigmatic Island despite having an area just over a third of the latter.

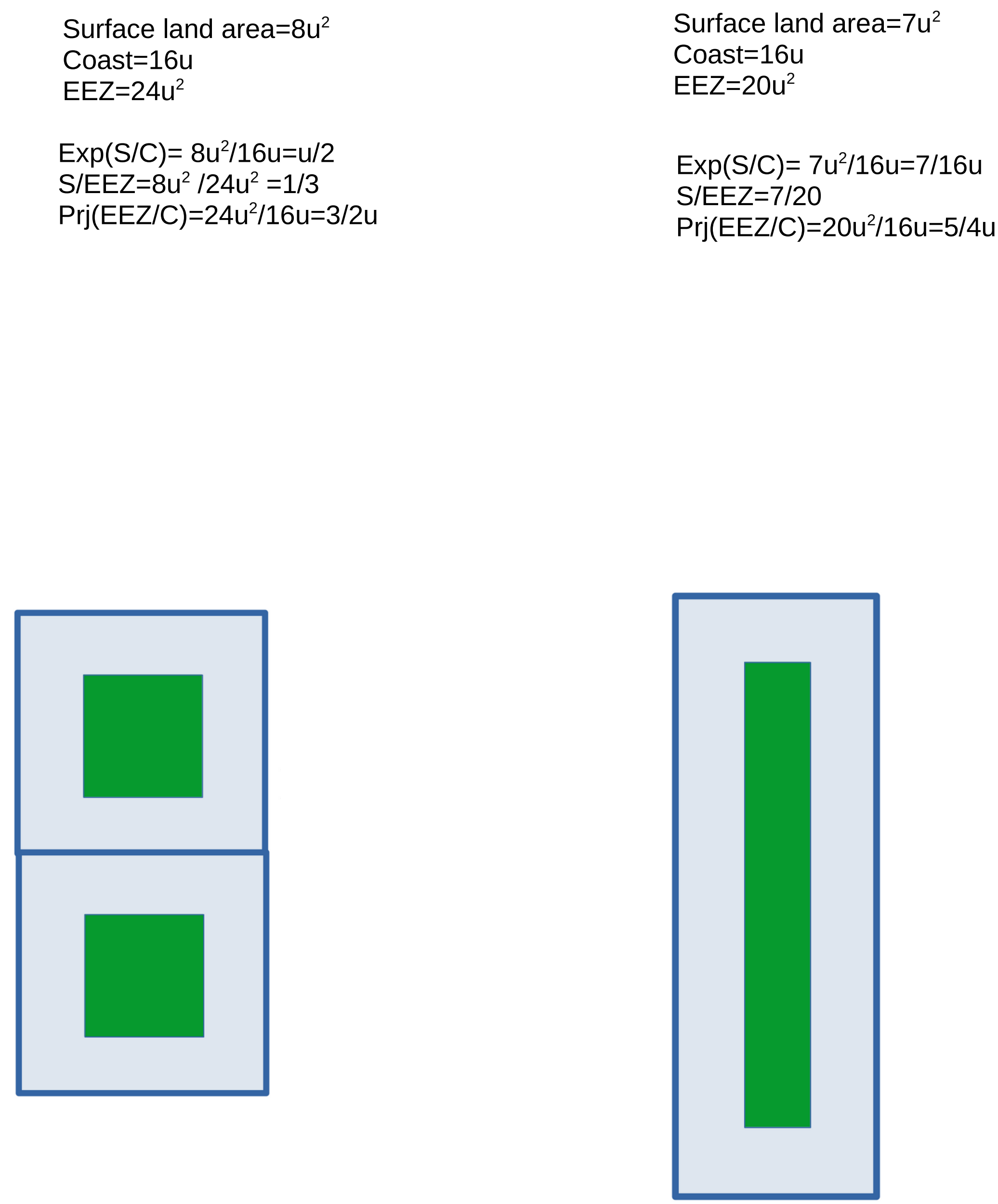


Fig. 3.6. An archipelago with large islands; an oblong island. Fractioning provides an advantage even relative to the most advantageous self–connected geographic units (here, maximum elongation).

The use of our model must take into account the inevitable idealization inherent in it. Among the elements from which it abstracts is the fact that the calculation of EEZs must often take into account neighboring states, which inevitably reduce the area of a state's EEZ. Inland seas, such as the Mediterranean, leave no room for waters outside the EEZ of coastal states and compress the latter's respective EEZs when the distance between the relevant baselines is <2u. Thus the Croatian archipelago (>1000 islands, clustered along the coast) confers maritime territories whose surface area (55502 km^2) is only slightly larger than the EEZ (52923 km^2) of the 20 or so islands and islets of Malta, which are at a greater distance from the nearest coasts (Fig. 3.7).

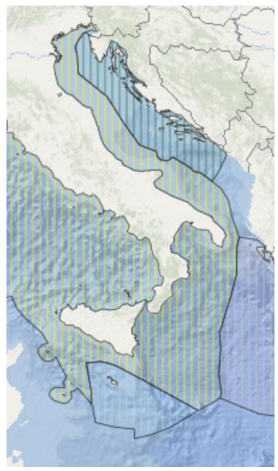


Fig. 3.7. In spite of a very different number of islands, Malta and Croatia have EEZ of comparable size. Image source: https://emodnet.ec.europa.eu/en/map–week–%E2%80%93–exclusive–economic–zones

Another simplifying factor in this model is the absence of a discussion of peninsularity, which by necessity is the possession of a land frontier in addition to a sea frontier (the simplified model considers only islands). On the one hand, peninsularity generally reduces Projection (the land–only part of the frontier does not contribute to the projection); on the other hand, it can instead contribute to Projection, to the extent that the shape of the country, as for example in the case of Italy, induces an advantageous relationship between the length of the coastline and the surface area of the EEZ. Approximating an island is a good way to gain marine space.

3. Discussion

Carl Schmitt, a controversial thinker and one of the ideologues of the Third Reich, published in 1942 *Land and Sea*, a pamphlet (Schmitt, 1997) on world geopolitics (at the height of the Second World War, when Germany's fortunes were beginning to wane). Schmitt's main thesis is that there are two types of power struggling on the world stage: maritime power, exemplified by colonial power, embodied first by the British empire and then by the US; and land power, represented by continental nations, embodied namely by the Russian and German states. Schmitt's thesis enjoys a certain popularity, but at this point we can only observe that the post–war territorialization of the sea has so profoundly altered the very notion of territory, that a clear distinction between land power and sea power is no longer so easy to apply.

The assumption of the present work has been to consider the EEZs as *sufficiently similar* to actual territories to be considered full–blown territories in their own right. The assumption can be contested for many reasons, but it is an essential *methodological* component of our argument, as it allows us to investigate the *consequences* of the territorial approach to ocean spaces. The discussion is therefore about these consequences and their importance, which our heuristics captures in terms of direct rankings provided by some basic indices (Eql, Mpd, Exp, Prj). If the consequences are considered problematic, one should consider questioning the International Court of Justice's 1969 fundamental principle that "the land rules the sea", cited in (United Nations, 2000), section 103. It should be noted that the choice of data in our contribution should not be seen as supporting the marine territorial claims made by some states. Our exercise is about territorialization in a broad sense and the imbalances that a territorial approach to the sea almost automatically entails. The existence of imbalances does not appear to be substantially affected by the absence of ongoing territorial dispute resolution.

The main finding of our analysis is (1) that historical and geographic contingencies explain a large fraction of the differences between EEZ areas. Two consequences can be pointed out: that (2) the relative size of EEZs (or cumulative land+sea territories) does not track land power distribution, and (3) that at the same time this non–reflection foreshadows possible future power re–balances.

The significance of the indices we have proposed is of course questionable in itself. As in the case of sea surface, land surface is a weak predictor of other interesting characteristics, such as the wealth of a country. Some small territories have resources (water, forests, gas) that are sometimes qualitatively better than those of larger territories (desert areas); higher population density does not *per se* mean a higher level of competition for resources; vast EEZs require large and costly means for their control and management; insularity is a brake to development. In the abstract, insularity enhances territoriality, given its links both to Exposure and to Projection; but it is also a well–known brake to development. Most islands are too small to generate sufficient domestic demand, and at the same time isolation creates logistical problems that hinder exports (Andreani, 2004).

Moreover, while some indices of straightforward construction (such as the area/population ratio, i.e. population density) have long been automatically integrated into the public debate, others (marine population density) require more careful calibration and their entry into the public debate is more complex: people often consider themselves deeply rooted on land, but have only indirect links with "their" EEZ.

To structure the conversation, we felt it important to introduce the *coastal factor*. The size and dimensional relationships between populations, land and sea territories hide complexities related to geographical and geo–historical contingencies. Both the shapes and the relative positions of coastlines can, with their differences, explain some of the imbalances. The ownership of a coast is in turn explained by a combination of historical and geographical factors.

From the measures we have introduced, we can also predict the following relationships with fractal dimensions:

– The fractal size of a state is directly proportional to the state's Exposure Index.

– The fractal size of a state is inversely proportional to the projection index Prj of that state.

Note that in the first ratio the fractal dimensions are independent of land area, while in the second ratio the EEZ area is determined by drawing a fixed boundary 200 nautical miles from the coastline baseline. An unpublished database calculating the fractal number for some countries was not considered reliable enough to test this hypothesis, which is left for future work.

It is important to note that the various types of imbalances, although they do not automatically represent power relations, do not automatically correspond to injustices either, however one intends to define the latter. For example, demographic inequalities depend on various factors, including the demographic policies of the countries being compared. At the same time, in a situation of limited resources and of an environmental crisis that can no longer be absorbed, the populations of some countries will find it unfair to have to bear the costs of maintaining the unacceptably high standards of living of other countries when the latter plunder local and global resources. Landlocked states (Armstrong, 2022) that have been excluded from marine resources may question the fact that the territoriality of coastal states arbitrarily extends into the sea for a full length of 200 nautical miles. Is this figure not unjustifiably high? What would be an acceptable figure and what kind of access to maritime resources can be guaranteed under international law to landlocked states? Can we imagine forms of "partnerships" between a landlocked state and a coastal state? In the absence of deep reflection prior to international agreements, the feared rebalancing of land–based power relations projected onto marine territories risks finding a "natural" outlet in the high seas, outside national jurisdictions.

It is certainly an interesting historical and geographical fact that some states have increased their territories practically overnight with the promulgation of UNCLOS, as a consequence of a decision–making process that does not seem to have considered all the potential consequences including the inequalities induced by the vagaries of their geographical situation. The algorithm for negotiating and drawing maritime boundaries has a history and logic that is reflected in these consequences, but the consequences do not seem to have been fully anticipated in the construction of the algorithm. Indeed, the negotiations for drawing EEZs are predominantly local, as they involve neighboring states; whereas the sea is a global resource. From these findings, many avenues are open, from modifying certain parameters (e.g., limiting the width of EEZs to 100 miles), to looking for completely different forms of sea management, which for example may give more space to temporal rather than spatial delimitations, or which restore the sea's unity and give it some rights (David, 2019).

Acknowledgments

This paper expands and integrates a previously published article in Italian:

Casati, R., Gurchani, U., 2023, Il mare come territorio: equilibrio, proiezione ed esposizione marina nei Paesi del mondo. *Gnosis*. 1/2013, 100-123.

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Appendix

The whole dataset, and a number of related visualizations, is publicly available at this link on Public.tableau.com:

EEZ as Territories

The dataset is organized in tabs, that correspond to the different indices discussed in the article.

For some indices, we provide both a graph and a map, on different tabs.

In each map, the color scale is arbitrarily chosen to make some features salient. As a byproduct, landlocked states sometimes figure as having colors close to that of non-landlocked states at the extreme of the distribution.

In each map, mouseover a country provides the essential data of the country in a callout. The same procedure holds for bars in each diagram. (A number of interesting features are displayed in each callout).

Callout information about small states, and in particular about small island states, can only be obtained by zooming in.

For some graphs, the spread of values is so large that it is difficult to usefully compress the information in a screen-wide spatial scale. We could have opted for a log scale, but we preferred to display the actual imbalance, leaving the information in the callouts for the reader to explore. A log scale is added for comparison to the Projection Graph in a separate tab.

In the graph tabs, readers can choose the Data Source Order by clicking on the small icon on the top left above the graph - the icon appears when mouseover on "Country". The database from time to time defaults to alphabetic order. Alphabetic order is applied by default to landlocked states.

From left to right, the tabs are as follows (in some cases we add comments to assist perusing):

Marine Population Density Map (EEZ_Area/Population)

Marine Population Density Graph (EEZ_Area/Population)
(Click on "Country" to order by density.)

Projection Land to EEZ Map (EEZ_Area/Land_Area)
(In this map, dark countries are the most projective, light countries the least projective.

Projection Land to EEZ Graph (EEZ_Area/Land_Area)
(Mouseover a country to obtain a callout with the ratio.)

Projection Map (EEZ_Area/Coastline_Length)
(Mouseover a country to obtain a callout with the index value. E.g., for India, 1km of coastline projects 332km² of EEZ, its coastline is 7000km long, and its ZEE is 2323935 km² wide.)

Projection Graph (EEZ_Area/Coastline_Length)
(Mouseover a country to obtain a callout with the index value and information about EEZ area and coastline length. E.g., for India, 1km of coastline projects 332km² of EEZ; India has .)

Exposure Map (Land_Area/Coastline_Length)
(In this map, dark countries are the least exposed, light countries the most exposed.)

Exposure Graph (Land_Area/Coastline_Length)
(In this graph, exposure is on inverse scale: longer bars indicate lesser exposure. Mouseover a country to obtain a callout with the index value. E.g. for India, 1km of coast is the sea interface for 425km² of land.)

Projection Graph on Log-Scale (EEZ_Area/Coastline_Length)
(The data is the same as in the Projection Graph, but the visualization uses a log scale. This makes comparisons easier in the middle part of the distribution.)

Cumulative Area Graph (Land_Area + EEZ_Area)
(This graph ranks countries bu cumulative land+sea surface. Color distinguishes the respective contributions of land (green) and of sea (blue) to the overall surface. Consider for instance the contrast between France and China. The European Union is added for comparison.

Cumulative rank (Land_area vs EEZ_Area)

Equilibrium (Land_area vs EEZ Area)

Equilibrium Index (Land_Area vs EEZ_Area)
(The right-hand column give the index - mouseover to obtain the callout with the index and the respective areas of EEZ and of land. E.g. Fiji has an index of almost 50, meaning that its EEZ dwarfs its land. Ghana has an index of 0, meaning that it has as much land as it has EEZ.)

Equilibrium Index Numeric (Land_Area vs EEZ_Area)

Cluster Similar Coast_Line Length
(Here countries are clustered based on similar coastline lengths, with some thresholds: 1, 2, 3, 4, 5, 6, 7, 51, and 105 thousands of kilometers. Information about each country is available in callouts obtained by mouseover. Not all countries are represented.)

Every effort has been made to ensure accuracy of the underlying dataset. The sole purpose of the presentation is to show the consequences of a territorial approach to the ocean. The instrument we provide is not meant to be as a means to assess, let alone endorse, territorial claims or disputes.