Global implementation of marine protected areas considering socio-economic factors: Is the developing world being left behind?

Sophie Marinesque[1, 2a*], David M. Kaplan[1b], Lynda D. Rodwell[3c]

1. Institut de Recherche pour le Développement (IRD), UMR EME 212 (IRD/Ifremer/Université Montpellier 2), Centre de Recherche Halieutique Méditerranéenne et Tropicale, Avenue Jean Monnet, B.P. 171, 34203 Sète cedex, France
2. School of Marine Science and Engineering, University of Plymouth, Drake Circus, Plymouth PL48AA, United Kingdom.
3. Marine Institute, University of Plymouth, Portland Square, Drake Circus, Plymouth PL48AA, United Kingdom.

E-mail addresses: (a) Sophie.marinesque@postgrad.plymouth.ac.uk,
(b) David.Kaplan@ird.fr (c) lynda.rodwell@plymouth.ac.uk

*** Corresponding author:** Phone: +33 (0)6 72 47 38 08; Fax: +33 (0)4 99 57 32 95

Highlights

- Developing nations lay far behind developed countries in terms of MPA implementation.
- Patterns of MPA use are extremely heterogeneous within each development group.
- MPA creation is opportunistic and primarily influenced by international agreements.
- MPAs are increasingly used for meeting integrative and adaptive management goals.

Abstract

While the global network of marine protected areas (MPAs) has recently been evaluated in the light of bio-geographic targets, there has been no attempt to evaluate the relative conservation efforts made by the different nations with regards to their level of socio-economic development. Using information mostly gathered from the world database on protected areas (WDPA), this paper gives a comparative assessment of MPA progress in countries from different economic categories, ranging from advanced economies to least developed countries (LDCs). Potentially explanatory socio-economic and environmental factors, such as fishing activity and existence of vulnerable marine ecosystems, for variability between nations in the level of MPA implementation are also explored. Existing MPA databases demonstrate a clear gap between developed and developing nations in MPA establishment, with advanced economies accounting for two thirds of the global MPA network. Patterns of MPA use, however, remain extremely heterogeneous between countries within each development group. International agreements on marine conservation, above and beyond the influence of country socio-economic and environmental profiles, are identified as a stimulating factor to MPA implementation. The level dependence on marine resource extraction appears to impede MPA implementation, though the relationship is not statistically significant due to large heterogeneity among countries. Leading developed nations increasingly use MPAs to designate integrated and adaptive management areas, and implementation of large "no-take" reserves in relatively-pristine overseas areas continues to accelerate. These analyses highlight certain limitations regarding our ability to assess the true conservation effectiveness of the existing global MPA network and the need for improved indicators of MPA restrictions and management efforts.

Keywords: marine protected areas (MPAs); meta-analysis; conservation targets; international policy; gap analysis; developing world

1. Introduction

Marine ecosystems play a crucial part in the economic, social and political development of many countries. Nevertheless, the world oceans are subject to an increasingly diverse set of anthropogenic disturbances [1-3]. The threat of a significant or even complete loss of the goods and services provided by coastal ecosystems [4] has prompted the adoption of a wide range of management and protection strategies. Among these, marine protected areas (MPAs), defined as "any area of intertidal or subtidal terrain, together with its overlaying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" [5], are increasingly viewed as a key tool to conserve and restore marine biodiversity and support sustainable use of marine resources [6-9]. Most nations have consequently agreed to commitments made at the World Summit on Sustainable Development (WSSD) in 2002, at the 5th World Parks Congress (WPC) in 2002 and at the 8th Ordinary Conference of the Parties to the Biological Diversity (CBD) in 2006, to effectively protect at least 20-30% of each marine habitat by 2012 [10] and fully conserve at least 10% of the world's eco-regions by 2010 [11] through the establishment of a representative global network of MPAs.

Three recent studies have assessed the progress in MPAs coverage in relation to global marine protection targets [11-13]. Their findings suggest that, though significant efforts have been made, only a few countries have come close to meeting targets and, at present rates of increase, global MPA coverage targets will only be met towards the middle of this century [11-13]. Few countries have well developed national MPA networks and these nations are almost exclusively advanced economies, such as the United States, Canada, Australia and New Zealand. Therefore, it could be assumed that advanced economies have made more progress with respect to marine conservation thanks to their larger management and conservation infrastructures (e.g. financial and technical support). Nevertheless, several key studies that initially established MPAs as an efficient tool for marine ecosystem conservation and sustainable management have been conducted in developing or least developed countries (LDCs). These studies demonstrated the positive effect of MPAs on various aspects of ecosystems health, notably through the conservation of "keystone" species and coral ecosystems restoration [14-16], as well as their value for local fisheries activity [17,18] and their key role in ecosystem based approaches or community-based management [19-24].

Given these examples, it is logical to question the representativeness of these conservation successes in the developing world. Furthermore, developing nations contain a disproportionate fraction of vulnerable marine ecosystems (VMEs), e.g. coral reefs and mangrove forests [25], and are therefore increasingly prompted and supported by the international community to improve their MPAs network [26].

In order to maximize the protection and management of marine biodiversity, national and international organizations have provided support to coastal managers and policy makers through the development of guides for applying MPAs [27,5]. In addition, since the inclusion of non-preservationist goals in conservation concepts during the 1980s, a wide range of MPA tools, ranging from "Strict Nature Reserves" to more flexible "Managed Resource Protected Areas", have been created to guarantee their broad use with regards to local contexts and capacities [28,29]. Despite growing debates on the difficulty of assessing management effectiveness and MPA conservation performance [13,16], an international marine conservation framework is essential to assessing global MPA coverage and representativeness. It is therefore of broad interest to evaluate the level of compliance with international standards among the world's different socio-economic regions to quantify their current contribution to the network and identify where support is needed. Furthermore, analyses of current patterns in the use of distinct MPA categories may indicate the type and level of conservation effort conducted in different parts of the world.

The present study examines differences in the rate and level of MPA implementation between countries from different economic development levels. Analyses are based primarily on data in the World Database on Protected Areas (WDPA), as well as various publicly-available indicators of country socio-economic and environmental status. The principal aims of the study are to (1) quantify the contribution of each economic development group to global marine conservation, (2) compare growth of the network over time, (3) highlight possible specific patterns in their use of distinct MPA tools and (4) identify potential factors that facilitate or obstruct MPA implementation. Results are placed in the context of identifying areas in need of international guidance and support, as well as limitations in our ability to assess conservation efforts on a global scale using existing databases.

2. Methods

2.1. MPA and indicator data sources

For the purpose of this study we created an integrated database to assemble both data concerning Marine Protected Areas (MPAs) worldwide and indicators of the profile of each country where MPAs have been established. We used the 2010 release of the WDPA, Beta version 1 database [30] as the principal source of quantitative and qualitative information on MPAs. The WDPA is held in a geographical information system (GIS) and contains one dataset with 5092 geo-referenced polygons of marine protected sites and another with 1742 geo-referenced points when no other spatial data were communicated by MPA managers. Both datasets notably include, for each MPA, information on their name, establishment date until 2009, IUCN category, current status, management type and the affiliated country and Exclusive Economic Zone (EEZ). An additional MPA database provided by the Food and Agriculture Organization (FAO) of the UN containing complementary information on whether or not MPAs contained no-take areas was also used where necessary.

For each country included in the WDPA, we gathered data on their social, economic and environmental profile, from global databases available online, such as those of the World Bank [31], the Food and Agriculture Organization [32], the United Nations Environment Programme [33] and the World Resources Institute [34]. A total of 66 indicators were pre-selected based on their accessibility and their potential to explain variance in the global distribution of MPAs. After harmonization and partial completion, we stored the data in a common dataset organised in terms of seven different indicator types: General sea boundaries, Economic and social development, Environmental state and governance, Fisheries and Tourism.

2.2. Data processing

We significantly transformed the resulting database to obtain an appropriate format for intended analyses (**Error! Reference source not found.**). Residual terrestrial parts were removed from the MPAs spatial data by intersecting the WDPA polygons layer with the high resolution shoreline layer, gshhs-h-l1 version 2.1.0, provided by the National Oceanic and Atmospheric Administration [35]. To simplify this process, we chose not to consider the upper intertidal or upper estuarine waters in our MPA analyses, though these are included in the IUCN definition of MPAs [36]. We then merged the resulting polygons in ArcGIS (ESRI-

version 9.3) to generate a dataset with no over-counting of MPAs coverage when designations overlapped. For certain analyses, overlapping polygons from different IUCN protected area categories were reduced to just a single layer keeping only the strictest IUCN category. Although IUCN classification is not a strict hierarchy of MPA quality, importance or naturalness [5], we consider that the categories, from I to VI, give a good proxy of the ascending level of human interactions with the environment or exploitation of marine resources within the protected area. We extended this scale of anthropogenic impact to the "not applicable" and "not reported" areas in the WDPA. "Not applicable" areas are sites protected under international jurisdiction (e.g. Barcelona Convention and World Heritage Convention) that may not possess national restrictions on their use, and therefore, were treated in our analyses as more flexible than other IUCN categories, but stricter than areas not reported in the IUCN classification. We separately looked at no-take areas, portion of the marine area where extraction of living and non-living resources is prohibited, as they can be include in all designation types. The limited capacity of evaluating the level of control in MPAs due the lack of adequate indicators is further detailed in the Discussion section. We also excluded MPAs degazetted, recommended, proposed or with no status reported in the WDPA polygons and points datasets. These sites represent an approximate 3% of the total MPAs coverage. MPA areas were calculated using solely the polygonal data, whereas MPA numbers includes all sites from both point and polygon datasets. Steps of this process of MPAs data is summarised in the first column in Figure 1.

Out of the initial set of national indicators, we only kept those with data for a minimum of half of the studied countries. We used cross-correlation analyses to eliminate redundant indicators within the same indicators group. We then explored the dataset with simple plots looking at potential influences of each indicator separately on MPAs number, coverage and EEZ coverage (Fig. 1, column 3). As a result, 22 indicators that well represent all indicator groups (approximately 3 indicators per group) and are potentially relevant for explaining variance in MPA implementation were finally selected for further analyses (Table S3). Some variables, such as Gross Domestic Product (GDP) and coastal length, were kept in the dataset despite poor visual correlation with MPA numbers or area as these seemed likely explanatory factors for MPAs and scatter plots may not pick up relationship when multiple factors operate simultaneously.

These final datasets were first examined considering all countries, sometimes aggregated by sovereign nation to facilitate concordance between datasets, then considering country

development groups. Four main development groups were chosen based on the International Monetary Fund and United Nations Statistics Division classifications systems [37,38]. These were: Advanced Economies; Emerging Economies; Least Developed Countries (LCDs) and Small Island Developing States (SIDS)[1]. A small number of coastal countries, including Haiti, Guyana, Western Sahara, Somalia, Djibouti and Nigeria, are not comprised in the development groups as there is insufficient data for the calculation of their development indices [37,38].

2.3. MPA distribution analyses

The first set of analyses consisted in a broad description of MPA distribution worldwide in number, coverage and percentage of EEZ protected (MPA descriptors). We generated a set of maps with GIS software in order to compare distribution in numbers, area and EEZ coverage between country groups. The spatial analyses are completed with basic statistics done within each MPA group and for each MPA descriptor and include minimum, maximum and mean values as well as standard deviation, coefficient of variation and GINI coefficient [39]. For each development group, we analyzed in more details the proportion of MPAs in each IUCN categories. In relation to international policies, we also looked at the fulfillment of the CBD targets for countries which ratified the convention.

2.4. Time Series

Following the spatial analyses, we evaluated, through time series, the cumulative evolution and rate of MPAs establishment in each IUCN category and compared them between development groups. In the original WDPA, approximately 10% of sites with "effective status" had no establishment year reported. We completed the database with official dates reported in national documents for the 40 largest sites (over 1000 ha), which represents 70% of the area for this sites with no previous establishment dates. For time series with MPAs areas, we used both the MPAs datasets with over-counting due to overlapping designations to look at the global evolution in each IUCN categories and the datasets which only keeps the strictest category to evaluate reclassifications of sites over time. We included "no take" zones as a supplementary category to look at general trends in number only. Spatial analyses were not carried out as no consistent datasets are currently available. We additionally looked for correlations between MPA establishment trends and international policy events, such as

congresses or conventions promoting MPAs and setting conservation targets (e.g. World Summit on Sustainable Development (WSSD) and 5th World Park Congress).

Although the WDPA includes data from 1888 to 2009 we focused our analyses and discussion on the period 1960-2005 for which the database is better documented (Fig. S.2).

2.5. Correlations between country profiles and MPA distribution

We used Fitting Linear Models (LM), Quantiles Regression [40] and Generalized Linear Models (GLM) within the R statistical computing environment (R Development Core Team 2010) to verify the preliminary correlations identified with exploratory analyses. Measured variables (number of MPAs, area of MPA coverage, area and percentage coverage of EEZ) had first to be transformed to fit with the statistical hypothesis of LM which requires Gaussian distributions of measured variables. A BoxCox transformation was used to achieve normality of predicted variables. In all cases, the BoxCox lambda parameter was close to zero, producing approximately a logarithmic transformation of the data [41]. For analyses of the number of MPAs only, we additionally tested GLM with a quasi-Poisson distribution. All countries with missing values for the tested predictors were excluded from the statistical analyses which reduced the number of observations but allowed for a wider set of analyses. For example the influence of tourism and fisheries indicators could respectively be tested for 113 and 120 nations instead of the initial 182 included in the database.

3. Results

3.1. The Global distribution of MPAs according to development group

5 753 marine protected areas, nationally or internationally recognized, have been reported in the WDPA as of December 2010. These MPAs cover 3 180 101 km^2 of coastal waters, representing 2.2 % of the world's EEZ and 0.88% of the global ocean. Only MPAs associated with a specific country (i.e., not in international waters) are considered here, allowing us to analyze their global distribution in terms of the home-country development level.

Among the 182 territories with MPAs, aggregated in 146 sovereign nations, the 27 advanced economies represent 63% of the total number of MPAs and 68% of the total marine area protected. The 29 least developed countries (LDCs) and the 32 small island developing states (SIDS), respectively, contain 3% and 7% of the total number of MPAs, accounting for 14% and 13% of their surface area. These two groups have 9 countries in common, including the

Republic of Kiribati, which has one of the world largest MPA (include in the database so far). Without this large outlier, their contribution in area to the global MPAs network is reduced to less than 1% each. Other MPAs are distributed between the 69 emerging and developing countries which are neither SIDS nor LDCs.

Whether we look at marine reserves in number, area or EEZ coverage, their distribution is characterized by a very high heterogeneity mainly due to the presence of large outliers (Fig. 2) that significantly complicate the assessment of global MPA implementation in terms of driving factors. Leading countries in MPA establishment are not the same, nor are they all advanced economies, depending on what descriptor is being examined. Although EEZ coverage is a good overall indicator of the marine conservation effort of each nation [11], it does not take into account the range of effort needed to cover an immense EEZ or a very small one. Canada, for instance, counts 517 MPAs covering only 0.2% of its large EEZ, whereas the Republic of Kiribati, with only 14 MPAs, including Phoenix Island (162 thousand km^2), covers almost 40% of its marine territory. The GINI coefficient is a measure of the inequality of a distribution, a value of 0 being total equality and 1 being maximum inequality. It is often applied to income or wealth distribution. Here we calculated the GINI coefficient for the three MPAs descriptors (Table S.3), which minimize the effect of outliers. The results confirm the uneven distribution within all development groups, particularly in terms of surface area (values ranging from 0.89 to 0.93) and EEZ coverage (0.79 to 0.88). Advanced economies, however, lead the way in MPA implementation with the highest average number of marine reserve (135 MPAs against 15 in other countries), even though they only manage to protect 1.22% of their EEZ, whereas the LDCs have protected 5.56% of theirs (3.6% if Kiribati is excluded) (Table S.3).

Although there is no real means of evaluating the quality or effectiveness of the MPA networks within each economic group, we can evaluate their compliance with the standard management categories of the International Union for the Conservation of Nature (IUCN) [5]. Advanced economies have a far better representation of each IUCN categories in their MPA networks than the rest of the world's countries, both in terms of number (78% of their MPAs have an IUCN category in the database, versus 50% in LDCs and SIDs and 60% in emerging countries) and in terms of EEZ coverage (49% versus 8% for LDCs and SIDS and 30% for emerging and developing countries) (Fig. 3). For all development groups, the system of management categories is more extensively used if we consider the distribution in numbers, as opposed to area. Nevertheless, a large proportion of MPAs remain unclassified.

Categories I to IV, considered having the strictest conservation goals [5], are largely under-used in all development groups and never account for more than 10% of the protected surface (Fig. 3). National Parks (category II), which aim to preserve ecological integrity of ecosystems, are the least represented type of reserves in all MPA networks. In advanced economies, the largest area of reserve classified is in category VI, Managed Resources Protected Areas, where natural ecosystems are managed to sustainably assure community needs. Other countries mainly protect their coasts through Natural Monuments (category III), Wilderness areas (category Ib) and internationally recognized areas, including RAMSAR sites, UNESCO biosphere reserve, Barcelona Convention and World Heritage Convention reserves.

3.2. MPA establishment trends in world development groups

Management of coastal resources through conservation tools is not a new phenomenon. The number of MPAs has been growing exponentially since 1970 and large marine reserves have been regularly created since 1980 (Fig. 4), particularly in advanced economies, as noted by Wood et al. [11]. We observe the same trends in all development groups but in much lower proportions for LCDs, SIDS and emerging countries than for advanced economies than developed countries. The rate of MPA establishment, in number, is however similar between categories (Fig. S.3). Focusing on the establishment of MPAs under the strictest IUCN categories (I to IV), one finds that despite their modest contribution to the global area of protected waters, the strictest IUCN categories include at least three of the largest marine reserves created in advanced economies (1980, 1983 and 2000). They also play a key role in the increase of the number of MPAs in all development groups as they account for 40% of individual MPAs in advanced economies and for an average of 30% in the other groups.

The creation of large marine reserves in all groups is apparently fostered by international events that promote marine conservation or integrated management of coastal areas. The establishment of the Marine Program of the World Commission on Protected Areas (WCPA) in 1980 particularly seems to be the starting point for creation of larger MPAs (Fig. 4a,c). Following the Jakarta Mandate on marine and coastal biological diversity in 1995, the rate of creation of large reserves increased in advanced economies when all categories are considered (Fig. 4a), as well as in the strictest categories for emerging countries and SIDS (Fig. 4c). Rapidly after the World Summit on Sustainable Development (WSSD) in 2002 and the 5th World Park Congress (WPC) in 2003, very large areas were established in all development

groups to reach the targets of protecting at least 20-30% of marine habitats by 2012 (Fig. 4a). Large MPAs created after these events are, however, not classified among the strictest categories, for which a plateau is observed among all development groups after 2002. The apparent global decrease of MPA establishment rate in recent years (2005 to 2009) is very likely due to incomplete data in the WDPA (newly created MPAs not documented yet) for those years (Fig. S.2). Therefore, the influence of the 8th Ordinary Conference of the Parties to the Convention on Biological Diversity (CBD), held in 2006, cannot currently be evaluated.

If international guidance for marine conservation seems to spur the protection of larger areas (Figure 4), these events do not appear to be creating balanced networks of MPAs or networks with large areas in the strictest conservation categories (Fig. 5). Strict IUCN categories (I to IV) account for the largest number of marine reserves in advanced economies, but surface area is largely dominated by MPAs reported in no category or under international recognition (i.e., "Not applicable" category), although the surface in strict IUCN categories should be significantly increased by the creation of the Chagos MPA in British Indian Ocean Territory, future world largest MPA with more than 650 thousand km^2 (Fig. 5a,b). Recent increases in marine reserve coverage is largely due to numerous MPAs created in category VI (Fig. 5a,b), as well as to the reclassification of two of the world's largest MPAs, North-Western Hawaiian Islands in 2001 and the Great Barrier Reef in 2004, respectively from "not reported" and international status to category VI (Fig. 5a). This rapid growth of areas of sustainable management is not so striking in the rest of the world, although the Galapagos marine reserve, the fifth largest MPA in the world, was also re-designated from international status to category VI in 1996. The global trend for these countries is a tremendous increase of the number of unclassified or not applicable MPAs (Fig. 5d), which has nearly multiplied by four the area in marine reserve since the WSSD and WCP events. The surface in all other categories steadily increased, but in much lower proportions.

We additionally looked in more details at the WDPA for the years following the CBD conference in 2006, the effect of which could not be seen in global time series. We noted that the 62 MPAs established since 2006 are equally reported as category VI or un-classified for the 20 largest, which are mostly located in Australian external territories (14 MPAs). Nearly all other MPAs (30 MPAs), covering less then 10km^2, were all part of the international RAMSAR convention and located in emerging or developing countries.

Among the ten largest MPAs, representing 73% of the total coverage, three are in category VI, one has an international status and four are unclassified. The only two in strict conservation categories, Greenland (II) and Heard Island and Mc Donald Islands (Ia), have very low population density. Apart from the Great Barrier Reef, none of these MPAs, whether they are or not in developed countries, are located along the coast of sovereign nations. In addition, we superimposed the distribution map of MPAs (with polygons data) with the Global Map of Human Impacts on Marine Ecosystems [2] and found that 6 of the ten largest MPAs are located in areas of very low impact and the three others in areas of medium impact which is the third less impacted level out of six.

Surprisingly, the "no take area" designation reported in the FAO MPA database, an indicators of strict conservation with respect to fisheries in at least some part of the total MPA surface area, is not always associated with the strictest IUCN categories, but can be found in all IUCN categories, as well as not reported and not applicable (Fig. 6). Besides being largely under-represented in the global MPAs network (Fig. 5), this designation is mainly used for unclassified MPAs in emerging or developing countries and in LDCs and SIDS (Fig. 6b), making assessment of their marine conservation status difficult.

3.3. Influence of country profiles on MPA establishment

Linear models tested for each pre-selected indicators of country profiles to explain MPA distributions, considering all three descriptors (number, area and EEZ coverage), gave no consistent results, apart from coastal length, which is, not surprisingly, positively correlated with MPA surface and number.

In three indicators groups, environment state, social development and fisheries activities, exploratory analyses seem to reveal a global effect on MPA implementation, though effects are highly variable and non-linear. The proportion of labor force employed in fisheries and the consumption of fisheries products appears to act as limiting factors on the percentage of EEZ covered by MPAs (Fig. 7). Inversely, the number of MPAs seem to increase with the level of social development as the highest MPA numbers are scored by countries with the highest Human development index (HDI) (i.e., advanced economies), while LDCs and SIDS with the lowest HDI generally account for the lowest number of MPAs. Finally, clear correlations between global net trade in live coral and proportion of EEZ protected highlighted a significant gap between advanced economies and SIDS. Coral extraction, which almost exclusively happen in developing countries , including SIDS and LDCs, is always associated

with very low MPAs coverage, whereas the highest protected surface areas occur in advanced economies which almost all import live coral (23 importing countries out of 27) and count the biggest importing nations.

4. Discussion

As previously observed by Wood et al. [11] and Spalding et al. [12], the current growth rate of marine protected areas, mostly maintained (in terms of area) by the creation of large MPAs in offshore territories and island nations, is not sufficient to reach international targets either in terms of global conservation or in terms of bio-geographic scope. The number and area of MPAs has continued to grow at relatively low rates. This brings the total number of MPAs to 5 753, which now cover 0.9% of the global ocean and approximately 2% of the waters within EEZ. Nevertheless, a significant number of MPAs, including the recently-created no-take MPA in the Chagos / British Indian Ocean Territory (BIOT), which protects over 650 000 km^2 of territorial waters [42], and the MPA network recently implemented in California, USA, representing 15% of the 'state waters' (i.e. area out to 12 nm) [43,44], have not yet been included in the WDPA. Including just these two MPA creation events would bring the portion of world EEZs covered by MPAs to approximately 2.5%.

A detailed examination of the distribution of MPAs among countries differing in their level of socio-economic development indicates that poorer nations are largely being left behind in the race to build a comprehensive global MPA network, though there is also enormous variability in levels of MPA implementation among countries inside individual economic groups. The 27 nations with advanced economies, including their external territories, comprise two thirds of the marine conservation network, both in terms of MPA number and surface area. LDCs, which represent 90% of all nations containing coral reefs [25], only account for 1% of this marine reserve coverage if we exclude the Phoenix Islands reserve of the island nation of Kiribati (LDCs account for 3% of the total number of reserves). However, the level of development is an imperfect indicator of MPA coverage as there is a very high level of variance within development groups (GINI index of 0.8-0.9 for % EEZ area and 0.45-0.7 for number of MPAs) and the relationship between development and MPA creation is far from linear (Fig. 6a).

Given that one cannot simply predict marine conservation activity based solely on development level, it is natural to consider other potential explanatory variables. We regarded a large number of widely-available international socio-economic and environmental

indicators. Simple statistical models were unable to reveal clear correlations between these indicators and MPA use, most likely due to the nature of the dataset which counts a large number of zeros and is highly heterogeneous as shown by the calculation of the Gini index (Table S.3). Nevertheless, visual inspection suggests highly non-linear negative impacts on MPA use by high levels of local marine extraction (e.g., live coral trade and fisheries activity; Fig. 6b,d) and high levels of local consumption of marine resources (Fig. 6c), though more sophisticated non-linear and/or multi-variate statistical analyses are required to confirm these relationships. Overall, these results indicate that though development level and importance of marine resources in the local economy influence MPA creation, MPA implementation remains extremely opportunistic and heterogeneous. As such, the establishment of a representative network of MPAs is unlikely to be adequately or efficiently achieved via blanket support for implementation in the developing world or by addressing a small number of sectarian issues identified as potential obstructive factors, but rather must take into account the particularities of each nation and the rareness or vulnerability of available ecosystems.

Temporal trends for the creation of MPAs appear to be principally driven by the establishment of international targets for marine conservation. Following recent international agreements on marine conservation (e.g., WSSD, WPC, CBD), significant increases in MPA area are observed, principally driven by the creation of large, remote MPAs by advanced countries. MPA creation in developing nations follows temporal trends in developed nations, but at a much lower rate in terms of area and number of MPAs. Overall, trends indicate that developing economies are responding to demands for marine conservation in a similar fashion to advanced economies, but that the response lacks the momentum or level achieved in the developed world.

It is now well established that the IUCN protected-area classification system is not sufficient by itself to assess the quality of conservation in MPAs [13,16,5], however it remains a good proxy of the effort to comply with international goals and standards, and in some ways is an indicator of the success or failure of existing tools to fit with local management needs. The level of compliance with the management categories system is relatively low for all economic groups in terms of MPAs surface area, but is extremely weak for the poorest nations (from 49% of MPAs in advanced economies having an IUCN categorization to 30% in emerging and developing countries and 8% in SIDS and LDCs). Nevertheless, the majority of IUCN-classified MPAs in advanced economies are classified in categories I to IV, i.e., those having the highest conservation goals [5], and a significant number of MPAs have been reclassified

to have a standard IUCN classification in recent years, including several of the world's largest MPAs (e.g. part of the Great Barrier Reef, Western Hawaiian Islands). Therefore, though considerable work is still required to conform to international standards for MPA classification, there are signs of progress.

The recent increase of MPAs designated in category VI (Managed Resource Protected Areas) in advanced economies, in combination with the growing recognition of community based management as an efficient tool for conservation in developing countries [45], suggest that the historical emphasis on MPAs as strict conservation tools is rapidly blending into more flexible and integrative approaches, such as Ecosystem Based Management [24,46]. A growing number of tools and studies are being developed to improve and better assess the performance of integrated approaches to contribute to maintain global ocean health [24, 46]. However, as these tools are currently imperfect or incomplete, the current MPA databases do not contain the fine grained information necessary for EBM assessments, and international agreements tend to focus primarily on conservation targets in terms of area protected with limited reference to the precise nature of that "protection" (although "strict protection" is mentioned in the 5th WPC targets), it is reasonable to question whether emphasis on integrated management areas will water-down the value for marine conservation of MPA establishment. Given some working definitions of minimal requirements for MPA designation being the existence of an integrated management plan (Kaplan, personal communication), one could in the near future simply define the entire EEZs as MPAs, technically meeting most MPA coverage targets, though the real value for marine conservation is debatable.

These considerations suggest that international agreements and MPA definitions should be revisited and/or MPA databases needs to be extended to include significantly more metadata on MPA restrictions and management so as to be able to clearly separate MPAs as a strict conservation tool, which have been widely demonstrated to provide significant benefits for marine populations and ecosystems [7,47,48] from more flexible and adaptive approaches that require more fine-grained analyses to assess the value of management efforts [49-51]. Greater precision and eventually restraint in the use of the MPA title may have some side-benefits, for example by reducing conflict generated by the use of the word MPA when actual integrated management goals may cause fewer concerns [45,52], though it is hard to estimate the long-term conservation value of even symbolic MPA designation.

In order to rapidly address the lack of MPA coverage in vulnerable and/or biodiversity-rich marine ecosystems and to reach international conservation goals, initiatives such as the Global Ocean Legacy [26] have pushed for the creation of very large no-take MPAs in remote and pristine places. These efforts have been successful in rapidly increasing the MPA surface area for certain advanced economies, and ongoing establishments, notably in the Chagos/BIOT EEZ [42], Northern Mariana Islands, Australia's Coral Sea and New Zealand's Kermadec Trench [26], indicate that this trend will surely continue. While these efforts undoubtedly have significant long-term conservation interest, they, as well as all other existing very large MPAs with the exception of the Great Barrier Reef in Australia, are located in remote areas with relatively low human impacts, and therefore will contribute little to the reduction of existing global pressures on ocean ecosystems [2,3]. The phenomenon of "not-in-my-backyard" (NIMBY) strict conservation has also launched debates regarding the social justice issues regarding the right of overseas territories to manage their own resources [42]. Therefore, one must use extreme caution when assessing world progress toward marine conservation goals via these efforts and assessments at the level of individual EEZs and/or ecosystems are necessary to ensure adequate coverage of all marine habitats.

In conclusion, existing MPA databases demonstrate a clear gap between developed and developing nations with respect to marine conservation via MPA implementation, though patterns of MPA use remain extremely heterogeneous and MPA creation remains in many cases opportunistic. While international agreements have been particularly useful in advancing the cause of MPAs, recent trends of overseas implementation in relatively pristine areas and the increasing use of MPAs to designate integrated and adaptive management areas highlights the need for increased vigilance with respect to the use and abuse of the MPA designation, as well as the need to expand existing MPA databases to more accurately assess conservation value of the global MPA network.

Acknowledgments

Many thanks to the members of the IRD and IFREMER for their technical support at many stages of this work, as well as to the WCMC team for their support in using the WDPA datasets. The work of DMK was supported by the AMPED project (www.amped.ird.fr) through a grant from the French National Research Agency (ANR), Systerra Programme, grant number ANR-08-STRA-03.

References

[1] Wilkinson CR, Network GC. Status of coral reefs of the world: 2004. Darwin, Australia: Australian Institute of Marine Science; 2004.

[2] Halpern BS, Walbridge S, Selkoe KA, Kappel CV, Micheli F, D'Agrosa C, et al. A global map of human impact on marine ecosystems. Science 2008; 319: 948.

[3] Worm B, Hilborn R, Baum JK, Branch TA, Collie JS, Costello C, et al. Rebuilding Global Fisheries. Science 2009; 325: 578-585.

[4] Naeem S, Thompson LJ, Lawler SP, Lawton JH, Woodfin RM. Declining biodiversity can alter the performance of ecosystems. Nature 1994; 368: 734–737.

[5] Dudley N. Guidelines for Applying Protected Area Managment Categories. New York: World Conservation Union; 2009.

[6] Pauly D, Christensen V, Guénette S, Pitcher TJ, Sumaila UR, Walters CJ, et al. Towards sustainability in world fisheries. Nature 2002; 418: 689–695.

[7] Halpern BS, Warner RR. Review Paper. Matching marine reserve design to reserve objectives. Proceedings of the Royal Society of London. Series B: Biological Sciences 2003; 270: 1871.

[8] Lubchenco J, Palumbi SR, Gaines SD, Andelman S. Plugging a hole in the ocean: the emerging science of marine reserves. Ecological Applications 2003; 13: 3–7.

[9] Agardy MT. Advances in marine conservation: the role of marine protected areas. Trends in Ecology & Evolution 1994; 9: 267-270.

[10] IUCN. Fifth IUCN World parks congress, recommendation V.22, p.91. Durban, South Africa, 8-17 September 2003. 2003;.

[11] Wood LJ, Fish L, Laughren J, Pauly D. Assessing Progress Towards Global Marine Protection Targets: Shortfalls in Information and Action. Oryx 2008; 42: 340-351.

[12] Spalding MD, Fish L, Wood LJ. Toward representative protection of the world's coasts and oceans-progress, gaps, and opportunities. Conservation Letters 2008; 1: 217-226.

[13] Chape S, Harrison J, Spalding M, Lysenko I. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Philosophical Transactions of the Royal Society B: Biological Sciences 2005; 360: 443.

[14] Duran LR, Castilla JC. Variation and persistence of the middle rocky intertidal community of central Chile, with and without human harvesting. Marine Biology 1989; 103: 555-562.

[15] Russ GR, Alcala AC. Marine reserves: Rates and patterns of recovery and decline of

predatory fish, 1983-2000. Ecological Applications 2003; 13: 1553-1565.

[16] Weeks R, Russ GR, Alcala AC, White AT. Effectiveness of Marine Protected Areas in the Philippines for Biodiversity Conservation. Conservation Biology 2010; 24: 531-540.

[17] Bennett BA, Attwood CG. Evidence for recovery of a surf-zone fish assemblage following the establishment of a marine reserve on the southern coast of South-Africa. Marine Ecology-Progress Series 1991; 75: 173-181.

[18] Russ GR, Alcala AC. Do marine reserves export adult fish biomass? Evidence from Apo Island, central Philippines. Marine Ecology-Progress Series 1996; 132: 1-9.

[19] Attwood CG, Mann BQ, Beaumont J, Harris JM. Review of the state of marine protected areas in South Africa. SoutH African Journal of Marine Science-Suid-Afrikaanse Tydskrif Vir Seewetenskap 1997; 18: 341-367.

[20] King M, Faasili U. Community-based management of subsistence fisheries in Samoa. Fisheries Management and Ecology 1999; 6: 133–144.

[21] Pollnac RB, Crawford BR, Gorospe ML. Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. Ocean & Coastal Management 2001; 44: 683–710.

[22] Johannes RE. The renaissance of community-based marine resource management in Oceania. Annual Review of Ecology and Systematics 2002; 33: 317–340.

[23] Beger M, Harborne AR, Dacles TP, Solandt JL, Ledesma GL. A framework of lessons learned from community-based marine reserves and its effectiveness in guiding a new coastal management initiative in the Philippines. Environmental Management 2004; 34: 786–801.

[24] McLeod K, Leslie H. Ecosystem-Based Management for the Oceans. 1st ed. Island Press; 2009.

[25] Risk MJ. Paradise lost: how marine science failed the world's coral reefs. Marine and Freshwater Research 1999; 50: 831–837.

[26] Nelson J, Bradner H. The case for establishing ecosystem-scale marine reserves. Marine Pollution Bulletin 2010; 60: 635-637.

[27] Pomeroy RS, Watson LM, Parks JE, Cid GA. How is your MPA doing? A methodology for evaluating the management effectiveness of marine protected areas. Ocean & Coastal Management 2005; 48: 485–502.

[28] Agardy TS, Bridgewater P, Crosby MP, Day J, Dayton PK, Kenchington R, et al. Dangerous targets? Unresolved issues and ideological clashes around marine protected areas. Aquatic Conservation 2003;.

[29] Pajaro MG, Mulrennan ME, Vincent ACJ. Toward an integrated marine protected areas policy: connecting the global to the local. Environment, Development and Sustainability 2010; 12: 945-965.

[30] UNEP-WCMC. Data Standards for the World Database on Protected Areas. 2010;.

[31] World Bank. Data | The World Bank - http://data.worldbank.org/. 2011;.

[32] FAO. FAO Fisheries & Aquaculture - FishStat Plus. 2011;.

[33] UNEP. GEO Data Portal - The Environmental Database (search | map | graph | download). 2011;.

[34] World Resources Institute. EarthTrends: Searchable Database - Climate and Atmosphere. 2011;.

[35] NOAA. GSHHS A Global Self-consistent, Hierarchical, High-resolution Shoreline Database | ngdc.noaa.gov. 2011;.

[36] Kelleher G, Kenchington RA. Guidelines for establishing marine protected areas. Iucn; 1992.

[37] IMF. World Economic Outlook Database April 2010 -- WEO Groups and Aggregates Information. 2011;.

[38] UNSDS. United Nations Statistics Division- Standard Country and Area Codes Classifications (M49). 2011;.

[39] Gini C. Measurement of Inequality of Incomes. The Economic Journal 1921; 31: 124-126.

[40] Koenker R. Quantreg: quantile regression. R Package Version 2009; 4:

[41] Venables WN, Smith DM. An Introduction to R. Network Theory.; 2002.

[42] De Santo EM, Jones PJ, Miller AM. Fortress conservation at sea: A commentary on the Chagos marine protected area. Marine Policy 2010;.

[43] Stokstad E. Science Meets Politics Off California's Coast. Science 2010; 327: 1574-1575.

[44] Moffitt EA, Wilson White J, Botsford LW. The utility and limitations of size and spacing guidelines for designing marine protected area (MPA) networks. Biological Conservation 2011; 144: 306-318.

[45] Pajaro MG, Mulrennan ME, Vincent AC. Toward an integrated marine protected areas policy: connecting the global to the local. Environment, Development and Sustainability n.d.; 1–21.

[46] Halpern BS, Lester SE, McLeod KL. Placing marine protected areas onto the ecosystem-based management seascape. Proceedings of the National Academy of Sciences 2010;

107: 18312.

[47] Micheli F, Halpern BS, Botsford LW, Warner RR. Trajectories and correlates of community change in no-take marine reserves. Ecological Applications 2004; 14: 1709-1723.

[48] Claudet J, Osenberg CW, Domenici P, Badalamenti F, Milazzo M, Falcón JM, et al. Marine reserves: Fish life history and ecological traits matter. Ecological Applications 2010; 20: 830-839.

[49] Balgos MC. Integrated coastal management and marine protected areas in the Philippines: Concurrent developments. Ocean & Coastal Management 2005; 48: 972–995.

[50] White AT, Eisma-Osorio R, Green SJ. Integrated coastal management and marine protected areas: Complementarity in the Philippines. Ocean & Coastal Management 2005; 48: 948-971.

[51] Heck N, Dearden P, McDonald A, Carver S. Developing MPA performance indicators with local stakeholders' input in the Pacific Rim National Park Reserve, Canada. Biodiversity and Conservation n.d.; 1–17.

[52] McCrea-Strub A, Zeller D, Rashid Sumaila U, Nelson J, Balmford A, Pauly D. Understanding the cost of establishing marine protected areas. Marine Policy 2010;.

[1]Additional supporting information on the composition of each development group, on data sources and on processing steps before analyses may be found in the Fig. S.1 (world's development aggregations), Table S.1 (indicators nature and sources) and Table S.2 (indicators selection through exploratory analyses) in Appendices.

Glossary

Ecosystem based management (EBM): management strategy that aims to sustain the long-term capacity of marine ecosystems to deliver a range of ecosystems services, such as seafood, clean water, renewable energy (e.g. wave, tidal and biofuels), protection from coastal storms, and recreational opportunities, with a focus on both ecosystem health and human well-being (McLeod et al. 2005).

Effectiveness: the degree to which the ecological management objectives of a MPA are being fulfilled, particularly with regard to biodiversity and sustainable resource use.

Marine protected areas (MPAs): “any area of intertidal or subtidal terrain, together with its overlaying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment” (Resolution 17.38 of the IUCN General Assembly 1988).

Figure captions

Fig. 1 Flow chart of data processing steps. From the left to the right columns respectively group data on marine protected areas, studied countries and indicators of country profiles. Horizontal boxes indicate the steps followed to create the consistent dataset for analyses from the initial data collection. Final data concerning countries have been split in four groups depending on the type of aggregation use: 1 no aggregation, 2 aggregations of all territories by sovereign nations (Sov.Agg), 4 aggregations by development levels (Eco.Agg) and 3 aggregation both by sovereign nations and development groups (Sov/Eco.Agg).

Fig. 2 MPAs distribution. Distributions are given by country (a) in percentage of EEZ covered, (b) in area, both including polygons data only, and (c) in number. Black bars represent advanced economies and grey ones, the rest of the world's countries.

Fig. 3 MPAs distribution by IUCN and non-IUCN categories. Distribution of MPAs is given for each aggregation group, (a) in percentage of EEZ covered, including polygons data only, and (b) in number. The size of each pie is in proportion of the sum of all values.

Fig. 4 Cumulative growth of marine protected areas (MPAs). Trends are given in each development group including all categories of MPAs (a) in area and (b) in number; including only IUCN categories I to IV (c) in area and (d) in number. Each black cross represents a significant international event: Marine Program of the World Commission on Protected Areas (WCPA) in 1980; Jakarta Mandate (JM) in 1996; World Summit on Sustainable Development (WSSD) in 2002; 5th World Park Congress (WPC) in 2003; and the 8th Ordinary Conference of the Parties to the Convention on Biological Diversity (CBD) in 2006.

Fig. 5 Time series of MPAs categories. Cumulative growth of marine protected areas (MPAs) in each categories (IUCN, not IUCN and "no take zone") for Advanced economies in term of (a) area and (c) number and for the rest of the world's countries, also in (b) area and (d) number. Black crosses represent significant international events as described in Fig. 4.

Fig. 6 No-take areas distribution. Distribution of marine protected areas (MPAs), with part or all area in no-take, between each IUCN and non-standards categories, for (a) all countries and (b) advanced economies and the rest of the world's countries.

Fig. 7 Influence of four country profile indicators on marine protected areas (MPAs) distribution in each development group. (a) MPAs number distribution in function of Human Development Index (HDI), percentage of EEZ covered by MPAs in function of (b) the portion of active population employed in fisheries, (c) the daily food supply from fisheries and aquaculture and (d) the global net trade in live coral.

Supplementary figure Captions

Fig. S1 World development aggregations. World's countries distribution within the three development groups including advanced economies, developing and emerging countries and least developed countries, together with the location of the small island developing states.

Fig. S2 Time series of marine protected areas (MPAs). MPAs are reported as point data (empty bars) and polygon data (black bars) in the World Database on Protected Areas (WDPA) datasets for each establishment years; (a) including all years reported in the WDPA and (b) focusing on the years 1970, early start of the "MPAs boom", to 2009.

Fig. S3 Normalized cumulative growth of marine protected areas (MPAs). Time series are given in each development group including all categories of MPAs in (a) area and (c) number; including only IUCN categories I to IV in (b) area and (d) number. Black crosses represent international events which promoted establishment of MPAs as described in Fig. 4.

Supplementary Table Captions

Table S1 Indicator groups and sources. Detailed lists of initial indicators on country profiles and MPAs descriptors together with their nature (file types), sources, last update, geographical scale and downloading web address when available.

Table S2 Indicator selection through exploratory analyses. Results of the exploratory analyses are presented as potential correlations or trends in country profiles indicators. Indicators in grey are the one discussed in the results for which the preliminary observations were the most significant (strongest potential correlation).

Table S3 Statistics on marine protected areas (MPAs) distribution. Statistics are given globally and in each development group, considering MPAs area in km^2, coverage of the national EEZ in percentage and MPAs number. It includes for each dataset: the cardinal (n), the total, minimum, maximum, mean values as well as standard deviation, coefficient of variation and GINI coefficient. The Phoenix Island MPAs (408 400 km^2) in the Republic of Kiribati, which is include in all development group except advanced economies, was removed for calculation as it is the largest outliers in these three groups.

Figure 1

Figure1

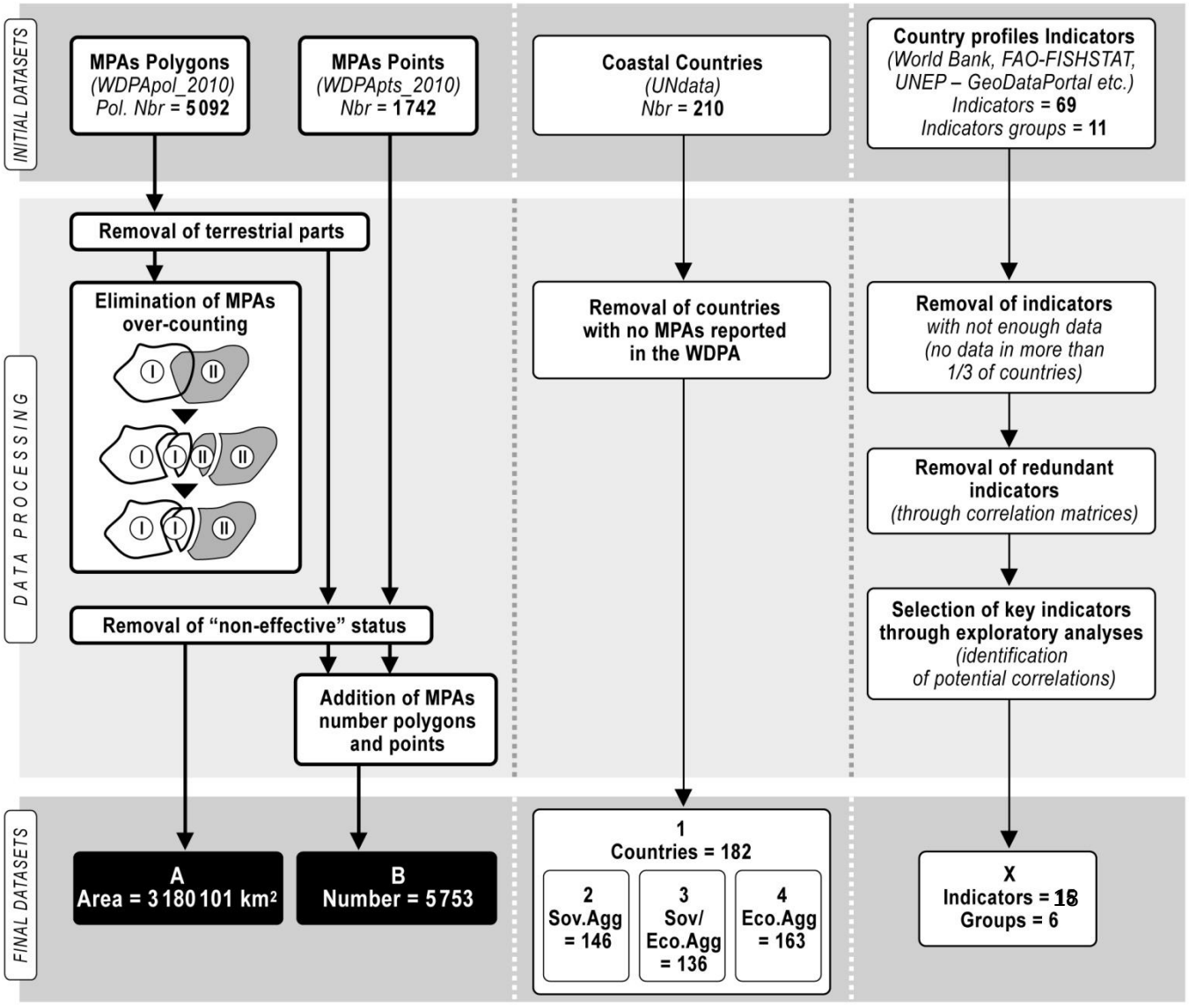


Figure 2

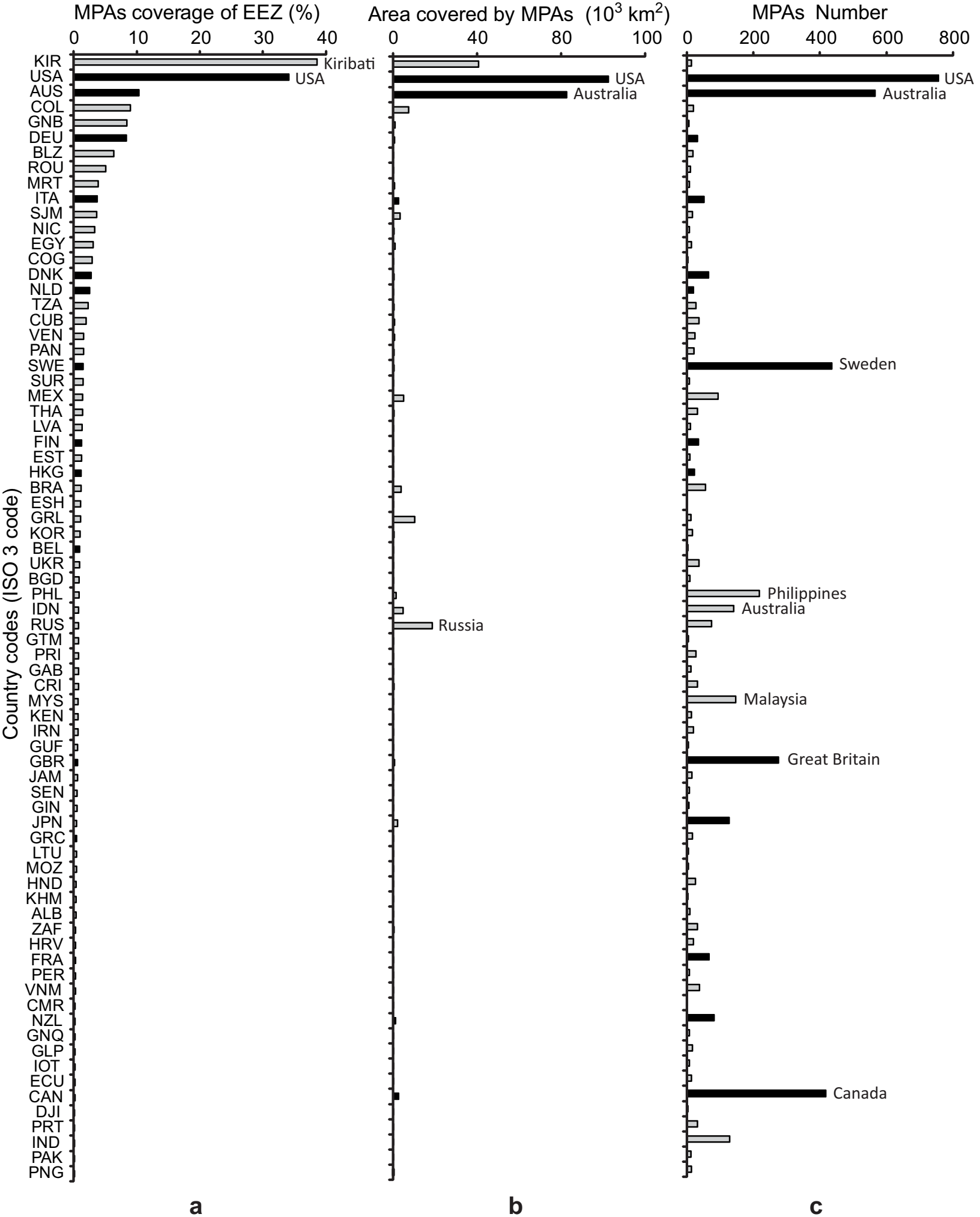

MPAs coverage of EEZ (%)
0
10
20
30
40
Area covered by MPAs (10^3 km^2)
0
40
80
100
MPAs Number
0
200
400
600
800
Country codes (ISO 3 code)
KIR
USA
AUS
COL
GNB
DEU
BLZ
ROU
MRT
ITA
SJM
NIC
EGY
COG
DNK
NLD
TZA
CUB
VEN
PAN
SWE
SUR
MEX
THA
LVA
FIN
EST
HKG
BRA
ESH
GRL
KOR
BEL
UKR
BGD
PHL
IDN
RUS
GTM
PRI
GAB
CRI
MYS
KEN
IRN
GUF
GBR
JAM
SEN
GIN
JPN
GRC
LTU
MOZ
HND
KHM
ALB
ZAF
HRV
FRA
PER
VNM
CMR
NZL
GNQ
GLP
IOT
ECU
CAN
DJI
PRT
IND
PAK
PNG
Kiribati
USA
USA
Australia
Russia
USA
Australia
Sweden
Philippines
Australia
Malaysia
Great Britain
Canada
a
b
c

Figure 3 (colour)

Figure 3

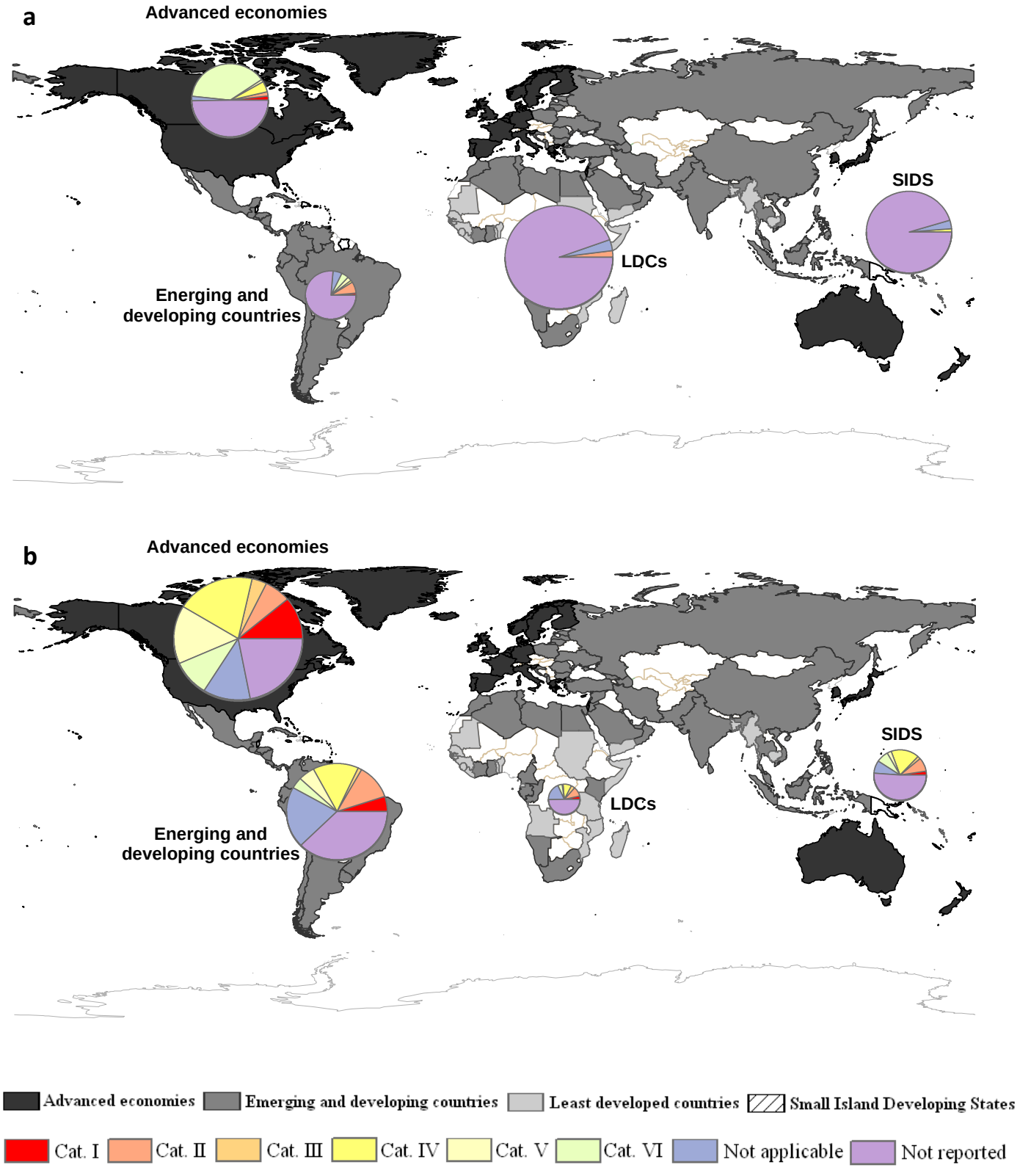


Figure 4

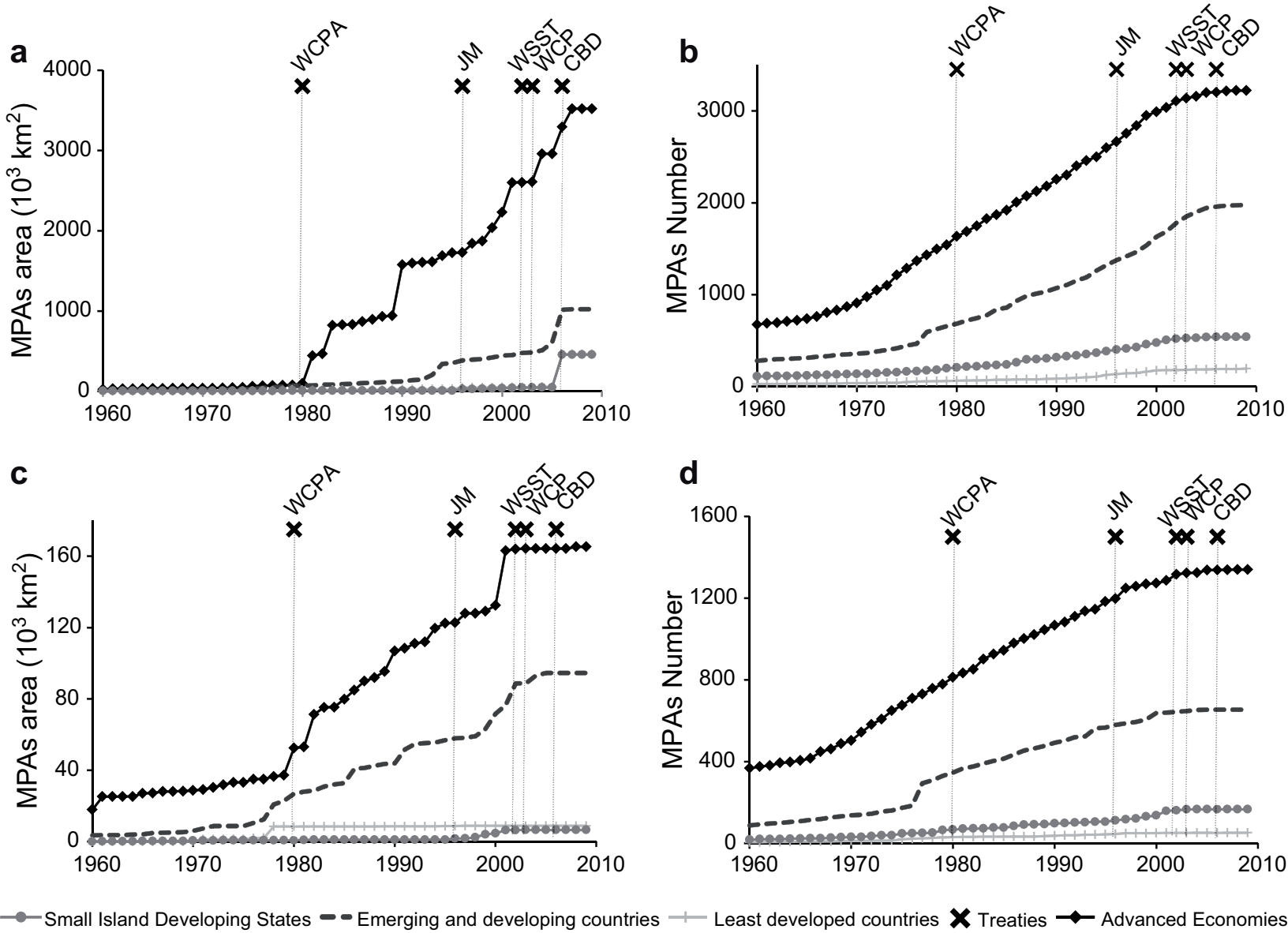

a
b
c
d
WCPA
JM
WSST
WCP
CBD
MPAs area (10^3 km^2)
MPAs Number
1960
1970
1980
1990
2000
2010
Small Island Developing States
Emerging and developing countries
Least developed countries
Treaties
Advanced Economies

Figure 5

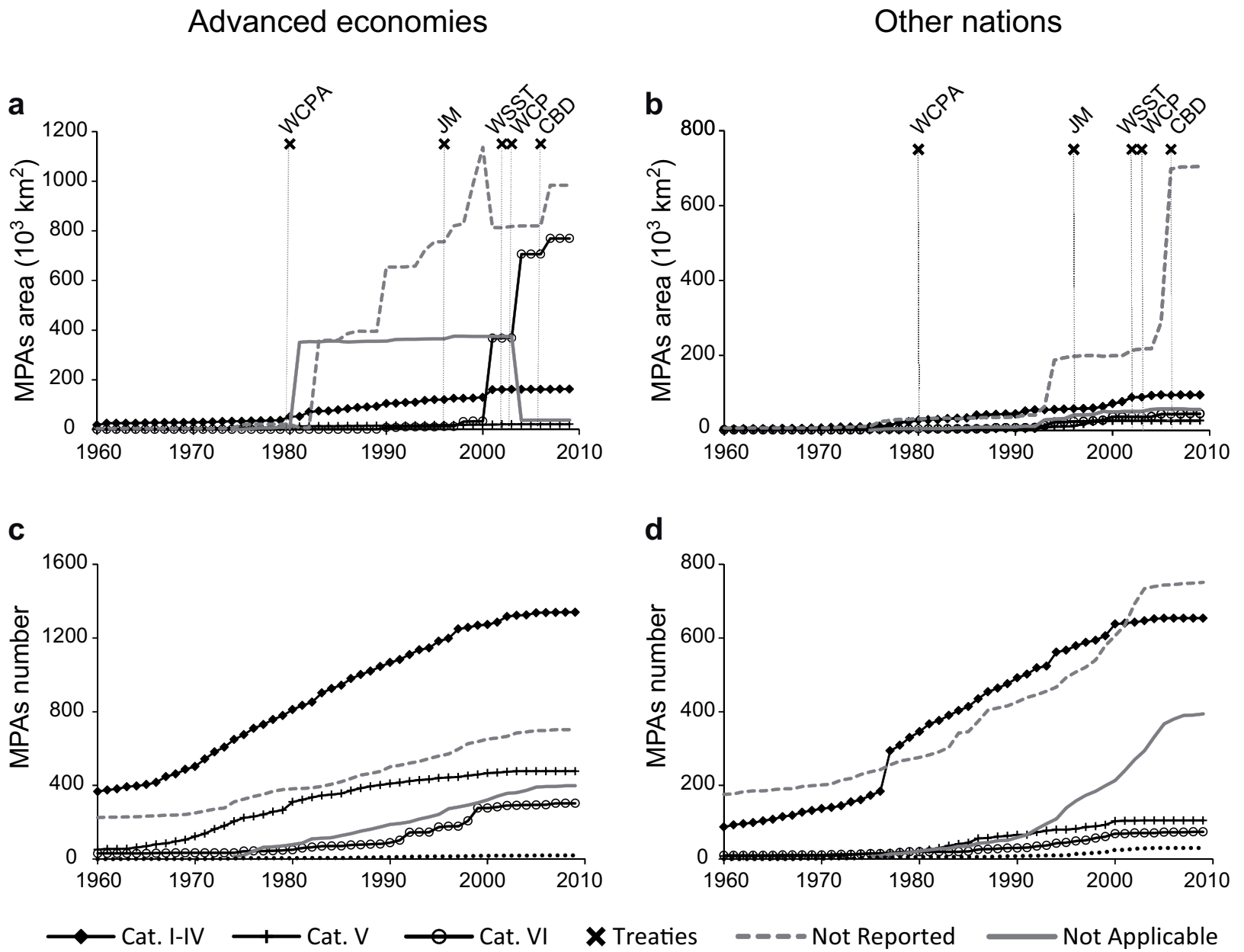

Advanced economies
Other nations
a
b
c
d
WCPA
JM
WSST
WCP
CBD
MPAs area (10^3 km^2)
MPAs number
1960
1970
1980
1990
2000
2010
Cat. I-IV
Cat. V
Cat. VI
Treaties
Not Reported
Not Applicable

Figure 6

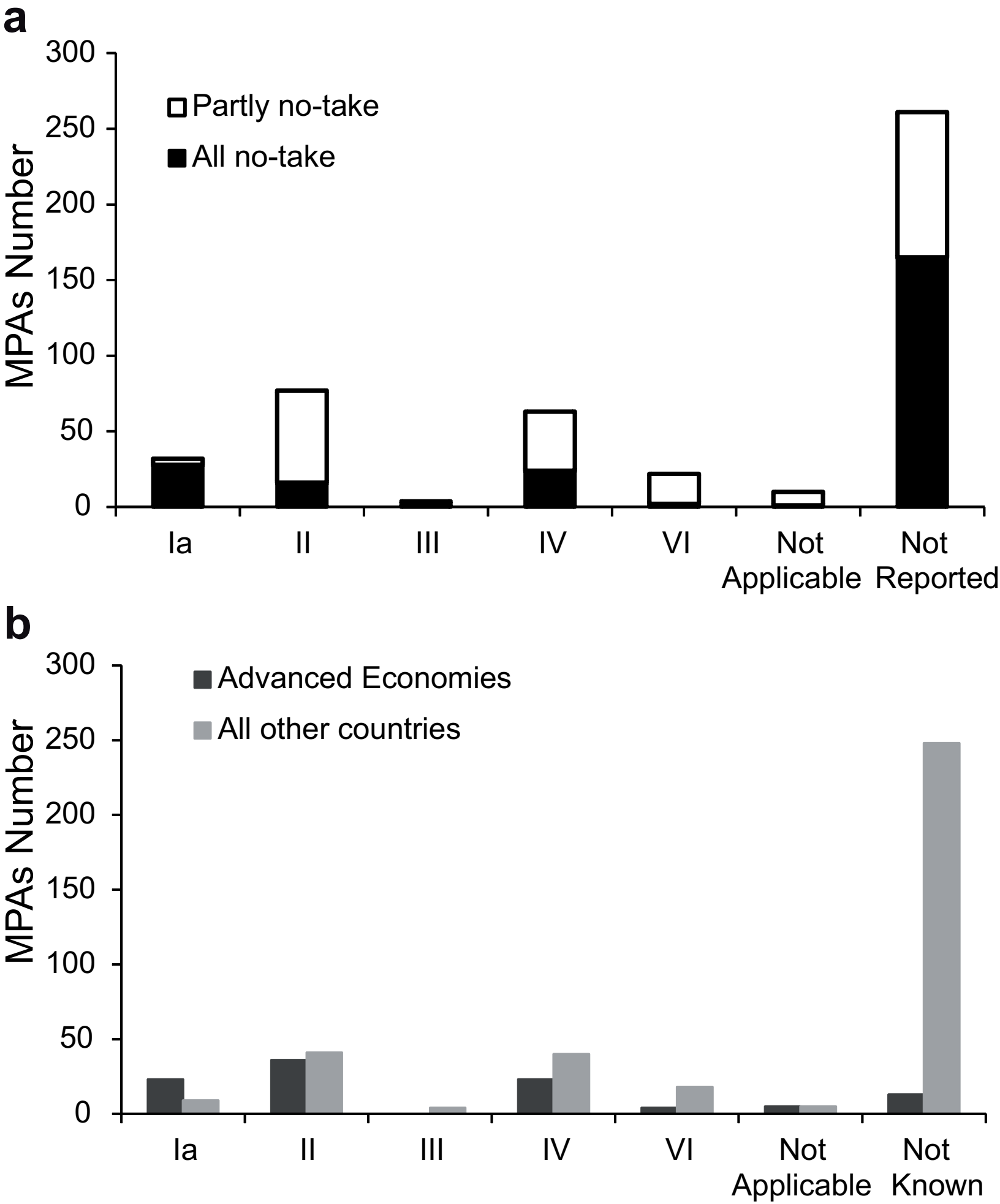
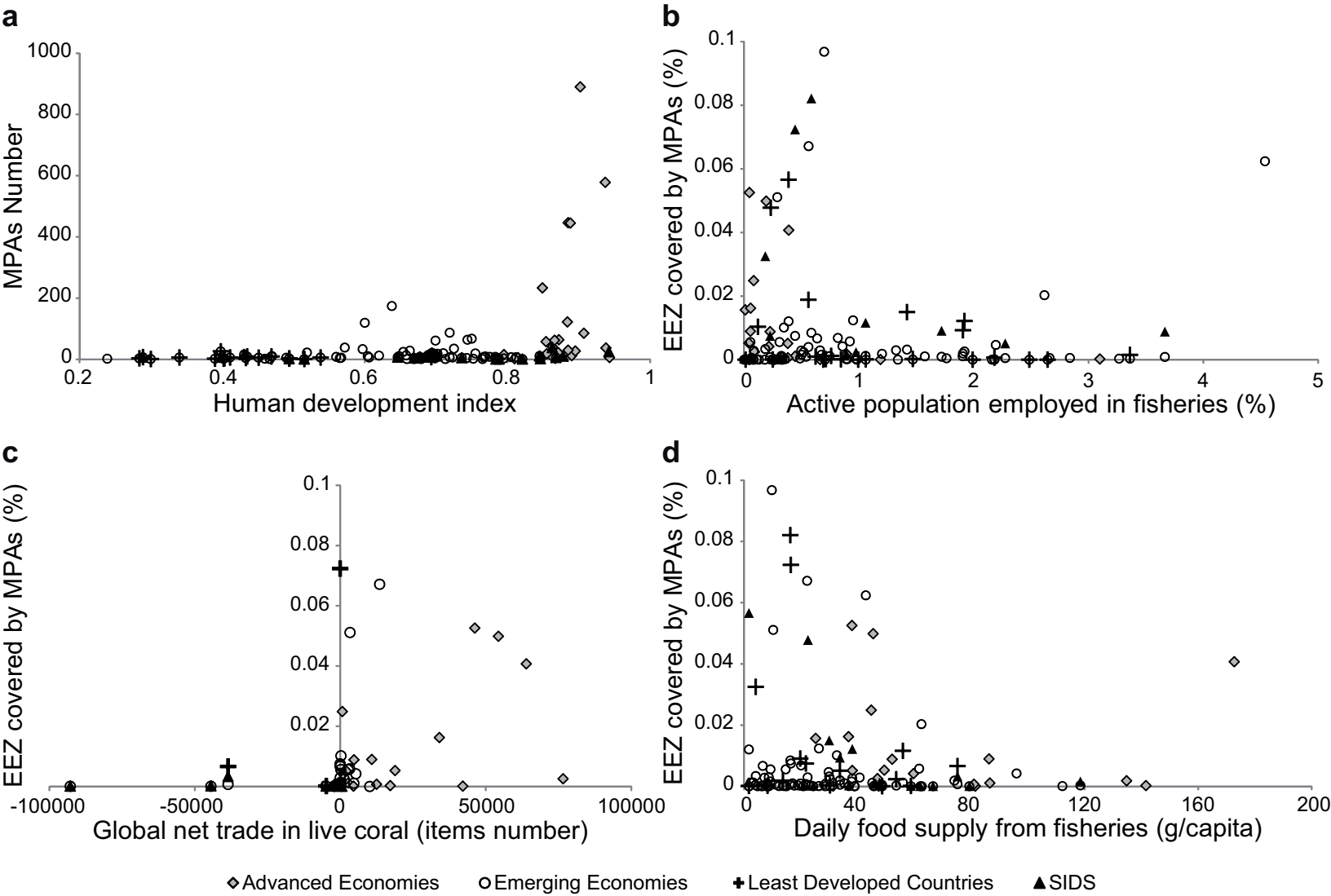

a
300
250
200
150
100
50
0
MPAs Number
Partly no-take
All no-take
Ia
II
III
IV
VI
Not Applicable
Not Reported
b
300
250
200
150
100
50
0
MPAs Number
Advanced Economies
All other countries
Ia
II
III
IV
VI
Not Applicable
Not Known

Figure 7


a
MPAs Number
1000
800
600
400
200
0
0.2
0.4
0.6
0.8
1
Human development index
b
EEZ covered by MPAs (%)
0.1
0.08
0.06
0.04
0.02
0
0
1
2
3
4
5
Active population employed in fisheries (%)
c
EEZ covered by MPAs (%)
0.1
0.08
0.06
0.04
0.02
-100000
-50000
0
50000
100000
Global net trade in live coral (items number)
d
EEZ covered by MPAs (%)
0.1
0.08
0.06
0.04
0.02
0
0
40
80
120
160
200
Daily food supply from fisheries (g/capita)
Advanced Economies
Emerging Economies
Least Developed Countries
SIDS

Supplementary data

Supporting tables and figures

Figure S.1

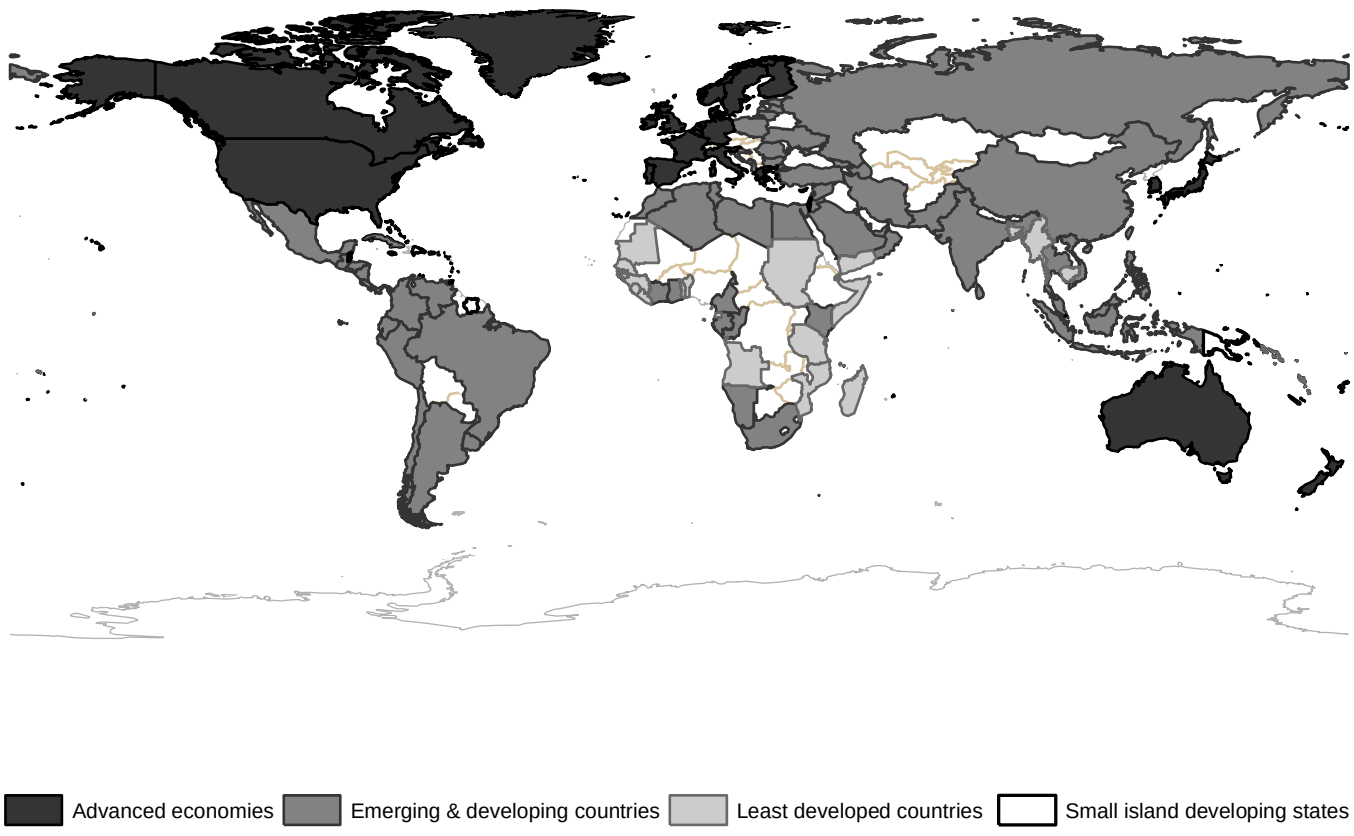

Advanced economies
Emerging & developing countries
Least developed countries
Small island developing states

Table S.1

INDICATORS GROUP	INDICATORS	FILE TYPES	LATEST YEAR AVAILABLE	Geographic extent / SCALE	SOURCE	Internet links
Marine Protected Areas (MPAs)	MPAs point (name, code, country, sub-location, designation, designation scale, UICN category, status, status year, government type, management author and plan, radius)	geospatial - SHP	2010	GLOBAL/ COUNTRY	WDPA	http://protectedplanet.net/
	MPAs polygons (" + marine and total area)		2010		WDPA	
	MPAs EEZ Geozone (" + owner type, subtidal, intertidal, EEZ name, country, area, geo-region)		2010		FAO - Geonet	http://www.fao.org/geonetwork/
	MPAs and Coral Reef ("+ presence of coral and area, presence of seagrass and mangrove)	XLS & geospatial - SHP	2010		ReefBase	http://www.reefbase.org/global_database/
	Protected Areas (Marine, IUCN Categories I-VI and not Classified) - Percent of Marine Area	GEOspatial - SHP & DBF	2010	GLOBAL/ COUNTRY / REGION	Geo Data Portal - UNEP	http://geodata.grid.unep.ch/
	Protected Areas (Marine, IUCN Categories I-VI and not Classified) - Total		2010			
GENERAL ENVIRONMENT	Fish species threatened in number	XLS Tables	2008	GLOBAL/ COUNTRY	World Bank	http://data.worldbank.org/
	GEF benefit index for biodiversity		2008			
	Mangrove forest area (km2)		1997		WRI (ISME)	http://earthtrends.wri.org/searchable_db/
	Global net trade in live coral (number)		2002		WRI (UNEP-WCMC/CITES)	
	Seagrass species number		1999		WRI (UNEP-WCMC)	
	Mangrove species number		1997		WRI (ISME)	
	Scleractinia coral species number		1999		WRI (UNEP-WCMC)	
	Disasters of Natural Origin - Affected People	GEOspatial - SHP & DBF	2004	GLOBAL/ COUNTRY / REGION	Geo Data Portal - UNEP	http://geodata.grid.unep.ch/
	Floods - Killed People		2008			
	Waves/Surges - Killed People		2008			
ENVIRONMENTAL GOVERNANCE	Participation in Treaties - Convention on Biological Diversity	GEOspatial - SHP & DBF	2010	GLOBAL/ COUNTRY / REGION	Geo Data Portal - UNEP	http://geodata.grid.unep.ch/
	ISO 14001 Certifications		2007			
	Participation in Treaties - Convention on International Trade in Endangered Species of Wild Fauna and Flora		2010			
	Participation in Treaties - United Nations Convention on the Law of the Sea		2010			
	Participation in Treaties - World Heritage Convention		2010			
	Participation in Treaties - Convention on the Conservation of Migratory Species of Wild Animals		2010			
SOCIAL DEVELOPMENT	Labor force total	XLS Tables	2008	GLOBAL/ COUNTRY	World Bank	http://data.worldbank.org/
	Life expenctancy at birth female - year		2008			
	Life expenctancy at birth male - year		2008			
	Proportion of seats held by women at parliaments %		2008			
	Technical cooperation grant US dollar		2008			
	Human Development Index (HDI)		2010		UNDP	http://hdr.undp.org/en/statistics/hdi/
	Expenditure per student tertiary % of GDP/capita		2008		World Bank	http://data.worldbank.org/
	Literacy rate adult %		2008			
	Literacy youth %		2008			
	Public spending on education %		2008			
	Land area km2		2008		World Bank	http://data.worldbank.org/
	Total population		2008			
	Rural population % of total population		2008			
	Urban population % of total population		2008			
	Population within 100 km of coast %		2000		WRI (CIESIN)	http://earthtrends.wri.org/searchable_db/

INDICATORS GROUP	INDICATORS	FILE TYPES	LATEST YEAR AVAILABLE	Geographic extent / SCALE	SOURCE	Internet links
ECONOMICAL DEVELOPMENT	GDP current us dollar/ GDP per capita	XLS Tables	2008	GLOBAL/ COUNTRY	World Bank	http://data.worldbank.org/
	Foreign direct investment US dollar		2008			
	Net official development assistance US dollar		2008			
	CPIA public sector and institution cluster average		2008			
	Country groupments (LDCs and SIDS)		2010		Geo Data Portal - UNEP	http://unstats.un.org/unsd/methods/
	R&D expenditure in % of GDP		2007		World Bank	http://data.worldbank.org/
	Researcher in R&D/million people		2007			
	Scientific and technical journal article		2005			
	Container port traffic		2008			
	Internet users/100 people		2008			
	Secure Internet server/ one million people		2008			
TOURISM	Arrivals of non-resident visitors at national border - Thousands	XLS	2008	GLOBAL/ COUNTRY	UNWTO	http://unwto.org/en
	Arrivals of non-resident tourists at national border - Thousands		2008			
	Arrivals of same day visitors - Thousands		2008			
	Cruise passenger arrivals - Thousands		2008			
	Tourism expanditures million US$	XLS Tables	2005		WRI (World Bank)	http://earthtrends.wri.org/searchable_db/
	International Tourism receipt million US$		2006			
	Tourism arrivals and departures	GEOspatial - SHP & DBF	2009	GLOBAL/ COUNTRY / REGION	Geo Data Portal - UNEP	http://geodata.grid.unep.ch/
FISHERIES & AQUACULTURE	Aquaculture Production Tonnes/Thousands US $	XLS Tables	2008	GLOBAL	FAO - FISHSTAT	http://www.fao.org/fishery/statistics/software/fishstat/
	Capture Production Tonnes (+number)		2008			
	Commodities production and trade tons/Thousands US $		2007			
	Trade in fish and fisheries products- imports value (Thousands US$)		2005			
	Trade in fish and fisheries products- exports value (Thousands US$)		2005			
	Total food supply from fish & fishery products metric tons		2002	GLOBAL/ COUNTRY	WRI (FAO - FISHSTAT)	http://earthtrends.wri.org/searchable_db/
	Fish Protein as a % of total protein supply %		2002			
	Daily food supply per capita from fish and fishery products (g/capita/day)		2002			
	Annual food supply per capita from fish & fishery products (kg/person)		2002			
	People employed in fishing and aquaculture, number		2000		WRI (FAO - FIDI)	
	Decked fishery vessels, number		1998			
GENERAL SEA BOUNDARIES	Disputed territorial sea, area (km2)	XLS Tables	2000		WRI (GMBD)	http://earthtrends.wri.org/searchable_db/
	EEZ	geospatial - SHP	2008 - 2009	GLOBAL/ COUNTRY	FAO (sea around us project & Geonet)	http://www.seaaroundus.org/
	Territorial sea		2001	GLOBAL/ COUNTRY / REGION	Geo Data Portal - UNEP	http://geodata.grid.unep.ch/
	Continental shelf		2001			
	Length of coastline		2001			
	EEZ version 5	GEOspatial - SHP & DBF	2009	GLOBAL/ COUNTRY	flanders marine institute	http://www.vliz.be/vmdcdata/marbound/download.php

Table S.2

INDICATORS GROUP	INDICATORS	Pre-correlations observed with simple plots
GENERAL SEA BOUNDARIES	Exclusive Economic Zone	Higher MPAs area in countries with largest EEZ
	Length of Coastline	The higher the lenght of coastline, the more positive correlation with MPAs number and area
GENERAL ENVIRONMENT	GEF benefit index for biodiversity	Higher GEF index where higher MPAs number
	Global net trade in live coral (number)	All exports from SIDS, where EEZ% covered by MPAs is very low, towards advanced economies where EEZ% covered by MPAs is very high
	Mangrove species number	All except advanced economies: The more sp. the lower EEZ% covered by MPAs.
ENVIRONMENTAL GOVERNANCE	Participation in Treaties - Convention on Biological Diversity Participation in Treaties - Convention on International Trade in Endangered Species of Wild Fauna and Flora Participation in Treaties - United Nations Convention on the Law of the Sea Participation in Treaties - World Heritage Convention Participation in Treaties - Convention on the Conservation of Migratory Species of Wild Animals	Higher percentage of EEZ covered by MPAs mostly in countries that have ratified a given treaty (mainly Adv. Eco). Most SIDS have not ratified the treaties and have lower proportion of MPAs (number and coverage)
SOCIAL DEVELOPMENT	Population within 100 km of coast %	In advanced economies: lower EEZ% covered by MPAs for higher coastal population In SIDS: inverse trend
	Human Development Index (HDI)	The highest MPAs numbers and coverages are observed for the highest HDI (e.g. in advanced economies)
ECONOMICAL DEVELOPMENT	GDP current us dollar/ GDP per capita	In advanced economies: higher EEZ% covered by MPAs for higher GDP In LDCs and SIDS: inverse trend
TOURISM	Tourism expanditures million US$	In LDCs: Highest MPAs number for highest tourism expanditures
	Tourism arrivals	In LDCs: Highest MPAs number for highest tourism expanditures
FISHERIES & AQUACULTURE	Fish Protein as a % of total protein supply %	All aggregations groups: the higher the proteins from fish the less EEZ% covered by MPAs
	Daily food supply per capita from fish and fishery products (g/capita/day)	All aggregations groups: the higher the supply in fisheries products the lower EEZ% covered by MPAs
	People employed in fishing and aquaculture, number	All aggregations groups: the more people employed in fisheries the lower EEZ% covered by MPAs

Table S.3

Aggregations		n	Total	Minimum value	Maximum value	Mean value	Standard deviation	Coefficient of variation	GINI coefficient
All coastal countries	**MPAs Area (km^2)**	6304	3213965	8E-12	408400 (KIR)	510	8583	16.8	0.93
	MPAs number	146	5753	1	831 (USA)	39.4	105	2.7	0.73
	MPAs %EEZ	113	**2.16**	9E-10	38.6 (KIR)	1.5	4.4	3	0.81
Advanced economies	**MPAs Area (km^2)**	4522	2184315	8E-12	327582 (USA)	436.5	7580	17.4	0.89
	MPAs number	27	3644	1	831 (USA)	135	214	1.6	0.69
	MPAs %EEZ	26	3.12	2	21 (USA)	2	0.05	0.025	0.79
Emerging and developing countries	**MPAs Area (km^2)**	1388	927287	8E-7	408400 (KIR)	668	11608	17.4	0.92
	MPAs number	107	1978	1	218 (PHL)	18	32	1.8	0.48
	MPAs %EEZ	81	1.22	2E-5	38.6 (KIR)	0.01	4.5	450	0.86
LDCs	**MPAs Area (km^2)**	104	436387	6E-5	7140 (GNB)	271	995	3.7	0.93
	MPAs number	29	195	1	27 (TZA)	6.7	6.8	1	0.45
	MPAs %EEZ	18	5.56	1.4E-3	38.6 (KIR)	3.1	9.1	2.9	0.81
SIDS	**MPAs Area (km^2)**	272	435225	3E-6	7140 (GNB)	22906	506	4.7	0.89
	MPAs number	32	383	1	37 (CUB)	12	10	0.3	0.69
	MPAs %EEZ	19	3.47	7E-5	38.6 (KIR)	3	8.9	3	0.79

Figure S.2

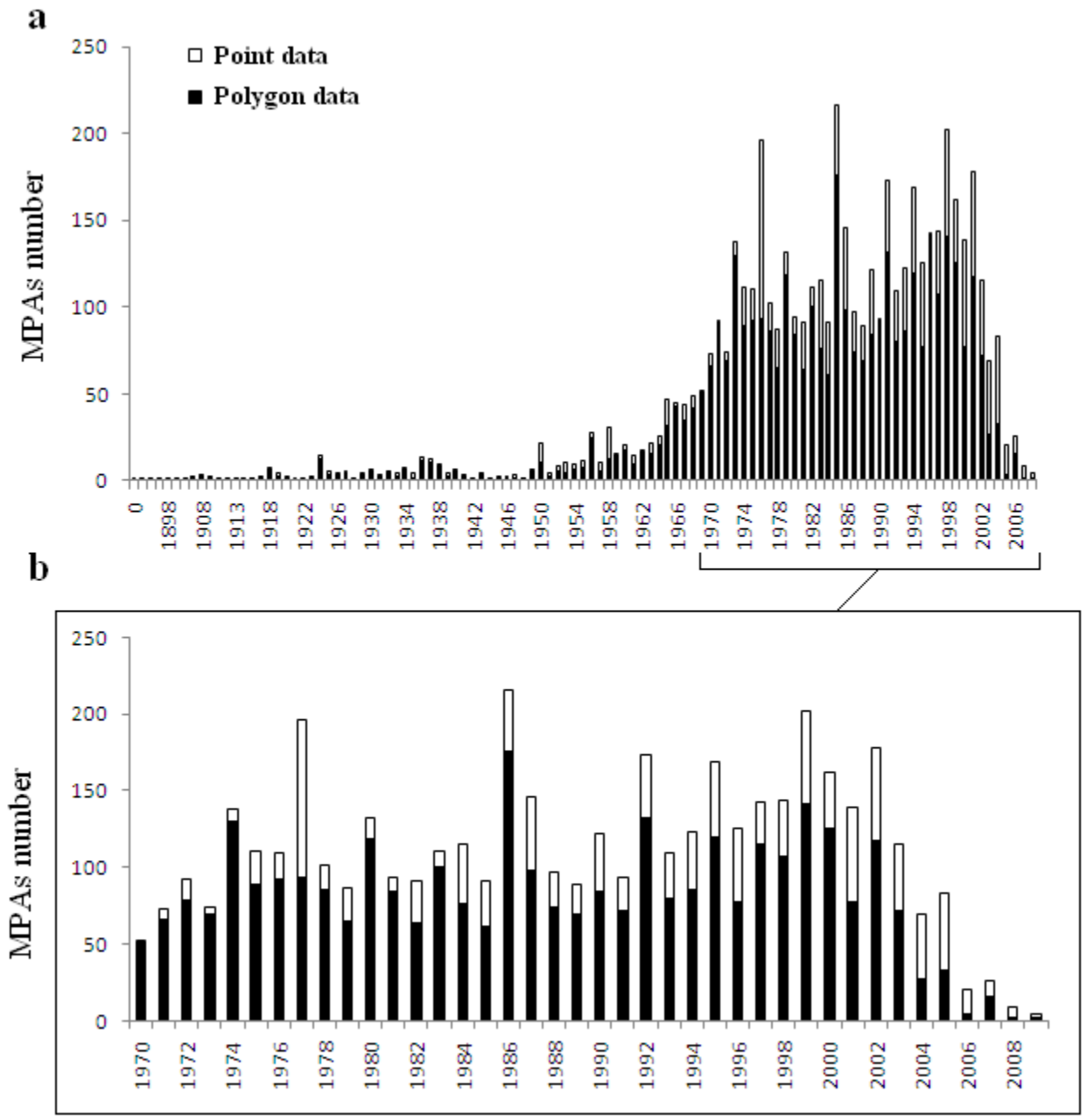
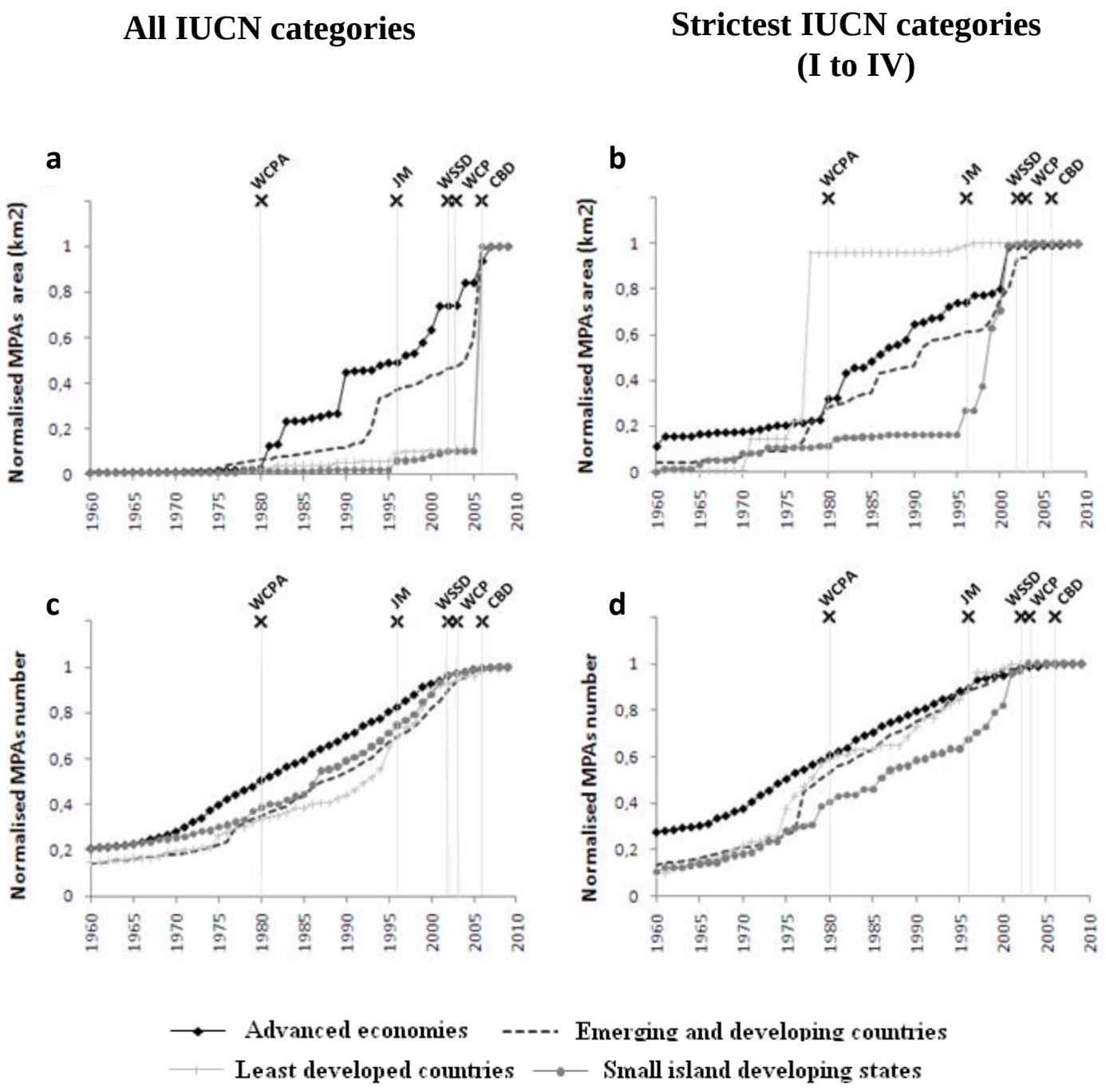

a
Point data
Polygon data
MPAs number
250
200
150
100
50
0
0
1898
1908
1913
1918
1922
1926
1930
1934
1938
1942
1946
1950
1954
1958
1962
1966
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
b
MPAs number
250
200
150
100
50
0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

Figure S.3


All IUCN categories
Strictest IUCN categories (I to IV)
a
b
c
d
WCPA
JM
WSSD
WCP
CBD
Normalised MPAs area (km2)
Normalised MPAs number
0
0,2
0,4
0,6
0,8
1
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Advanced economies
Emerging and developing countries
Least developed countries
Small island developing states