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PRELIMINARY ESTIMATES OF NATIONAL AND GLOBAL COSTS OF MARINE PROTECTED AREAS[1]

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ABSTRACT

Marine Protected Areas (MPAs) are widely seen as an important part of the solution of the global crisis of fisheries, characterized by overcapacity, habitat degradation, and declining stocks. A relevant factor in the establishment of MPAs is that of cost. This contribution estimates, based, among other things, on an empirical model linking costs and area protected, and a global database of MPAs within the EEZs of the world's maritime countries, the annual maintenance cost of the current global network of MPAs, covering 0.7 % of the world's ocean, and 1.5 % of EEZs. Results reveal a global cost estimate of about 870 million US$ for the year 2000, corresponding to about 1% of the ex-vessel value of global landings. A larger area than the present MPA coverage (e.g., 20-30 %), as targeted by various institutions, would probably be cheaper on a per area basis, as it would benefit from economies of scale.

INTRODUCTION

The most commonly used definition of a Marine Protected Area (MPA) is that established by IUCN:

> "any area of intertidal or subtidal terrain, together with its overlying 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" (Kelleher, 1999).

Clearly, the MPA concept is quite broad. Indeed, Agardy (2000) points out that it can encompass parks, ecologically focused reserves and areas designated off limits to certain fishing gears. In the past, there have always been areas of the ocean that people could not access, be they too far from shore, too deep, or too remote i.e., because we did not have the technology to exploit them (Pauly *et al.,* 2002). Such 'default' protection guaranteed that some areas remained sanctuaries for sea life (Agardy *et al.,* 2003).

Things are very different today. Dramatic advances in echolocation, catching and on-board processing technologies, along with a general increase in the size of vessels enable fishing to be conducted far offshore, and in deep waters and remote areas, such that fish are exploited anywhere they occur, and there is no more default protection. Thus, explicit MPAs have become necessary (Roberts and Hawkins, 2000; Jones, 2003), notwithstanding residual uncertainty as to their precise effects in some specific conditions (Gell and Roberts, 2003; Sale *et al*., 2005).

A number of targets for global MPA coverage have been set by the international community. Thus, in 2002, the delegates to the World Summit on Sustainable Development (WSSD) agreed that by 2012, "representative networks of MPAs" must be established (United Nations, 2002), and

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the World Conservation Union's (IUCN) 5th World Parks Congress (WPC) in 2003 echoed the advocate for such networks by 2012 (IUCN, 2003). These targets, and the exceedingly slow pace toward achieving them (or not) are reviewed in Wood *et al*. (2008).

One essential aspect of MPAs is the costs associated with their creation and maintenance. Such costs are clearly connected with socio-economic factors which, to date, have been given little emphasis (Stewart and Possingham, 2005; Sumaila and Charles, 2002). If MPAs are to play a vital role in the conservation of our oceans, we must acknowledge, as with any conservation technique, that MPAs generate, on an annual basis, costs for enforcement, management, and research, to name a few. On the other hand, MPA costs can be seen as an investment into the future of fisheries, ensuring the continuation of the resource and overall sustainability of the industry (Roberts and Hawkins, 2000). It is for this reason that the costs associated with MPAs have been categorized by Khan *et al*. (2006) as "good" subsidies to fisheries (although they were not included in their evaluation of global subsidies to fisheries).

This study aims to estimate the running costs in the year 2000 (and in 2000 US$) of the MPAs in the Exclusive Economic Zone (EEZ) of 192 maritime countries (and territories) of the world, with emphasis on the 53 countries, jointly contributing 95 % of the world catch, and which are the focus of the other contributions in this volume (Alder and Pauly, this volume).

MATERIALS AND METHODS

The three main sources of data used for this contribution were the global database of MPAs assembled and described by Wood *et al.* (2008)[2], the global fisheries catch and value database of the *Sea Around Us* Project (Pauly, 2007; Sumaila *et al.*, 2007; see also www.seaaroundus.org), and the study of Balmford *et al.* (2004) on the projected costs of future MPA networks.

Balmford *et al.* (2004) gathered their MPA cost data from approximately 500 informants working on, or otherwise connected with, MPAs. From the quotes below, we can gather that the type of MPA sampled in their study was diverse, and the size of MPAs, varied. Thus, their questionnaire focused on "information on MPA area, protection type, and goals, staffing, recurrent income and expenditure, and how much (if any) extra expenditure and staff were required for minimum effective protection."

Balmford *et al.* (2004) obtained data for 83 MPAs: "12 from Africa, 12 from Asia, 10 from Australasia and Oceania, 13 from Europe, 13 from Latin America and the Caribbean, and 23 from North America, and ranging in size from <0.1 km² to >300,000 km². As well as encompassing a broad geographic and size range [their] sample included a wide spectrum of management types (run by government agencies, nongovernmental organizations, and local communities; zoned and not zoned), objectives (e.g., biodiversity protection, recreation, conflict reduction, and fishery enhancement), and resources protected (e.g., coral reefs, whales, and coastal scenery). Of the 76 MPAs that reported their purpose, 75 (98.7%) listed habitat and species protection (the remaining MPA was solely for research), and protection was the primary purpose for 58 (76.5%)." Thus, they concluded that their sample was "broadly representative of the range of MPAs in use worldwide and should produce a meaningful approximation of the costs of running a global MPA system". However, there was one caveat: "questionnaires were only distributed to MPAs for which [they] could obtain contact details, and only 16% responded; [thus, their] figures are probably biased toward relatively well managed and funded MPAs" (Balmford *et al.*, 2004).

Balmford *et al.* (2004) derived a number of multiple regression models from their data, and concluded that "just three variables could predict nearly all of the variation in total MPA running costs." These variables were the size of MPAs (i.e., their area in km²), the distance of MPAs from inhabited land (in km), and purchasing power parity. In this preliminary study, we use the simplest of their models:

[2] MPA Global is accessible via www.seaaroundus.org

$$\log_{10}(C) = 5.02 - 0.8 \cdot \log_{10}(A) \quad \text{...1)}$$

where C is the annual cost per km², in 2000 US$, and A the MPA area in km², and which explained almost 80% of the variance in the dataset ($r^2 = 0.79$).

Equation (1) being logarithmic in both variables (i.e., highly non-linear), the cost of the MPAs of a given country must be calculated for each MPA separately, then added up (rather than adding up the MPA areas beforehand, then applying Equation (1) only once). The huge differences due to this effect, also discussed in Pauly and Ingles (1999) in connection with the relationships between shrimp catches and coastal mangrove area, are illustrated in Table 1.

Table 1. Hypothetical example of correct and incorrect applications of Equation (1) to data from a country with four MPAs of very different sizes.

MPA	Area (km²)	Cost per area ($·km^{-2})	Estimated cost (US$)
Little one	2.3	4.74	123,151
Larger one	57.4	3.61	235,348
Big one	149.6	3.28	285,098
Very big one	462.1	2.89	357,222
Total (correct)	-	-	1,000,819
Incorrect total	671.3	2.76	384,928

Equation (1) provides us with a method for approximating the cost of MPAs for a developmentally 'average' country. However, Balmford *et al.* (2004) do mention a difference in costs between developing and developed countries: the median cost of MPAs for 43 developing countries was stated as US$ 1,584·km^{-2}, while it was US$ 8,976·km^{-2} for 40 developed countries.

We used this information to correct the output of Equation (1) based on a two-step procedure: (i) we used the Gross Domestic Product per capita (GDP) of countries to slot them into one of five GDP classes; and (ii) we assigned to each country a GDP correction factor (F), based on the above medians and the GDP classes, and which was used to increase or reduce the initial cost estimates produced by Equation (1).

The GDP estimates used here originate from the World Bank (www.worldbank.org) and the International Monetary Fund, (IMF, www.imf.org), and pertain to the year 2000. Of the 192 territorial entities that have MPAs, and which are covered here, 57 lacked GDP per capita information, mainly small island states or dependent territories. The 135 countries with such GDP estimates were arranged in order of GDP per capita value, and grouped into five classes (see Table 2), with 25-29 countries per class. Given the MPA costs in developed and developing countries given above, a deviation from the mean cost (as predicted by Equation 1) of 1.7 for developed countries, and 0.3 for developing countries was calculated (which appears justified as the number of MPAs sampled from developed and developing countries were similar - 43 and 40, respectively). We then applied these multipliers to our country classes I and V, respectively, and interpolated the F-values for classes II and IV, class III having, by definition, a correction factor of 1 (i.e., we expect average costs). Table 2 presents the data involved here.

Table 2. Derivation of correction factor (F) for adjusting the output of Equation (1) to the GDP per caput (US$·10^3) of countries in 2000.

Country	GDP·caput^{-1}	F
I	>14.0	1.70
II	4.0-13.9	1.35
III	2.0-3.9	1.00
IV	0.8-1.9	0.65
V	<0.8	0.30

The 57 countries or territories lacking GDP per capita information from the World Bank or the IMF were subsequently assigned an F-factor of 1. It should be noted that these countries or territories have few MPAs, and that any subjective bias will have a limited influence on our global cost estimate. Also, in order to allow for comparison of the costs of MPAs in countries with small EEZs with those of countries with large EEZs, the MPA costs were divided, for each country and territory, by the ex-vessel value (in year 2000) of the fisheries catches in their EEZ, as given on the website of the *Sea Around Us* Project (see www.seaaroundus.org). The resulting dimensionless ratio is our proposed 'Investment to Marine Protected Areas', or MPA_{inv}, expressed in percent in Table 3. In assessing which countries are performing well in terms of running costs relative to the value of the fisheries catches, we considered an investment of 10% or more the target investment for all countries as demonstrated by Australia which is considered to be one of the most advanced countries in managing its marine protected areas, with just over 10% of its running costs. A score of 10 was assigned to those countries achieving the target investment, while countries with no investment or a low investment (i.e. MPA_{cost} = <0.5%) score zero and investments of 5% score 5.

For 55 countries, of which only one (Sweden) is included in Table 3, the method detailed above produced MPA cost estimates above 15 % of the value of their fisheries catches. In such cases, MPA_{costs} were set at 15 %; this corresponds to assuming that beyond this value, MPAs do not benefit fisheries. This does not have any impact on our scoring (see above).

Table 3. Estimates of the costs of running MPAs (in year 2000) for 53 countries jointly contributing 95% of the world marine fisheries catch, and estimates for the rest of the world (MPA costs are in US$·$10^3$; MPA_{cost} = Fisheries Protection by MPA Cost Index; see text).

Rank	Country	Costs for MPA	MPA Cost Index	Score	Rank	Country	Costs for MPA	MPA Cost Index	Score
1	Sweden	30,046	15.0	10	29	Indonesia	18,100	0.7	1
2	Germany	12,610	12.3	10	30	Japan	33,046	0.7	1
3	Australia	111,893	11.5	10	31	Norway	6,195	0.6	1
4	Denmark	21,100	8.6	8	32	Iran	1,647	0.5	1
5	UK	70,685	5.8	5	33	Ireland	1,971	0.5	1
6	Egypt	2,969	5.5	5	34	Morocco	1,248	0.5	1
7	Ukraine	1,053	4.0	4	35	Chile	2,005	0.4	0
8	Canada	141,275	3.9	3	36	Iceland	2,412	0.3	0
9	Italy	19,258	3.6	3	37	Russia	7,925	0.3	0
10	Netherlands	4,335	3.2	3	38	Myanmar	1,926	0.2	0
11	*USA	119,162	3.2	3	39	Angola	474	0.2	0
12	Spain	13,780	2.7	2	40	Senegal	322	0.2	0
13	South Africa	5,226	2.5	2	41	Bangladesh	345	0.2	0
14	Thailand	3,517	2.3	2	42	Pakistan	391	0.1	0
15	Malaysia	25,831	2.1	2	43	Viet Nam	1,880	0.1	0
16	Poland	980	1.9	1	44	Peru	635	0.1	0
17	France	8,616	1.8	1	45	Korea (South)	2,250	0.1	0
18	Brazil	16,300	1.7	1	46	India	1,198	0.1	0
19	Taiwan	3,214	1.5	1	47	Yemen	123	0.1	0
20	Sri Lanka	1,743	1.2	1	48	China	4,136	0.0	0
21	Portugal	2,602	1.1	1	49	Faeroe Islands	0	0.0	0
22	Philippines	14,182	1.0	1	50	Ghana	0	0.0	0
23	New Zealand	6,375	1.0	1	51	Korea (North)	0	0.0	0
23	Argentina	6,813	0.8	1	52	Namibia	0	0.0	0
25	Latvia	216	0.8	1	53	Nigeria	0	0.0	0
26	Mexico	6,967	0.8	1	-	--	--	--	--
27	Turkey	3,262	0.8	1	-	**All others**	**126,108**	**-**	--
28	Ecuador	376	0.8	1		**Total**	**868,722**	**-**	--

* USA includes Alaska and Hawaii

RESULTS AND DISCUSSION

Table 3 gives our MPA cost estimate for the world, and for the 53 countries which are the focus of this volume. (Detailed information for the other countries can be found, for each of the other countries and territories at www.seaaroundus.org). Globally, the estimate of MPA cost is nearly 900 million US$ for the year 2000, or about 1 % of the value of global catches. As a subsidy to fisheries, this would add about 3 % to the global estimate of 30-34 billion US$ (Khan *et al.*, 2006; Sumaila and Pauly, 2006), but in the form of 'good' subsidies, i.e., not adding to fleet capacity. As far as the 53 countries selected for comparison (Table 3), they contribute 81.1 % of the cost of MPAs in the world, below their contribution to world fisheries catches at 95 %.

The preliminary nature of these estimates cannot be overemphasized. The problems range from deficiencies in the underlying databases of MPAs, catch values and GDP, to the uncertainly in Equation (1) and its underlying database. Further, we do not believe that our attempt to correct for GDP per capita difference between countries, and hence in the cost of their MPAs, was optimal in any sense. However, not performing some type of correction would have certainly led to cost overestimates in developing, and underestimates in developed, countries. It should also be noted that Balmford *et al.* (2004) include only MPAs whose total area is at least 50 % marine; this differs from MPAs used in this research: MPA Global includes MPAs based on the IUCN definition noted previously, and incorporates MPAs that range from 0.03 % marine in area to 100% marine.

Balmford *et al.* (2004) mention other possible bias: the data from which Equation (1) was derived were from those individuals who responded to their survey, i.e., persons for the most part involved in MPAs easier to access or more responsive to the public. They also remark that upon collection of MPA data, if there was any ambiguity between terrestrial and marine reserve costs, they tended to ascribe all costs to the marine component, which could potentially contribute to an overestimation of MPA cost.

The data generated in this study shows a high percentage of the countries have low MPA_{cost} scores. This is in part a reflection of the dominance of small, relatively expensive to operate MPAs. Only three countries, which are already known to have large MPAs, scored the highest (i.e. 10) – Sweden, Germany and Australia, are all developed and relatively wealthy countries.

Although Balmford *et al.* (2004) do not give an annual cost estimate for the current global MPA system (as reflected in www.mpaglobal.org), they suggest an annual cost for 20-30 % coverage of global oceans of US$5-19 billion. Given that current MPAs cover only 0.7 % of the entire ocean (Wood *et al.*, 2008), but cost nearly US$900 million to maintain, one could assume that it would cost US$27-40 billion annually to protect 20-30 % of the global oceans. This value is much higher than the cost estimate in Balmford *et al.* (2004) because it is affected by the many small (and relatively costly) MPAs in MPA Global, which comprises over 4400 entries. Balmford *et al.* (2004), on the other hand, base their projections on 83, generally larger MPAs. The mean size of an MPA in MPA Global is 544 km², but the median is 4.6 km². This vast disparity between mean and median values is a result of the ten largest MPAs, which make up 68% of the world's cumulative MPA area (Wood *et al.*, 2008).

However, a high percent coverage of MPAs, i.e., the 20-30 % figure used above, is not achievable, within the next decades, by projecting present trends in number and cumulative coverage of MPAs (Wood *et al.*, 2008). Indeed, the CBD and WSSD target (see above) can be reached only by the rapid creation of a great number of very large MPAs. These are very 'cheap' on a per area basis (see Table 2), and hence both of the above cost estimates, ours and that of Balmford *et al.* (2004), are likely to be far too high. In any case, it would be a useful expense, given present trends of degrading fisheries resources and marine biodiversity.

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