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How healthy is the human-ocean system?

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Abstract

Halpern *et al* (2012 An index to assess the health and benefits of the global ocean *Nature* **488** 11397) propose a detailed measure of the state of the human-ocean system against ten societal goals. They devote less attention to the normative foundation of the index, which is crucial for assessing the overall health of the human-ocean system, notably when it comes to aggregation of potentially conflicting goals. Social choice theory provides several possible functional forms for assessing the compound change in various goals. The one chosen by Halpern *et al*, the arithmetical mean, is not only a specific but also an extreme case. It implicitly allows for unlimited substitution. A one-unit reduction in one goal can be fully offset by a one-unit increase in another with the same weighting factor. For that reason, the current index satisfies an extremely *weak* sustainability concept. We show that the results in Halpern *et al* are not robust when one adopts a *strong* sustainability concept. The overall health score of the ocean decreases, the ranking of the various coastal states changes substantially, and the assessment of sustainable development needs to be partially reversed.

Keywords: human-ocean system, sustainable development, strong and weak sustainability

1. Introduction

The ocean with its various services and resources is essential for human wealth and development—providing humanity with food, materials, essential substances, energy, and recreational opportunities. However, the free access to, and availability of, ocean resources and services has exerted major pressures on the health of the ocean, including overfishing, thoughtless pollution, or alterations to coastal zones that often cause the degradation of marine ecosystems (coral reefs, mangroves, etc), to name just a few (Visbeck *et al* 2014). Despite these threats, approaches to achieving more sustainable utilization of ocean resources and services are still rare, and a comprehensive understanding and assessment of the various oceanic factors influencing human wealth has not been established. Against this background, the development of an ocean-health index by Halpern *et al* (2012) and its subsequent annual updating is an important step towards a sustainable development strategy for the ocean.

Halpern *et al* (2012) define ten ocean-related societal goals to represent the ecological, social, and economic benefits of the ocean and calculate the ocean-health index at the global and local level by taking the weighted arithmetical average score of these goals. The values associated with the goals reflect not only information about the present state but also contain projections of future states derived from the assessment of the pressures on, and the resilience of, the human-ocean system. Accordingly, the values also enable us to derive information on the sustainability of human-ocean system developments. In addition, a first estimate about trends is now possible, as the scores have meanwhile been updated for the year 2013.

However, even though Halpern *et al* carry out a sensitivity analysis with respect to the weighting of the various goals and the discounting of future states, they leave out the sensitivity of the result to the way in which conflicting goals are aggregated. Implicitly they consider a rather extreme 'normative frame', that of unlimited substitution possibilities among the various goals. Here, we show i) that their aggregation approach should only be considered one possibility among many in assessing the human-ocean system and ii) that assuming less optimistic substitution possibilities—which seems more appropriate when assessing the sustainability of complex human-ecological systems with possible irreversible degradations—has significant implications for the overall ocean health score, the ranking of countries, and the assessment of sustainable development.

A requirement for sustainable development is that the composite endowment with environmental assets does not decrease (e.g., Pearce 1993, Arrow 2003, Dasgupta 2009). However, aggregating environmental assets requires attention to the substitution potential among them—which may be limited for ecological or technical reasons or because social preferences only allow substitution to a limited extent (e.g., Bartelmus 1989, Daly 1991, Victor 1991). Varying degrees in substitution potential are reflected by the distinction between *strong* and *weak* sustainability. The concept of *strong sustainability* requires keeping all assets above critical levels to maintain sustainable development because it does not allow for substitution between them. The concept of *weak sustainability,* by contrast, allows for unlimited substitution and requires that the aggregate of the various assets (valued with their respective shadow prices) does not decline (e.g., Pearce *et al* 1989, Daly and Cobb 1989, Hartwick 1990, Hamilton 1994). Obviously, there exists a broad spectrum between these two extremes, and the appropriate level of substitution potential can be expected to differ dependent on the characteristics of the underlying assets to be assessed (e.g., Bateman *et al* 2011). However, facing complex ecological-human interactions like the human-ocean system, limited substitution possibilities satisfying a rather strong sustainability concept seem to be better suited to accounting adequately for the influence of the various stocks on wealth (e.g., Dasgupta and Heal 1979, Pearce *et al* 1989, Ekins *et al* 2003, Ayres 2007, Visbeck *et al* 2014).

We employ results from social choice theory to show that, based on the underlying assumptions in Halpern *et al* (2012), a meaningful aggregation of the individual goal scores can be obtained by applying a *generalized mean*. Accordingly, there is a full family of specific functional forms for the ocean-health index depending on the specification of a parameter that characterizes the substitution possibilities. Following the literature on natural resource and ecosystem assessment, we assume limited substitution possibilities for the various goals reflecting the state of the human-ocean system. Decreasing the substitution parameter lowers the overall index from 65 to 52 in 2012 and 2013 because it reduces the potential for offsetting poorer performances in certain goals by better performances in other goals. The implications of a decreased substitution parameter become more striking when we turn to the assessment of individual countries. Countries with an unbalanced performance across the goals significantly deteriorate in the ranking compared to countries with a balanced performance. For example, Russia and Greenland fall in the ranking for 2013 by about 107 and 118 places (out of 220) respectively, while Indonesia and Peru improve by about 78 and 88 places respectively.

This effect also becomes significant in assessing the sustainability of current development by comparing the scores between 2012 and 2013. For 29 out of 220 countries, the ocean-health index increases if we assume unlimited substitution possibilities but decreases if we assume limited substitution possibilities. By contrast, there are 21 countries whose score deteriorates under a concept of weak sustainability (unlimited substitution possibilities) but improves under a concept of strong sustainability. Hence we conclude that appropriate ocean management and governance requires thoughtful attention to the method used for data aggregation and the value of the parameter quantifying substitution possibilities among the various goals if we are to obtain a meaningful and appropriate assessment of the state of the human-ocean system.

2. Methods

The ten ocean-related societal goals of the ocean health index are 1) 'Artisanal Fishing Opportunities', 2) 'Biodiversity' ('Species' and 'Habitats'), 3) 'Coastal Protection', 4) 'Carbon Storage', 5) 'Clean Waters', 6) 'Food Provision' ('Wild Caught Fisheries' and 'Mariculture'), 7) 'Coastal Livelihoods&Economics' ('Livelihoods' and 'Economics'), 8) 'Natural Products', 9) 'Sense of Place' ('Iconic Species' and 'Lasting Special Places'), and 10) 'Tourism&Recreation' (Halpern *et al* 2012). Certain goals are aggregates of subgoals indicated by the terms in the parenthesis above. The goals and subgoals reflect the present and future state, the latter being derived from the assessment of the pressures on, and the resilience of, the specific goal. The ocean-health index is obtained by aggregating the various goals and is calculated at global and local level. Its first release in 2012 provided a ranking of 171 coastal states and regions based on the condition of their marine ecosystems in their EEZs. The index is updated annually, and at present information on ocean health for the year 2013 is already available on the ocean-health index website[4]. The updated ocean-health index for 2012 and 2013 ranks a total of 220 countries/islands compared to 171 countries/regions in Halpern *et al*. This is due to the fact that previously aggregated regions (like, say, the USA Pacific Uninhabited Territories) have now been evaluated and assessed separately.

In compiling an index, I, like the ocean-health index, a major challenge is the aggregation of different goals reflecting issues as different as oceanic carbon uptake and the number of jobs in the fishery sector. Generally, achieving a meaningful aggregation of such ratio-scale but non-comparable goals would require applying a (weighted) geometric mean (e.g., Ebert and Welsch, 2004). However, such an index would (a) only allow for an ordinal and not a cardinal comparison of the coastal zones and (b) preclude investigation of different levels for the substitution possibilities.

Consequently, Halpern *et al* assume the existence of goal-specific scaling factors to obtain *fully comparable* ratio-

[4] http://www.oceanhealthindex.org/.

scale indicators or goals. The scaling factors are obtained by the potential goal-specific best value, thus producing individual goals ranging between 0 and 1 that are then rescaled in terms of the ratio-scale property to be in the range between 0 and 100. According to social choice theory, meaningful aggregation for N ratio-scaled indicators or goals I_i is obtained by applying generalized means (Blackorby and Donaldson, 1982):

$$I\left(a_i, I_i, \sigma\right) = \left(\sum_{i=1}^{N} \alpha_i I_i^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

with weights $\alpha_i > 0$ and $0 \leqslant \sigma \leqslant \infty$. The parameter σ quantifies the *elasticity of substitution* between the different indicators for generating ocean health (Solow 1956, Arrow *et al* 1961, Armington 1969). Thus the ratio-scale fully comparable goals allow for a full class of specific functional forms for the index dependent on σ, which we denote by $I(\sigma)$ because we do not consider any variation in the weights or the individual indicators. Halpern *et al* have chosen the extreme case of unlimited substitution, $\sigma \to \infty$, which results in the arithmetical weighted mean

$$I(\infty) = \sum_{i=1}^{N} \alpha_i I_i. \tag{2}$$

For this specification of σ, the distribution of scores over the different indicators only has any bearing on the value of the ocean-health index to the extent that the constant weighing factors may differ.

Considering limited substitution possibilities instead, and hence subscribing to a concept of relatively strong sustainability, requires choosing a value for σ below 1 (e.g., Gerlagh and van der Zwaan 2002, Heal 2009, Bateman *et al* 2011, Traeger 2013). More specifically, Sterner and Persson (2008) suggest using $\sigma = 0.5$ in their study of the human-climate system. Instead of choosing a specific value for σ, we assume σ to be uniformly distributed between 0 and 1 and perform a Monte Carlo simulation ($n = 10\,000$) to recalculate the ocean-health index for 2012 and 2013 based on the equally-weighted individual goal scores obtained from the ocean-health website. The simulation results are not only used to derive the average score but also to calculate a ranking for each simulation and obtain average ranking information. Coastal states with one or more zero scores in an individual goal obtain an index value of zero for $\sigma \leqslant 1$ (22 and 21 countries in 2012 and 2013 respectively). Accordingly, all these countries were ranked last. To obtain further ranking information for these countries, we performed stepwise exclusion of those goals with a zero score. Accordingly, complete rankings for 220 countries have now been obtained. To further test the sensitivity of the results to the strong sustainability assumption, we repeated the entire calculation with σ assumed to be exponentially distributed with mean 0.5 so that substitution elasticities above 1 are also considered in the Monte Carlo simulation. The comparison of changes in ocean-health scores between 2012 and 2013 for the different specifications makes for further insights about the sensitivity of sustainable development to the substitution possibilities.

3. Results

Under a concept of weak sustainability (unlimited substitution possibilities, $\sigma \to \infty$) as assumed by Halpern *et al*, the index value for both 2012 and 2013 is 65 (with the best possible value being 100). If instead of this we apply a concept of strong sustainability with σ uniformly distributed between 0 and 1, the index values decrease to 52.14 (±8.26) and 51.99 (±8.17) in 2013 and 2012 respectively. The figures in parentheses show the standard deviation. The reduction in the index value is a necessary result of reducing the substitution possibilities because low substitution possibilities imply an unambiguously lower absolute score than with unlimited substitution possibilities, except for the special case of an equal (weighted) score in each goal. The concept of strong sustainability, corresponding to low substitution possibilities, imposes greater restrictions on the potential to compensate for poor performance in certain goals and therefore gives more weight to low-performing goals. Accordingly, assuming σ to be distributed exponentially with mean 0.5 and hence allowing for substitution elasticities above 1 results in a less extreme reduction of ocean-health scores, i.e. 57.92 (±8.07) and 57.70 (±7.98) for 2013 and 2012 respectively.

The implications of differences in substitution possibilities become especially important when comparing the performance of various countries or when assessing development over time. Figure 1 shows the rankings of the 220 countries for $\sigma \to \infty$ and $\sigma \sim U(0,1)$ in 2013, where the error bars indicate the standard deviation obtained from the sensitivity analysis. Without any effect from varying the substitution parameter, data points for all countries would be on the 45° line. The figure reveals, however, that the distribution of scores across goals significantly changes the ranking. Above the 45° line are those countries with a rather unbalanced performance and therefore with lower rankings under limited substitution possibilities than under perfect substitution possibilities, and vice versa for countries below the 45° line. Figures A1 and A2 in the appendix show the results for the first 50 countries in 2013 in more detail (A1) and the ranking comparison for 2012 (A2). Table A1 in the appendix provides index and ranking information for 2013 for all countries and islands and the change in the index between 2012 and 2013 resulting from the different specification for the substitution possibilities[5].

The sensitivity of the ocean-health index to substitution possibilities is particularly apparent for countries with rather uneven ocean-health characteristics. Figure 2 shows the ocean-health index in dependence on substitution elasticity for five selected countries/islands. While both the Amsterdam and Saint Paul's Islands and Ile Europe have low to

[5] Detailed index and ranking information on all countries and islands with regard to the different specifications for the substitution possibilities in 2012 are available from the authors upon request.

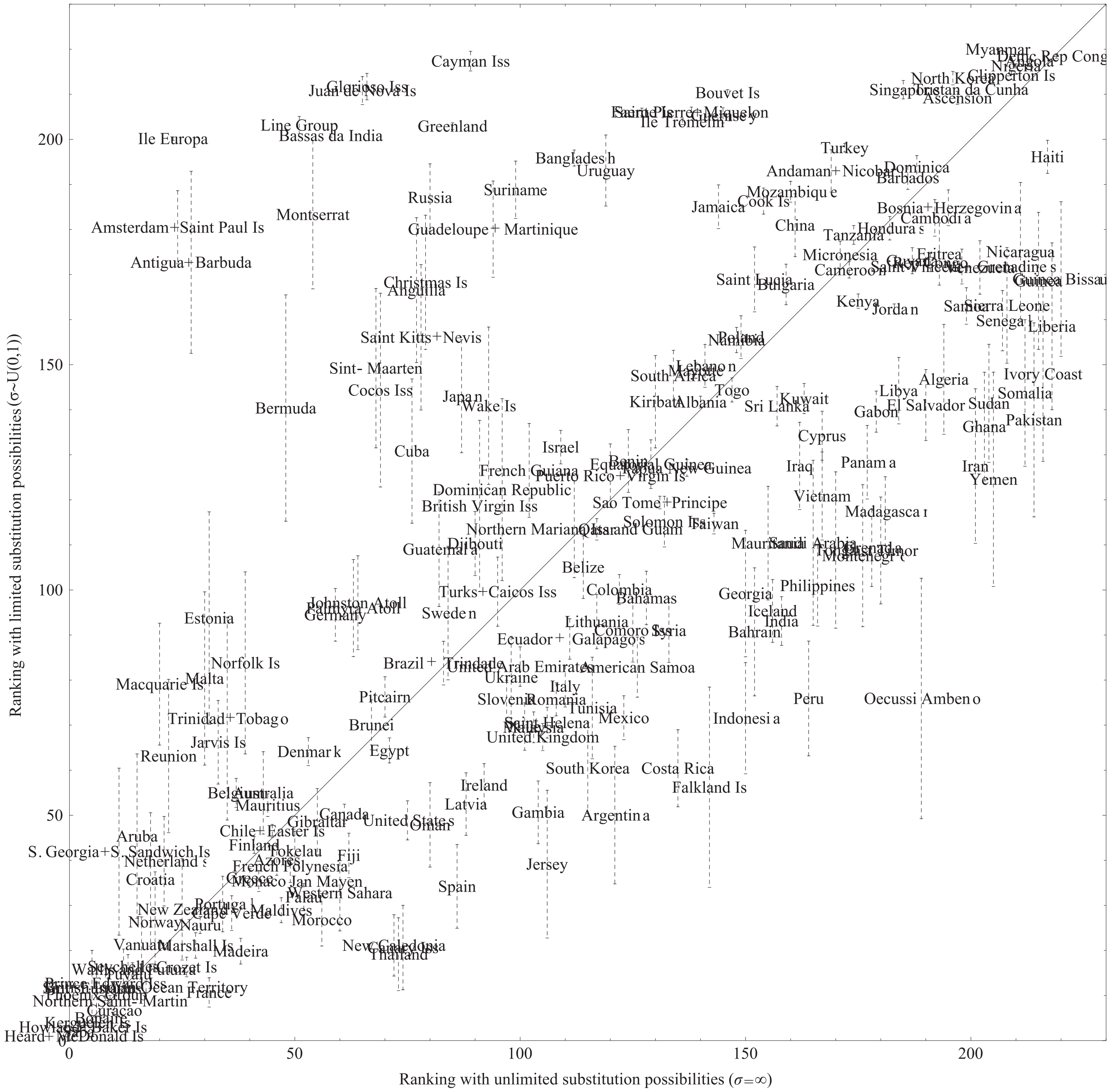

Figure 1. Comparison of ocean-health rankings in 2013 for 220 countries with unlimited substitution possibilities (weak sustainability) and with limited substitution possibilities (strong sustainability). The data point is in the middle of the respective country's name; error bars indicate ±1 standard deviation.

zero scores for $\sigma < 1$, they improve their score significantly when substitution elasticity increases beyond 1. For high substitution elasticities they obtain a larger index value than New Zealand, Thailand, and the Falkland Islands, whose individual goal scores add up to less but are more evenly distributed among the goals. Despite the very poor performance of the Amsterdam and Saint Paul's Islands in 'Food Production' (with a value of 2) and of Ile Europa in the individual goal 'Sense of Place' (with a value of 0) in 2013, a concept of weak sustainability would cause their human-ocean system to be assessed as healthier than, for example, that of the Falkland Islands, which perform much better in their lowest individual goal score ('Food Production', with a value of 34).

Consequently, accounting for the influence of the substitution possibilities is important when assessing sustainable development. Figure 3 shows the change in the overall ocean-health index between 2012 and 2013, again for weak sustainability ($\sigma \to \infty$) and strong sustainability ($\sigma \sim U(0,1)$). Of specific interest are those countries in the second and fourth quadrant in figure 2. The former shows those countries that have developed unsustainably in accordance with the concept

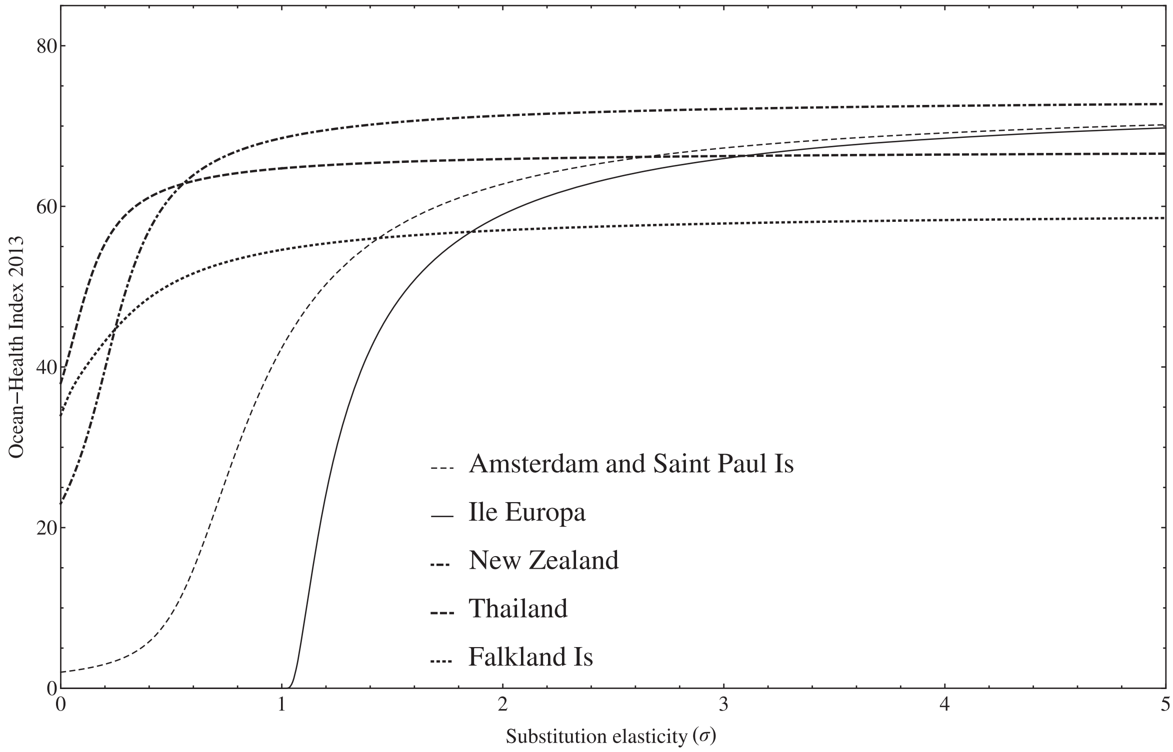

Figure 2. Ocean-health index dependent on substitution elasticity for selected countries.

of weak sustainability adopted by Halpern *et al*, but sustainably in accordance with a concept of strong sustainability. Among these 21 countries are prominent examples like Ghana, Canada or Australia. The fourth quadrant shows those countries that have developed sustainably in accordance with a concept of weak sustainability but unsustainably in accordance with a concept of strong sustainability. Among these 29 countries there are prominent examples like China, Brazil or South Africa.

4. Discussion and conclusion

The specification of the substitution possibilities cannot be derived from scientific research alone, but requires a normative foundation. Nevertheless, when dealing with such a variety of goals, all of which are essential for human well-being, the substitution possibilities should not be considered unlimited. Certainly, the goals defined by Halpern *et al* (2012) are interlinked by various biological relationships that reduce the probability of situations where certain goals deteriorate without affecting the health of other goals. However, these relationships are not fully understood, and the substantial score-spreads across goals among the countries indicate that various developments are not properly captured by biological relationships. Accordingly, we propose an alternative specification with substitution elasticity below 1 to allow for some degree of substitution but with a significant influence on the overall score by the least-performing goal.

Even though this approach satisfies a stronger sustainability concept, it is somewhat restrictive as it does not distinguish the substitution possibilities among the various goals. By contrast, it avoids any attempt to distinguish between the various goals to emphasize the importance of aggregation from a methodical perspective. However, there may be better substitution possibilities, for example, between goals like ‘Coastal Livelihoods&Economics’ and ‘Tourism&Recreation’ than between those goals and such an essential goal as ‘Biodiversity’. We can deal with these varying degrees of substitution potential or individual goal significance by using a nested index or by introducing safe-minimum standards respectively. In its existing form, the ocean-health index already entails goals that summarize different sub-goals, here again, however, with unlimited substitution possibilities. In general, applying a nested index with various levels allows for consideration of different substitution possibilities at different levels by, for example, first aggregating capital stocks or goals with better substitution possibilities (Dovern *et al* 2014). Furthermore, safe-minimum standards for ecosystem services can be sustained by avoiding potential critical zones for the state of these ecosystems (Ciriacy-Wantrup 1952). Such minimum standards can easily be introduced by defining lower bounds for certain goals. The individual goal score would drop to zero if the goal falls short of this bound, and the overall score will also drop to zero if substitution elasticities are assumed to be below 1 (Heal 2009), albeit without dominating the index score if the state is still in good condition,

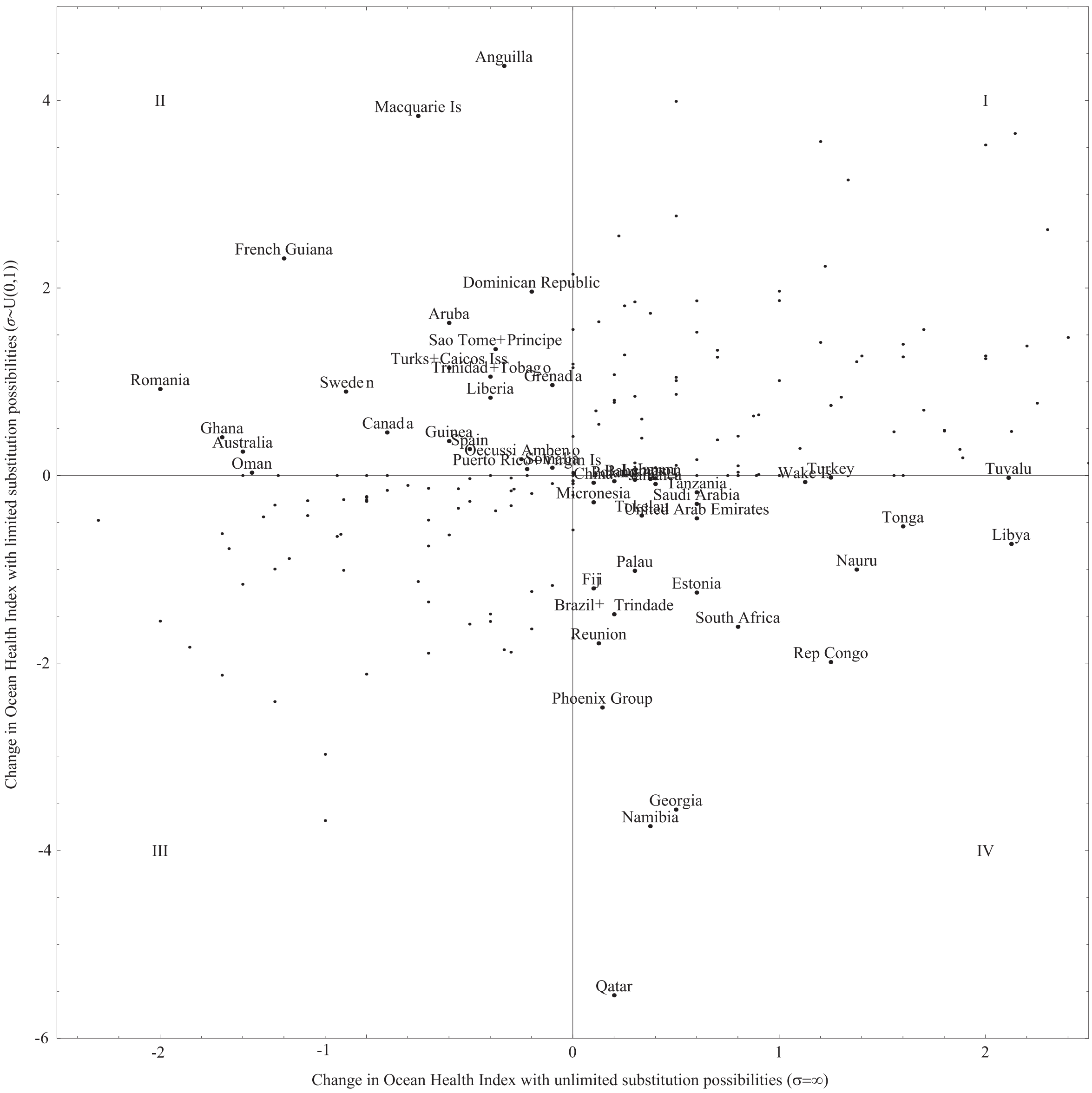

Figure 3. Comparison of change in the ocean-health index between 2012 and 2013 with unlimited substitution possibilities (weak sustainability) and with limited substitution possibilities (strong sustainability). Only the countries and islands in the second and fourth quadrants are indicated by name.

which would in turn result from significantly increasing the weight of the goal.

The work by Halpern *et al* represents a seminal contribution to better understanding and management of the human-ocean system. However, precautionary and sustainable ocean governance makes it essential to properly account for the social evaluation of ocean benefits and for the various risks and uncertainties involved in our interaction with the ocean. Policy assessment and advice based on an index with unlimited substitution possibilities could result in (a) certifying a healthy human-ocean system for countries that in reality neglect important aspects of ocean health and (b) identifying development trajectories as sustainable although this is actually not the case. For that reason, we argue that significant attention should be devoted to the proper aggregation of data in assessing the health of the ocean.

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Appendix

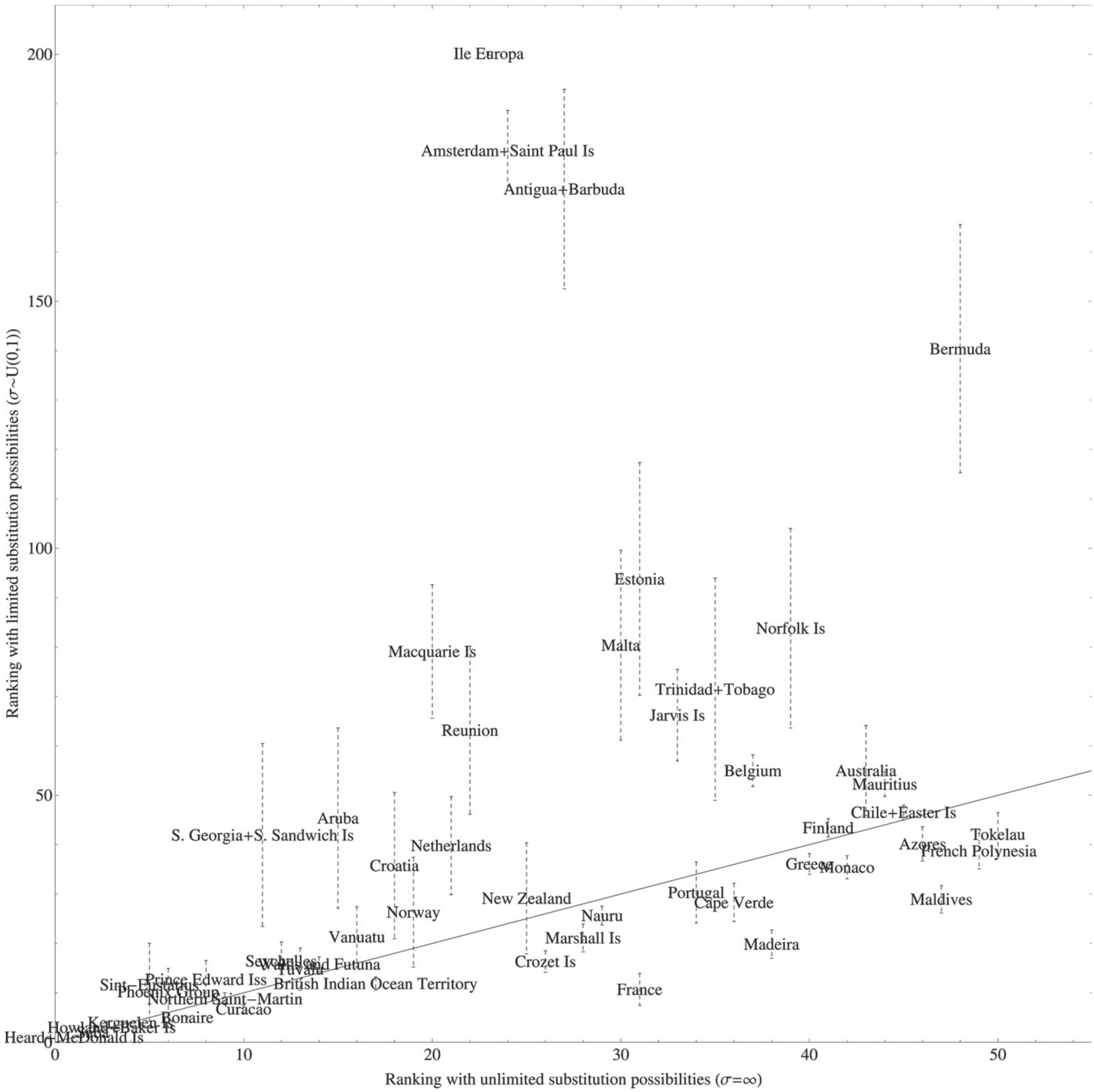

Figure A1. Detailed comparison of ocean-health rankings in 2013 for the first 50 countries ranked according to unlimited substitution possibilites.

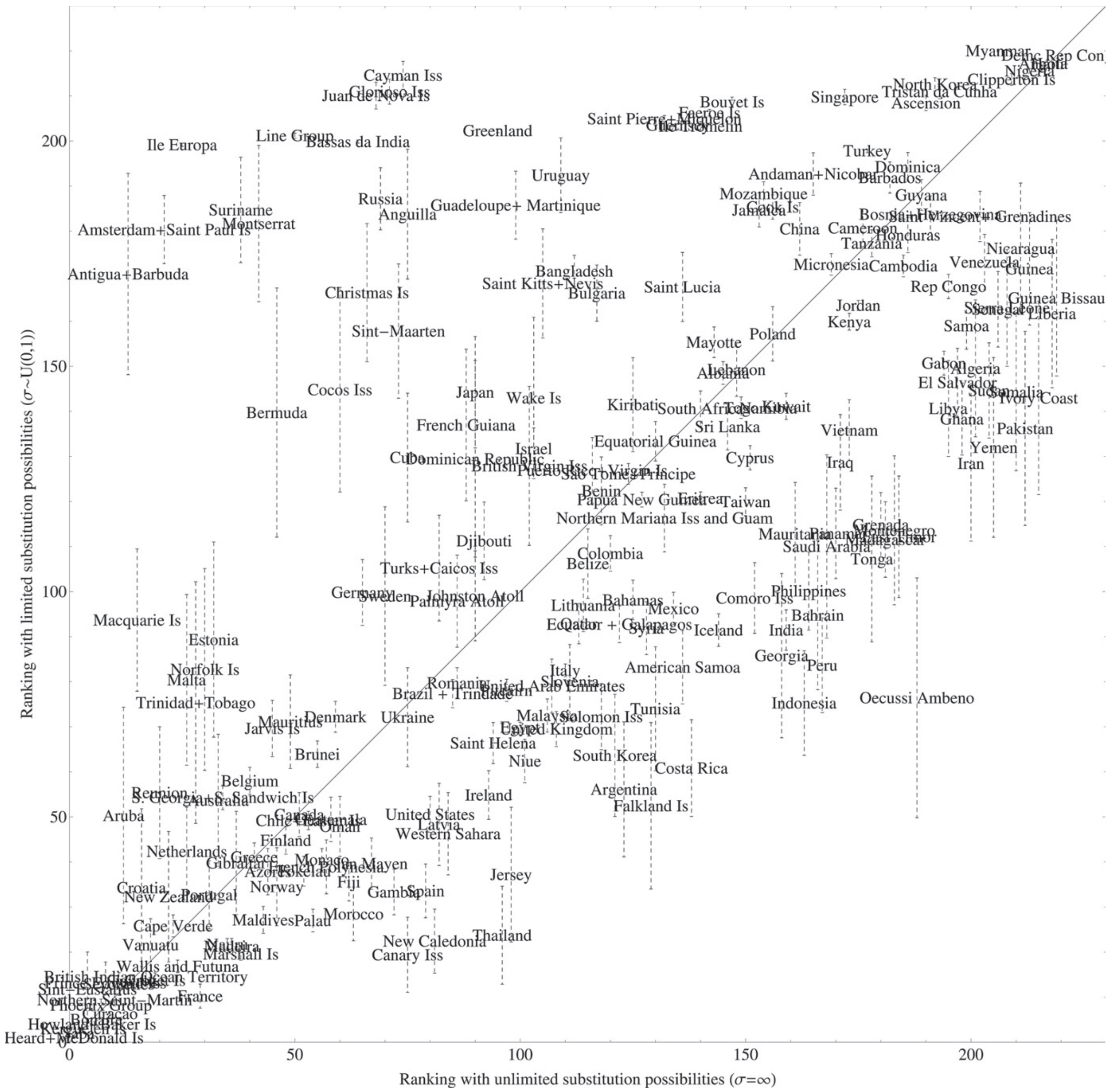

Figure A2. Comparison of ocean-health rankings in 2012 for 220 countries with unlimited substitution possibilities (weak sustainability) and with limited substitution possibilities (strong sustainability). The data point is in the middle of the respective country's name (with +/− standard deviation).

Table A1. Ocean-health index, ranking, and change for the various specifications of substitution elasticity.

	Ocean-Health Index 2013					Ocean Health Ranking 2013					Change in OH Index 2013–2012		
	$\sigma \to \infty$	$\sigma\sim$ $U(0,1)$	$\sigma\sim$ exp(0.5)	SD $U(0,1)$	SD exp(0.5)	$\sigma \to \infty$[a]	$\sigma\sim$ $U(0,1)$	$\sigma\sim$ exp(0.5)	SD $U(0,1)$	SD exp(0.5)	$\sigma \to \infty$	$\sigma\sim$ U(0,1)	$\sigma\sim$ exp(0.5)
Heard+McDonald Is	93.75	92.40	93.03	1.95	1.56	1	1.00	1.00	0.00	0.00	−0.75	−1.13	−0.97
Saba	90.00	86.44	88.11	4.20	3.47	2	2.00	2.00	0.00	0.00	−1.44	−2.41	−2.00
Howland+Baker Is	87.40	82.94	85.04	4.96	4.13	3	3.00	3.00	0.00	0.00	1.60	1.40	1.48
Kerguelen Is	86.20	81.35	83.62	4.91	4.18	4	4.00	4.00	0.00	0.00	−1.00	−2.12	−1.62
Sint-Eustatius	84.56	65.74	74.92	15.67	14.24	5	11.64	8.55	8.38	6.76	−1.44	−1.00	−1.31
Phoenix Group	84.43	66.31	75.11	14.56	13.38	6	10.21	8.41	4.71	3.84	0.14	−2.47	−1.19
Bonaire	83.89	75.26	79.38	9.19	7.75	7	5.03	5.39	0.18	0.73	−1.11	−1.01	−1.14
Prince Edward Iss	83.20	63.49	72.93	13.57	13.16	8	12.71	10.33	3.81	3.58	0.00	0.03	0.00
Northern Saint-Martin	81.50	67.13	74.02	12.34	11.06	9	8.79	9.11	1.20	0.89	−0.5	−0.28	−0.45
Curacao	80.89	70.93	75.69	10.01	8.57	10	6.72	8.31	0.87	1.56	−2.00	−1.55	−1.87
S. Georgia+S. Sandwich Is	80.00	50.81	64.89	16.12	17.29	11	41.94	24.71	18.53	19.91	8.60	2.76	6.08
Seychelles	77.30	59.88	68.14	11.83	11.51	12	16.44	14.50	3.87	3.29	−0.70	−1.89	−1.36
Tuvalu	77.33	60.68	68.62	12.09	11.47	13	14.80	13.23	4.28	3.44	2.11	−0.02	1.05
Wallis and Futuna	75.75	59.77	67.32	10.90	10.58	14	15.81	15.14	1.46	1.19	2.63	1.05	1.86
Aruba	75.60	50.00	62.40	16.00	16.21	15	45.37	30.15	18.25	18.94	−0.60	1.63	0.50
Vanuatu	75.50	57.58	66.11	12.20	11.87	16	21.32	18.51	6.13	5.12	1.30	0.84	1.07
British Indian Ocean Territory	75.25	62.24	68.45	11.07	9.94	17	11.86	13.37	1.36	1.60	1.00	1.87	1.48
Croatia	74.38	52.79	63.30	15.18	14.66	18	35.76	26.56	14.81	13.54	0.00	−0.05	−0.05
Norway	74.11	55.83	64.66	13.95	13.04	19	26.34	22.23	11.1	8.92	3.89	3.04	3.47
Macquarie Is	74.25	41.43	56.97	14.57	17.47	20	79.11	51.80	13.52	26.04	−0.75	3.83	1.74
Netherlands	73.70	51.80	62.25	13.33	13.61	21	39.81	30.91	9.93	10.58	1.00	1.01	1.02
Reunion	73.75	45.42	59.06	15.73	16.81	22	63.15	42.37	17.01	22.04	0.13	−1.79	−0.79
Ile Europa	73.80	0.00	33.26	0.00	30.59	23	200.16	140.50	0.37	69.09	0.80	0.00	0.14
Amsterdam+Saint Paul Is	73.60	15.10	43.18	13.13	26.11	24	180.49	113.98	8.12	60.69	0.00	−0.06	0.04
New Zealand	73.60	55.01	63.98	14.04	13.17	25	29.13	24.81	11.25	9.13	0.30	1.85	1.05
Crozet Is	73.50	59.36	66.00	9.65	9.34	26	16.34	18.92	2.17	2.85	−0.50	−1.58	−1.10
Antigua+Barbuda	73.20	17.05	45.42	16.62	27.10	27	172.72	100.68	20.21	63.65	−2.30	−0.48	−1.33
Marshall Is	73.30	57.74	65.17	11.19	10.66	28	21.11	22.07	2.82	2.09	2.50	0.13	1.27
Nauru	72.75	56.05	63.94	10.78	10.70	29	25.65	25.60	1.89	1.53	1.38	−1.00	0.13
Malta	72.60	40.76	56.15	16.46	18.26	30	80.37	54.76	19.22	26.85	−0.10	−0.09	−0.05
France	72.60	65.12	68.57	5.76	5.31	31	10.70	17.00	3.25	6.39	0.30	0.14	0.18
Estonia	72.50	37.53	54.53	17.62	19.83	31	93.77	63.01	23.57	32.30	0.60	−1.25	−0.22
Jarvis Is	72.50	44.55	57.78	13.63	15.49	33	66.21	49.01	9.27	16.79	2.25	0.77	1.54
Portugal	72.38	54.65	63.10	12.32	11.89	34	30.31	28.59	6.17	4.78	0.25	1.29	0.78
Trinidad+Tobago	72.00	43.16	57.38	17.57	18.07	35	71.47	48.88	22.51	25.73	−0.40	1.05	0.33
Cape Verde	71.86	55.32	62.94	9.38	9.79	36	28.29	29.18	3.86	3.38	−1.29	−0.27	−0.84
Belgium	71.40	48.01	58.90	11.64	13.01	37	54.97	46.87	3.22	8.02	0.70	1.26	1.03
Madeira	71.14	58.23	64.30	9.58	8.98	38	19.85	25.70	2.86	6.09	0.00	1.15	0.55
Norfolk Is	70.86	39.96	55.14	16.67	18.18	39	83.82	61.91	20.2	24.4	−1.29	−0.43	−0.77
Greece	70.75	53.09	61.44	11.05	11.11	40	36.10	35.01	2.09	2.81	0.13	1.64	0.92

Table A1. (Continued.)

	Ocean-Health Index 2013					Ocean Health Ranking 2013					Change in OH Index 2013–2012		
	$\sigma \to \infty$	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty^{a}$	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$	$\sigma \sim$ U(0,1)	$\sigma \sim$ exp(0.5)
Finland	70.33	51.46	60.22	10.64	11.16	41	43.41	43.37	1.86	1.56	0.33	0.40	0.39
Monaco	70.43	53.25	61.32	11.17	11.03	42	35.42	36.03	2.34	2.87	2.00	1.28	1.64
Australia	70.20	47.91	58.60	14.35	14.31	43	54.98	47.58	9.13	9.58	−1.60	0.26	−0.66
Mauritius	70.50	49.09	59.16	12.09	12.72	44	52.24	47.31	2.51	4.82	1.10	5.61	3.40
Chile+Easter Is	70.25	50.74	59.89	11.26	11.72	45	46.53	44.85	1.45	2.38	1.25	0.75	0.99
Azores	70.00	52.03	60.54	11.88	11.67	46	40.14	40.15	3.46	4.16	−0.29	−0.14	−0.24
Maldives	70.00	55.07	62.16	10.88	10.31	47	28.94	33.07	2.77	5.29	−0.30	−0.03	−0.18
Bermuda	69.67	26.66	48.07	17.62	22.62	48	140.37	94.87	25.12	43.07	−0.56	−0.35	−0.37
French Polynesia	69.50	52.80	60.59	9.83	10.13	49	38.73	43.04	3.63	4.91	1.10	0.29	0.70
Tokelau	69.44	52.06	60.07	9.97	10.35	50	42.09	46.90	4.39	5.35	0.33	−0.43	−0.11
Line Group	69.29	0.00	32.73	0.00	29.23	51	203.15	148.83	1.93	58.36	0.00	0.00	−0.31
Palau	69.20	54.45	61.36	9.86	9.62	52	31.86	38.86	2.97	7.42	0.30	−1.02	−0.44
Denmark	69.20	45.04	56.33	12.26	13.58	53	64.13	60.00	3.11	4.23	1.00	1.97	1.55
Montserrat	68.89	15.47	42.28	15.05	25.42	54	183.32	122.33	16.48	54.55	−1.44	−0.32	−0.80
Gibraltar	69.14	49.52	59.02	13.51	13.13	55	48.59	47.83	7.33	5.83	−1.86	−1.83	−1.88
Morocco	68.75	56.00	61.92	8.94	8.54	56	26.82	37.97	5.83	11.65	0.88	0.64	0.73
Jan Mayen	68.88	53.58	60.70	9.84	9.74	57	35.35	43.93	2.91	7.98	1.38	1.21	1.26
Bassas da India	68.50	0.00	29.15	0.00	27.58	58	200.84	167.88	0.37	46.71	0.75	0.00	0.11
Germany	68.30	37.75	52.03	13.65	16.23	59	94.49	79.38	5.85	13.85	0.70	1.34	1.06
Western Sahara	68.29	54.45	60.86	8.44	8.53	60	32.80	44.67	8.45	12.26	2.14	3.65	2.95
Canada	68.30	49.85	58.47	11.55	11.57	61	50.29	54.30	2.19	3.62	−0.90	0.46	−0.26
Fiji	68.00	51.82	59.57	12.18	11.42	62	41.10	48.62	4.93	7.14	0.10	−1.20	−0.58
Palmyra Atoll	67.80	37.07	51.93	14.64	16.99	63	95.99	78.13	10.77	16.91	1.80	0.47	1.18
Johnston Atoll	67.60	37.00	51.80	14.58	16.92	64	97.17	79.87	10.42	16.35	1.80	0.48	1.18
Juan de Nova Is	67.86	0.00	30.93	0.00	27.87	65	210.83	165.35	3.11	50.24	0.43	0.00	0.01
Glorioso Iss	67.71	0.00	30.87	0.00	27.82	66	211.71	166.82	2.94	49.57	0.43	0.00	0.01
Brunei	67.20	43.78	54.80	13.04	13.82	67	70.06	67.90	5.54	4.82	−1.60	−1.16	−1.31
Sint-Maarten	67.22	24.96	45.44	16.01	21.36	68	149.22	113.07	17.68	34.18	0.22	2.56	1.44
Cocos Iss	67.11	25.90	46.33	16.85	21.62	69	144.35	106.52	21.5	36.12	−1.00	−0.28	−0.48
Pitcairn	67.13	42.21	53.81	12.65	13.99	70	76.28	72.55	4.48	4.65	1.88	0.28	1.01
Egypt	67.30	44.96	55.53	12.41	13.19	71	64.40	63.84	2.78	2.66	2.40	1.47	1.99
New Caledonia	67.20	58.07	62.39	8.45	7.38	72	21.13	38.51	6.80	17.14	0.90	0.65	0.73
Thailand	67.00	59.46	62.97	6.60	5.84	73	19.17	38.76	8.08	19.03	1.70	1.56	1.60
Canary Iss	67.00	59.59	62.99	5.62	5.20	74	20.65	40.48	9.37	19.42	0.11	0.69	0.37
United States	66.90	50.10	58.10	12.04	11.48	75	48.88	56.12	4.34	6.90	0.30	0.84	0.54
Cuba	66.80	29.21	47.24	15.70	19.60	76	130.83	105.03	16.01	25.59	0.00	−0.09	0.03
Anguilla	66.56	19.64	43.01	15.86	23.22	77	166.54	123.65	16.07	38.93	−0.33	4.37	1.99
Saint Kitts+Nevis	66.44	22.65	44.22	16.10	22.10	78	156.07	119.26	16.13	33.86	2.00	3.53	2.81
Christmas Is	66.44	19.38	42.73	15.61	23.13	79	168.28	126.54	14.89	37.76	−1.11	−0.26	−0.54
Oman	66.56	50.49	57.77	8.43	9.08	80	47.88	58.41	9.37	12.17	−1.56	0.03	−0.76

Table A1. (Continued.)

	Ocean-Health Index 2013					Ocean Health Ranking 2013					Change in OH Index 2013–2012		
	$\sigma \to \infty$	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$[a]	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$	$\sigma \sim$ U(0,1)	$\sigma \sim$ exp(0.5)
Russia	66.50	13.97	39.04	12.97	23.65	80	187.11	145.92	7.46	37.43	−0.90	−0.16	−0.41
Guatemala	66.40	34.27	49.71	15.28	17.70	82	109.04	92.23	12.70	17.35	−1.90	−15.21	−8.76
Brazil + Trindade	66.30	40.45	52.62	13.09	14.56	83	83.77	79.08	4.84	5.60	0.20	−1.48	−0.63
Sweden	66.20	37.29	51.34	15.85	17.07	84	94.89	82.83	14.83	15.11	−1.1	0.90	−0.10
Greenland	66.33	0.00	32.62	0.00	28.55	85	202.92	153.50	0.75	49.01	0.89	0.00	0.31
Spain	66.20	54.32	59.86	8.86	8.28	86	34.22	50.73	9.29	16.22	−0.50	0.28	−0.13
Japan	66.20	26.42	45.39	15.15	20.02	87	142.99	117.86	12.53	23.90	0.40	−0.03	0.26
Latvia	66.00	49.16	56.91	9.38	9.87	88	52.48	62.15	6.93	10.79	−0.20	−1.24	−0.78
Cayman Iss	66.00	0.00	31.23	0.00	27.56	89	217.36	169.19	2.18	47.64	−0.90	0.00	−1.10
Djibouti	65.89	34.10	49.11	14.25	16.97	90	110.3	98.82	7.11	11.18	0.11	0.02	0.13
British Virgin Iss	65.78	32.08	48.68	16.53	18.97	91	118.64	97.42	19.02	22.97	1.22	2.23	1.84
Ireland	65.70	47.80	56.12	10.35	10.72	92	56.69	65.71	4.77	9.79	0.00	−0.58	−0.30
Wake Is	65.63	26.79	45.89	16.03	20.39	93	140.87	114.04	17.47	26.21	1.13	−0.07	0.54
Guadeloupe+ Martinique	65.60	15.17	40.05	14.29	23.76	94	180.08	139.79	10.68	35.95	0.50	0.87	1.22
Turks+Caicos Iss	65.60	36.53	50.35	14.40	16.25	95	99.63	92.00	7.68	8.90	−0.60	1.15	0.34
Dominican Republic	65.60	31.11	48.22	17.01	19.50	96	122.26	100.02	20.19	24.12	−0.20	1.96	0.96
Slovenia	65.00	42.55	52.89	11.25	12.48	97	75.79	82.86	4.19	8.14	2.00	1.25	1.70
Ukraine	65.10	41.12	52.57	13.91	14.52	98	80.63	81.01	9.07	8.49	−1.70	−2.13	−1.95
Suriname	64.90	13.72	38.26	12.72	23.14	99	188.81	152.00	6.36	33.08	−5.90	−1.08	−3.81
United Arab Emirates	64.40	41.04	51.77	11.19	12.71	100	83.00	91.08	4.38	8.77	0.60	−0.46	0.08
Niue	64.44	43.88	53.36	10.90	11.75	101	69.70	81.66	5.26	12.68	−0.33	−1.86	−1.17
French Guiana	64.50	30.12	46.41	14.76	18.04	102	126.53	115.35	10.41	12.3	−1.40	2.32	0.25
Malaysia	64.40	43.79	53.45	11.24	12.02	103	69.53	79.67	3.42	11.37	0.20	0.78	0.51
Gambia	64.30	49.70	56.52	9.47	9.35	104	50.66	67.29	6.96	17.34	−2.80	−4.29	−3.68
United Kingdom	64.10	44.08	53.43	11.95	12.23	105	67.38	80.70	3.02	13.74	0.80	0.42	0.59
Jersey	64.00	53.29	58.13	6.08	6.30	106	39.16	62.78	16.39	25.92	−1.13	−0.63	−0.86
Saint Helena	64.13	43.59	53.26	12.21	12.54	106	70.56	81.06	3.42	11.97	−1.38	−0.88	−1.19
Romania	64.00	42.55	52.54	11.32	12.27	108	75.74	86.77	3.67	11.73	−2.00	0.92	−0.47
Israel	63.80	29.15	45.24	13.23	17.27	109	131.71	123.18	3.73	8.11	−0.7	−0.14	−0.34
Italy	63.20	41.99	51.89	11.15	12.12	110	78.63	90.92	4.61	12.48	0.00	1.19	0.60
Ecuador + Galapagos	63.00	39.45	50.63	13.05	13.89	111	89.13	97.08	4.48	8.64	1.40	1.28	1.28
Northern Mariana Iss and Guam	63.00	33.69	47.82	14.81	16.59	112	113.52	110.09	10.79	8.90	2.56	0.62	1.63
Bangladesh	62.90	11.50	35.13	10.39	21.97	112	195.86	170.44	1.78	25.74	0.10	−6.97	−3.51
Belize	62.80	35.32	48.43	14.37	15.76	114	105.06	107.07	6.94	6.37	0.50	0.11	0.30
South Korea	62.88	46.80	54.12	8.65	9.22	115	60.46	82.09	10.07	21.67	1.25	0.75	1.02
Tunisia	62.63	43.46	52.16	9.27	10.43	116	73.82	92.38	11.27	19.10	2.13	0.47	1.31
Lithuania	62.67	38.57	49.67	11.11	12.89	117	92.97	103.63	6.03	10.95	0.33	0.60	0.51
Qatar	62.70	33.31	46.97	13.21	15.60	117	113.46	115.58	2.37	2.81	0.20	−5.54	−2.70
Uruguay	62.25	13.32	37.36	12.73	22.64	119	193.09	159.3	7.88	29.89	−1.00	−0.26	−0.59
Puerto Rico+Virgin Is	61.89	30.49	45.37	13.91	16.69	120	125.35	123.55	7.07	5.30	−0.22	0.07	0.01

Table A1. (Continued.)

	Ocean-Health Index 2013					Ocean Health Ranking 2013					Change in OH Index 2013–2012		
	$\sigma \to \infty$	$\sigma \sim U(0,1)$	$\sigma \sim \exp(0.5)$	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$[a]	$\sigma \sim U(0,1)$	$\sigma \sim \exp(0.5)$	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$	$\sigma \sim$ U(0,1)	$\sigma \sim \exp(0.5)$
Argentina	61.75	49.87	55.26	6.80	7.03	121	50.04	79.33	15.27	29.85	0.25	1.81	1.08
Colombia	61.70	36.61	48.60	13.31	14.52	122	100.09	108.00	3.33	8.43	0.00	1.56	0.87
Mexico	61.70	43.48	52.11	11.58	11.57	123	71.65	91.52	4.88	19.02	1.50	6.12	3.80
Benin	61.60	29.68	44.77	14.23	16.98	124	128.64	126.79	6.97	5.36	−0.20	−1.64	−0.86
Comoro Iss	61.30	39.04	49.29	11.08	12.34	125	91.10	106.58	7.09	15.04	2.20	1.38	1.75
American Samoa	61.56	41.25	50.65	10.84	11.66	126	82.87	100.30	6.67	17.05	1.56	0.47	0.99
Faeroe Is	61.33	0.00	29.97	0.00	26.26	127	206.09	174.11	0.85	31.97	1.56	0.00	0.66
Bahamas	61.20	37.51	48.40	11.24	12.83	128	98.23	111.65	5.93	12.97	0.30	−0.05	0.05
Equatorial Guinea	61.00	29.91	44.29	11.88	15.47	129	127.91	130.62	5.41	4.75	0.50	1.05	0.83
Kiribati	60.90	26.66	43.25	14.99	18.24	130	141.78	134.33	10.25	9.87	0.00	−0.21	−0.05
Sao Tome+Principe	60.75	31.92	45.34	12.72	15.19	131	119.41	125.58	1.40	5.75	−0.38	1.35	0.60
Solomon Iss	60.90	32.86	46.23	13.92	15.69	132	115.17	120.62	5.62	6.7	−0.90	−10.42	−5.64
Syria	60.75	39.09	49.15	10.92	12.12	133	90.99	108.08	7.08	16.54	0.00	0.02	0.03
South Africa	60.60	25.55	42.20	14.12	17.95	134	147.56	140.75	5.62	7.23	0.80	−1.61	−0.32
Costa Rica	60.70	46.80	53.30	9.56	9.21	135	60.44	88.77	8.55	26.92	0.80	0.10	0.40
Ile Tromelin	60.60	0.00	26.67	0.00	24.65	136	203.92	188.75	0.64	23.17	0.80	0.00	0.19
Papua New Guinea	60.40	30.29	44.46	12.8	15.71	137	127.06	130.43	1.84	3.64	−0.40	−1.56	−0.96
Saint Pierre+Miquelon	60.56	0.00	29.65	0.00	25.97	138	206.05	176.64	1.12	29.51	0.11	0.00	−0.08
Mayotte	60.30	25.35	41.67	12.86	17.24	139	148.68	144.40	1.71	4.18	0.60	1.53	1.09
Albania	60.00	27.10	42.46	12.97	16.61	140	141.69	140.78	1.30	2.18	0.38	1.73	1.14
Lebanon	59.75	24.89	40.74	11.60	16.45	141	149.74	150.38	4.76	4.86	0.38	−0.04	0.16
Falkland Is	59.57	48.55	53.42	5.46	6.01	142	56.23	92.41	22.23	37.16	−1.14	−0.65	−0.94
Taiwan	59.40	32.95	45.24	12.69	14.44	143	114.74	127.39	2.29	11.38	0.20	1.08	0.61
Jamaica	59.10	14.07	36.18	12.9	21.21	144	185.05	166.85	4.85	16.15	0.40	−0.09	0.20
Guernsey	59.13	0.00	28.50	0.00	25.17	145	205.32	183.59	1.69	23.33	−1.00	0.00	−0.62
Bouvet Is	59.00	0.00	25.02	0.00	23.34	146	210.36	199.26	0.69	17.6	−0.40	0.00	−0.49
Togo	58.60	26.61	41.58	13.28	16.46	147	144.40	147.12	2.67	4.24	−0.7	−0.48	−0.58
Namibia	58.88	23.47	40.16	13.03	17.52	148	155.48	153.21	2.81	3.06	0.38	−3.74	−1.75
Poland	58.60	23.04	40.03	13.77	18.00	149	156.11	152.96	4.74	4.68	0.20	−0.06	0.14
Indonesia	58.40	43.96	50.78	9.34	9.26	150	71.55	103.07	12.34	30.31	1.20	1.42	1.29
Georgia	58.75	37.10	46.77	9.17	11.04	150	99.21	122.87	14.03	23.54	0.50	−3.56	−1.81
Bahrain	58.30	39.27	48.00	9.41	10.50	152	90.71	117.08	14.21	26.15	1.70	0.70	1.22
Saint Lucia	58.50	18.51	38.17	14.14	19.90	152	168.93	158.44	7.21	10.33	−1.50	−0.44	−0.90
Cook Is	58.20	13.80	35.35	12.55	20.70	154	186.31	172.73	2.89	11.78	−0.20	−0.19	−0.18
Mauritania	58.00	34.56	45.13	9.56	11.82	155	110.39	131.39	12.61	21.38	0.13	0.55	0.32
Iceland	58.00	38.27	47.56	11.32	11.82	156	95.35	118.97	6.97	22.12	−1.67	−0.78	−1.23
Sri Lanka	57.80	27.21	41.84	13.72	16.38	157	140.80	145.65	4.39	7.39	−1.70	−0.62	−1.10
India	57.80	38.46	47.84	12.82	12.65	158	93.10	116.16	5.41	21.45	−0.30	−0.16	−0.24
Bulgaria	57.75	19.29	37.75	13.06	18.71	159	167.80	164.11	4.50	4.71	−4.25	−0.74	−2.28
Mozambique	57.80	13.56	35.01	12.3	20.56	160	188.38	175.48	2.31	11.12	−0.80	−0.10	−0.32

Table A1. (Continued.)

	Ocean-Health Index 2013					Ocean Health Ranking 2013					Change in OH Index 2013–2012		
	$\sigma \to \infty$	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$[a]	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$	$\sigma \sim$ U(0,1)	$\sigma \sim$ exp(0.5)
China	57.60	14.69	36.30	13.55	20.98	161	180.95	167.01	6.97	12.53	0.10	−0.08	0.11
Iraq	57.22	30.09	42.63	11.04	13.82	162	127.53	143.68	9.69	16.41	1.89	0.19	1.01
Kuwait	57.10	26.84	40.77	12.14	15.28	163	142.48	154.25	3.34	10.62	−1.00	−0.22	−0.54
Peru	57.00	42.76	49.48	10.07	9.62	164	75.92	110.96	12.74	33.36	0.6	1.86	1.22
Saudi Arabia	56.80	34.70	44.50	8.68	10.90	165	110.47	137.00	18.32	27.56	0.6	−0.30	0.12
Philippines	56.40	36.77	45.98	10.46	11.31	166	100.96	128.47	8.97	26.19	−0.6	−0.63	−0.62
Vietnam	56.20	31.88	43.19	10.90	12.90	167	120.86	141.90	9.77	20.80	1.20	3.56	2.41
Cyprus	55.88	29.06	41.61	11.82	14.15	167	134.23	151.25	5.44	15.63	−3.25	−0.86	−1.95
Andaman+Nicobar	56.11	13.36	34.52	12.31	20.26	169	193.02	180.00	4.69	11.48	−0.56	−0.14	−0.25
Tonga	56.00	35.02	44.38	8.81	10.65	170	108.87	138.20	17.34	29.26	1.60	−0.54	0.34
Micronesia	55.90	17.22	35.82	12.82	18.68	171	174.40	173.16	3.01	3.49	0.10	−0.29	−0.12
Turkey	55.88	11.23	31.86	10.13	19.40	172	198.14	191.40	0.93	7.44	1.25	−0.02	0.52
Cameroon	55.30	18.32	35.78	11.83	17.57	173	171.05	174.27	1.81	3.53	0.50	2.77	1.76
Tanzania	55.00	16.06	34.51	11.77	18.24	174	178.81	179.73	2.09	2.29	0.60	−0.18	0.21
Kenya	54.70	20.54	36.55	11.78	16.53	175	164.10	172.31	1.59	7.50	−0.30	−1.88	−1.04
Montenegro	54.50	35.22	43.98	9.16	10.40	176	107.61	141.27	15.75	32.01	0.50	1.01	0.77
Panama	54.30	30.04	41.34	11.71	13.29	177	128.36	153.52	8.17	22.96	−1.20	−3.68	−2.44
Grenada	54.20	34.37	43.69	11.26	11.81	178	109.40	140.09	8.63	28.38	−0.10	0.96	0.43
Gabon	54.10	27.40	40.51	13.68	15.30	179	139.58	156.63	4.57	16.02	2.30	2.62	2.58
East Timor	54.10	34.93	43.86	9.88	10.84	180	108.77	141.71	11.86	31.00	0.20	0.80	0.53
Madagascar	54.10	32.67	42.85	11.47	12.43	181	117.46	145.10	7.68	25.61	−0.10	−1.17	−0.63
Honduras	54.20	15.79	34.13	11.62	18.08	182	180.29	182.19	2.61	2.75	0.80	0.04	0.46
Jordan	53.90	21.04	36.63	12.14	16.34	183	162.36	172.22	1.12	9.27	−1.00	−0.23	−0.52
Libya	53.75	26.50	39.06	11.06	13.84	184	144.24	163.42	7.38	18.28	2.13	−0.73	0.68
Singapore	53.70	0.00	25.88	0.00	22.62	185	211.03	200.85	2.04	9.69	−1.60	0.00	−1.00
Barbados	53.60	12.47	31.88	10.96	18.63	186	191.49	191.14	2.59	2.12	−0.50	−0.03	−0.12
Guyana	53.40	17.36	35.02	12.89	17.97	187	173.06	177.96	2.89	6.06	0.50	3.99	2.33
Dominica	53.40	11.90	31.41	10.44	18.56	188	193.85	193.75	2.55	2.68	0.00	−0.09	−0.02
Oecussi Ambeno	53.13	43.83	47.99	5.51	5.57	189	75.92	125.28	26.67	49.11	−0.25	0.17	−0.03
El Salvador	53.10	27.10	39.13	11.06	13.47	190	141.03	163.41	7.88	21.1	1.60	1.27	1.36
Rep Congo	52.88	18.18	34.72	11.88	16.86	191	172.65	180.54	2.01	7.32	1.25	−1.99	−0.31
Cambodia	52.60	15.13	33.18	11.16	17.68	192	182.58	186.22	4.06	4.63	−1.20	−2.97	−2.04
Eritrea	52.60	17.40	33.58	10.79	16.30	193	174.57	185.58	6.91	10.73	−7.20	−14.43	−11.35
Algeria	52.63	25.64	37.57	9.46	12.78	194	146.76	170.77	12.20	22.92	2.63	0.47	1.43
Bosnia+Herzegovina	52.13	14.69	32.29	10.81	17.26	195	184.81	191.12	3.98	6.34	−0.38	−0.38	−0.44
North Korea	52.00	0.00	24.30	0.00	21.47	196	213.59	207.17	1.49	6.13	−0.22	0.00	−0.32
Ascension	51.43	0.00	23.82	0.00	21.34	197	209.20	206.76	1.47	4.15	−1.14	0.00	−0.70
Saint Vincent+ Grenadines	51.00	18.23	33.69	11.55	15.97	198	171.79	185.57	3.87	12.38	1.33	3.15	2.42
Samoa	50.90	20.80	34.83	11.60	15.02	199	163.03	181.18	4.05	16.18	0.00	−1.73	−0.75
Tristan da Cunha	50.71	0.00	23.27	0.00	20.90	200	211.10	209.08	1.09	3.46	−1.43	0.00	−0.85

Table A1. (Continued.)

	Ocean-Health Index 2013					Ocean Health Ranking 2013					Change in OH Index 2013–2012		
	$\sigma \to \infty$	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$[a]	$\sigma \sim$ $U(0,1)$	$\sigma \sim$ exp(0.5)	*SD* $U(0,1)$	*SD* exp(0.5)	$\sigma \to \infty$	$\sigma \sim$ U(0,1)	$\sigma \sim$ exp(0.5)
Iran	50.60	30.12	39.48	9.23	10.82	201	127.50	161.76	17.15	33.15	0.40	0.08	0.24
Venezuela	50.10	18.07	33.19	11.23	15.61	202	171.57	187.61	5.93	14.73	0.60	0.17	0.46
Ghana	49.60	28.21	38.16	10.43	11.77	203	136.26	168.08	12.07	29.69	−1.70	0.41	−0.67
Sudan	49.40	26.91	37.13	9.68	11.62	204	141.42	173.39	13.11	29.82	0.00	0.42	0.05
Yemen	49.30	31.22	39.21	7.31	9.01	205	124.56	164.54	23.77	39.66	0.00	2.15	1.10
Myanmar	48.90	0.00	20.73	0.00	19.34	206	220.00	215.97	0.00	4.72	0.60	0.00	0.08
Senegal	49.00	22.03	34.57	10.97	13.73	207	159.76	183.51	6.69	21.27	0.70	0.38	0.68
Sierra Leone	47.50	20.80	32.91	9.36	12.78	208	163.15	187.22	12.84	22.75	−0.30	−0.32	−0.21
Clipperton Is	47.00	0.00	18.52	0.00	17.85	209	214.21	216.31	0.93	2.79	0.25	0.00	−0.05
Nigeria	46.60	0.00	21.79	0.00	19.18	210	216.31	213.41	0.46	2.92	1.60	0.00	0.65
Nicaragua	46.40	16.81	29.67	7.78	12.82	211	175.06	194.90	15.39	20.63	0.90	0.01	0.37
Somalia	45.80	26.26	35.18	9.06	10.44	212	143.71	178.46	16.26	32.43	−0.10	0.08	0.02
Angola	44.90	0.00	20.59	0.00	18.21	213	217.38	216.02	0.48	2.080	1.00	0.00	0.37
Pakistan	44.70	27.47	35.29	8.09	9.24	214	137.75	176.98	21.53	37.59	−0.70	−0.75	−0.71
Guinea	44.40	19.11	30.42	8.29	11.77	215	168.59	192.82	15.21	23.82	−0.60	0.37	−0.23
Ivory Coast	43.80	25.19	33.56	8.32	9.73	216	147.95	183.01	19.44	33.52	−0.70	−1.35	−1.03
Haiti	42.80	9.59	24.51	7.73	14.26	217	196.12	207.47	3.67	10.82	0.20	9.59	4.97
Liberia	41.90	22.12	30.88	8.22	9.95	218	158.52	189.79	18.52	30.21	−0.40	0.83	0.18
Demc Rep Congo	41.90	0.00	18.79	0.00	16.72	219	218.49	218.58	0.50	2.09	0.50	0.00	0.13
Guinea Bissau	41.10	18.83	28.76	7.69	10.52	220	169.01	195.43	17.15	26.2	−0.40	−1.48	−1.09

[a] The ranking information for unlimited substitution potential in 2013 were obtained from www.oceanhealthindex.org and do not perfectly correspond to the ranking implied by the calculated ocean-health index values for ($\sigma \to \infty$) in the second column. The ocean-health index values on the website are reported without post decimal positions.

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