Chapter 8.2 Ocean Health Index for the Open Ocean

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8.2 Ocean Health Index for the Open Ocean

8.2.1 Summary and Key Messages

One of the greatest challenges for resource management is to comprehensively understand the condition of coupled human-natural systems, and make informed decisions about how best to improve them. Too often monitoring, assessments, indicators, and decisions are made within a single sector or with a single objective in mind, without full consideration of the broader implications of those actions. Both ecosystem-based management and marine spatial planning aim to overcome these management barriers, but relatively few tools exist to directly inform and support such comprehensive management approaches. Without a tool to measure overall ecosystem health and track progress towards improving it, we cannot effectively manage towards multiple integrated objectives. We need a transparent and quantitative means to make such assessments. In the marine environment, this challenge particularly persists in areas beyond national jurisdictions (ABNJ), beyond 200 nm from the coast: the high seas.

The Ocean Health Index (OHI) was developed in part to address this need. Using a common framework, the Index measures the performance of ten widely-held public goals for a healthy ocean, including food provision, carbon storage, coastal livelihoods and economies, and biodiversity (Table 8.1). Each goal is assessed against an ideal state, defined as the optimal, sustainable level that can be achieved for the goal. Global datasets spanning ecological, social, economic, and governance measures are used for the assessments. To date, three annual assessments have been completed at the global scale for the years 2012 through 2014 for each of 221 coastal countries or territories (exclusive economic zones; EEZs). In the most recent assessment, the Index was calculated for the high seas regions of 15 Food and Agriculture Organization (FAO) marine major fishing areas. Because many of the ten goals in the Index are driven by direct human interaction with the ocean (for example: coastal livelihoods) or benefits from the ocean (for example: coastal protection), the high seas are assessed on the subset of goals that are relevant to ocean health in these remote areas. Here we focus on these high seas results.

Ocean Health Index (OHI) scores for the 15 high seas regions ranged from 53 to 79 out of 100 (average per-region score, 66), with all high seas regions together scoring 67. The lowest scoring high seas regions were in each of the main ocean basins (Arctic, Pacific, Indian and Atlantic), as were the highest scoring regions (excluding the Arctic). Very few goals from the Index framework are relevant to high seas, so high seas scores were primarily driven by the status of biodiversity and wild-caught fisheries. Data deficiencies for both of these goals create some uncertainty in overall scores.

Key Messages

Four key results and messages emerge from this assessment of overall ocean health in the high seas:

1. On average, the high seas scored lower according to the OHI than coastal regions, confirming the need for coordinated international action to better manage these areas beyond national jurisdiction;
2. For all regions, there remains substantial opportunity to improve the sustainability of harvest of wild caught fisheries. Achieving this outcome could benefit global food security;
3. Biodiversity in the high seas is at slightly less risk of extinction than in most coastal waters, although the subset of species iconic to people are proportionally faring much worse in the high seas, particularly in the Arctic; and
4. Many aspects of ocean health in the high seas remain poorly monitored, hindering our ability to comprehensively assess ocean health across space. Improving data reporting standards from all UN member states, especially for fisheries catch and better monitoring of deep-sea habitats, would significantly aid assessments of ocean health and decision making based on those assessments.

Management of the high seas should ideally be comprehensive and span the ecological, economic and social aspects of how people interact with ocean ecosystems. Such management is challenged when faced with disparate data and information focused on different aspects of the human and natural system; integration is left to the individual and is often *ad hoc*. The OHI provides a framework for combining this disparate information into a single, comparable, quantitative and transparent measure of ocean health and its many component factors. The Index highlights the relative performance of different human values and goals for the ocean, and with repeated calculations can help elucidate where and why tradeoffs among goals may occur under different management actions.

8.2.2 Main Findings, Discussion and Conclusions

People value ocean ecosystems for the food they provide, the aesthetic beauty they carry, the livelihoods they support, and the existence and vast diversity of species within them. Even though the relative importance of each of these benefits varies from person to person, their value is nearly universal. The ocean enriches our lives in many ways, but the sustainable delivery of these benefits is jeopardized when ocean health is compromised. Although the high seas are rarely visited by people, they support key goals people have for the ocean, most notably food provision through wild-caught fisheries and the iconic and existence value of species. To fairly assess the condition, or health, of the high seas, one must measure the status of all relevant goals achieved from high seas ecosystems.

Managing for ocean health is inherently a transboundary challenge, as many processes that produce and support the values we have for ocean ecosystems cross national boundaries, including: provision of seafood from fish stocks straddling boundaries or largely unregulated in the high seas, existence value of the many migratory species making up the ocean's rich marine biodiversity, and the cultural and spiritual value of iconic species through which we relate to the ocean. Exploring how these goals are faring in the high seas provides a valuable lens through which to view these issues and the challenges they represent, and through that lens we can identify key opportunities to enhance their sustainable delivery to people, conserve and protect the underlying processes supporting the values, and mitigate threats to them.

The OHI tracks the current status and expected future condition of these human values for ocean ecosystems. It does this by assessing the cumulative stressors on ecosystem services and tracking the resulting status of the sustainable delivery of services to people. It also incorporates measures of governance as a means of quantifying the potential resilience of the system. As such, the Index directly captures stages 4-6 in the Conceptual Framework (see Section 2) and indirectly stages 1a and 3, thus spanning both the human and natural systems. In combination with cumulative human impact (CHI) assessments, which directly measure the connection between stages 3 and 4, ecosystem service valuations, and more comprehensive governance assessments, a complete picture of high seas condition emerges.

Table 8.2 Name, abbreviation (in parentheses) and definition of each goal and sub-goal of the Ocean Health Index. Only those goals and sub-goals marked with an * were assessed for the high seas.

Goal	Sub-goal	Definition
*Food provision (FP)	*Fisheries (FIS)	Harvest of sustainably caught wild seafood
	Mariculture (MAR)	Production of sustainably cultured seafood
Artisanal fishing opportunity (AO)		Opportunity to engage in artisanal-scale fishing for subsistence and/or recreation
Natural products (NP)		Sustainable harvest of natural products, such as shells, algae, and fish oil used for reasons other than food provision
Carbon storage (CS)		Conservation status of natural habitats affording long-lasting carbon storage
Coastal protection (CP)		Conservation status of natural habitats affording protection of the coast from inundation and erosion
Tourism & recreation (TR)		Opportunity to enjoy coastal areas for recreation and tourism
Coastal livelihoods & economies (LE)	Coastal livelihoods (LIV)	Jobs and wages from marine-related sectors
	Coastal economies (ECO)	Revenues from marine-related sectors
*Sense of place (SP)	*Iconic species (ICO)	Cultural, spiritual, or aesthetic connection to the environment afforded by iconic species
	Lasting special places (LSP)	Cultural, spiritual, or aesthetic connection to the environment afforded by coastal and marine places of significance
Clean waters (CW)		Clean waters that are free of nutrient and chemical pollution, marine debris and pathogens
*Biodiversity (BD)	Habitats (HAB)	The existence value of biodiversity measured through the conservation status of habitats
	*Species (SPP)	The existence value of biodiversity measured through the conservation status of marine-associated species

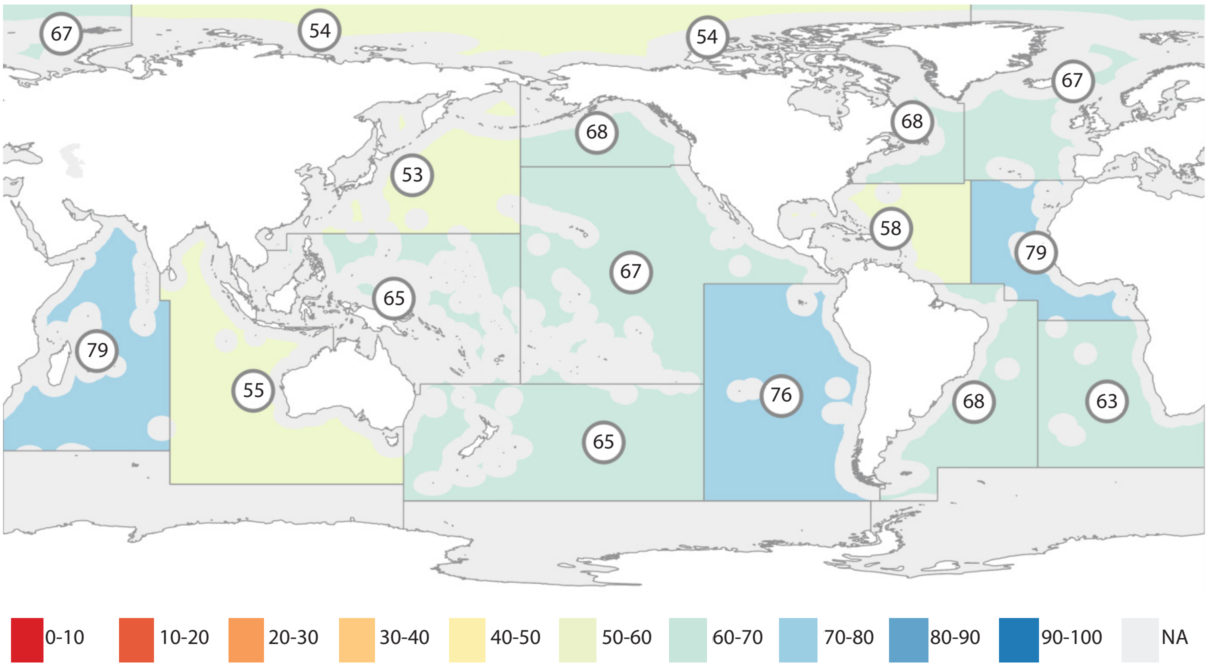
Results

Overall Index scores varied from 53 to 79, with an average regional score of 66 and an area-weighted total high seas score of 67 (Figure 8.2). The highest scoring regions were the Western Indian Ocean (79), the Eastern Central Atlantic (79) and the Southeast Pacific (76), while the lowest scoring regions were the Pacific Northwest (53), Arctic Sea (54), and Eastern Indian Ocean (55; see Table 8.3). These scores suggest a lot of room for improvement in ocean health – substantial room in the lowest scoring regions – but also that some dimensions of ocean health are faring better (described below). In general, high seas regions scored lower than EEZ regions globally, except for species biodiversity, which scored slightly higher in the high seas (Table 8.3).

Overall Index scores were largely driven by differences in the scores for the fisheries sub-goal. Scores for the fisheries sub-goal were much more variable, and were sensitive to the underlying stock assessment models used and the composition of stocks (for which catch data were reported) in each region. The highest scoring regions on the fisheries sub-goal were the Eastern Central Atlantic (81) and the Western Indian Ocean (80), but both had catch dominated by three tuna species that data-limited assessment models predict are currently sustainably fished. The lowest scoring regions were the Pacific Northwest (6), Eastern Indian Ocean (8) and Western Central Atlantic (11).

High seas regions differed very little in the species biodiversity scores, with all regions except the Arctic scoring between 79 and 84 (see Table 8.3). On average, these scores are similar to those in coastal (EEZ and Large Marine Ecosystem (LME)) waters (see the TWAP LME Technical Assessment Report Chapter 7.2.5), indicating that biodiversity (that has been assessed) may be at similar risk in the high seas. The Arctic scored significantly lower than other high seas regions for biodiversity (66), largely due to having relatively few assessed species for the region and a much higher proportion of those at risk of extinction. Similar patterns are seen for the iconic species sub-goal, which is

Figure 8.2. Map of Ocean Health Index (OHI) scores per FAO high seas region.



based on a subset of species that are culturally important to people. The same set of species was considered iconic for all regions of the high seas (their differential distribution determined the different scores for this sub-goal). Most high seas regions scored between 71 and 81 for the iconic species sub-goal, with the Western Central Pacific scoring higher (85) and the Northwest Atlantic, Northeast Atlantic, and Arctic all scoring lower (63, 61, and 41, respectively).

Table 8.3 Full results of Ocean Health Index (OHI) scores and component goal scores for each high seas region. Only three sub-goals were assessed for the high seas; the goal scores are thus determined solely by the sub-goals. See Table 1 for goal and sub-goal abbreviations.

High Seas Region	Index	FP (FIS)	SP (ICO)	BD (SPP)
All high seas	67	45	75	80
Pacific, Northwest	53	6	71	81
Arctic Sea	54		41	66
Indian Ocean, Eastern	55	8	78	80
Atlantic, Western-Central	58	11	81	83
Atlantic, Southeast	63	34	77	80
Pacific, Southwest	65	43	75	79
Pacific, Western Central	65	30	85	82
Pacific, Eastern Central	67	47	74	79
Atlantic, Northeast	67	61	61	81
Pacific, Northeast	68	48	71	84
Atlantic, Southwest	68	45	79	80
Atlantic, Northwest	68	63	63	79
Pacific, Southeast	76	74	74	79
Atlantic, Eastern Central	79	81	74	83
Indian Ocean, Western	79	80	76	81
All EEZs	67	59	60	83

Discussion and Conclusions

Overall, the high seas scored lower on the OHI than waters within EEZs, primarily due to the limited number of goals that are relevant and assessable in the high seas and the relatively poor performance of those goals. The range of scores was smaller in the high seas than EEZ regions, with the former ranging 53-79 (Table 8.3) and the latter ranging 45-94 (Halpern et al. 2015). This is *likely* due to the larger size of high seas regions (goal scores tend to be less extreme when averaged over larger areas) and the fewer number of reporting regions (15 high seas regions versus 220 coastal regions).

No ocean-basin scale patterns in Index scores emerged. The highest scoring and lowest scoring high seas regions were found in each of the main ocean basins (Table 8.3). These patterns were largely driven by the scores for fisheries, as this goal had the largest range of values (and was one of just three goals that could be assessed). Given the large role that fisheries play in determining overall ocean health in the high seas, improving the taxonomic and spatial resolution of catch data being reported to FAO, as well as further improvement of models used to assess data-limited stocks, would go a long way towards improving the accuracy, and thus utility, of assessments of the health of the high seas. Assessment, and ultimately management, of high seas fisheries is compounded by the fact that most stocks straddle EEZ boundaries (often multiple EEZs), requiring multilateral as well as global efforts to address fisheries management.

Scores for species biodiversity and iconic species represent the average of the status of all (assessed) species that overlap a reporting area; regardless of the amount of area each species potentially occupies (Halpern et al. 2012). Because of the very large size of each high seas region, more smaller-range species are *likely* to overlap with the region than might be expected in smaller areas, such that these species have a stronger influence on scores. Smaller-range species tend to have higher extinction risk (Gaston 1998). These patterns in biodiversity scores in turn influence overall OHI scores. For example, the poor performance of ocean health in the Arctic high seas region is solely due to the high level of extinction risk to the species in that region, given that no other goals, including fisheries, were relevant or measurable in the region. In particular, a large proportion of iconic species in the Arctic are faring poorly, most notably the fin whale (*Balaenoptera physalus*) and the polar bear (*Ursus maritimus*). Ocean health in the Arctic high seas would benefit from strong measures to protect and restore biodiversity. See Section 3 for more details on governance.

The high seas represent nearly two-thirds of the world's ocean, yet this large area is divided into only 15 separate regions that were assessed here (due to FAO delineations and data resolution constraints), compared to 220 EEZ regions (summarized for 66 LMEs in the TWAP LME Technical Assessment Report Chapter 7.2.5). The ability to monitor and manage the high seas is challenged by the huge scale of these regions. The condition and location of the goals being delivered by these regions is almost certainly highly variable spatially across each region; informed decision-making would thus benefit from higher resolution assessments, which depends on higher resolution monitoring and reporting data.

Cross-system comparisons are made possible by the fact that OHI assessments are quantitative and measured in directly-comparable metric. Because Index assessments are fully transparent in their methods and process, they can easily be repeated (to check results or to update with new data) and they are more amenable to policy and management decisions. For example, OHI assessments were also done for LMEs, providing an opportunity to directly compare all regions of the world's ocean with the same indicator. Transparency and repeatability are hallmarks not only of the scientific process but are also essential for decision making if it is to be trusted by all involved and effected. All indicators rely on the underlying data that informs them. Uncertainty in OHI assessments is thus dependent on the quality and certainty of all of the input data. This concern is particularly true for assessment of fisheries in the high seas. Furthermore, key gaps remain for assessment of certain goals of the Index in the high seas (in particular pollution and its influence on the clean waters goal and the location and condition of habitats and the influence of that on the biodiversity goal), leading to higher uncertainty in assessments of overall ocean health than was possible for the LMEs. Most notably missing from this assessment is the status of deep-sea habitats. Although physical maps of these habitats exist, almost no information exists on their condition relative to historical, undisturbed baselines.

Results from OHI assessments capture most of the dimensions of the Conceptual Framework (see Section 2) that defines what needs to be known and understood for measuring the condition of high seas regions. Missing from these assessments is direct measure of how human pressures affect ecosystem state (although this is indirectly captured in the Index), and how changes in the components of the Index may (or should) affect governance and management decisions. In particular, climate change and its associated pressures on the ocean (increasing temperatures and acidification, and potential deoxygenation) are not directly transparent in the Index (although they are captured in the CHI assessment; see Chapter 8.1), and their future impact on the ocean is expected to be particularly large (Harley et al. 2006 and also see Sections 4 and 5 of this Report) but is not part of the Index beyond near (5 year) timeframe.

Connecting Index assessments to the scale and location of service delivery (instead of the entire high seas region) would *likely* produce very different results and potentially be much more informative. In particular, although it is possible to achieve a perfect score on all goals in the Index simultaneously, most actions and changes in the system result in tradeoffs among goals. For example, patches of the high seas that are highly productive and thus heavily fished may offer high levels of food provision but at cost to the status of iconic species that feed in that region. Improved and higher-resolution maps of where such tradeoffs *likely* occur would allow for much more informed decision-making regarding strategies to mitigate impacts and improve ocean health.

Managing the high seas is challenged by at least two broad issues: lack of comprehensive assessment and lack of strong governance institutions. The assessment reported here helps address the first of these; the latter is an active topic of research and discussion (for example: Berkman and Young 2009). As future assessments help refine our understanding of the spatial pattern of the health of the high seas and new institutions are developed or existing ones strengthened, the tools will be in place to significantly improve ocean health in the open ocean.

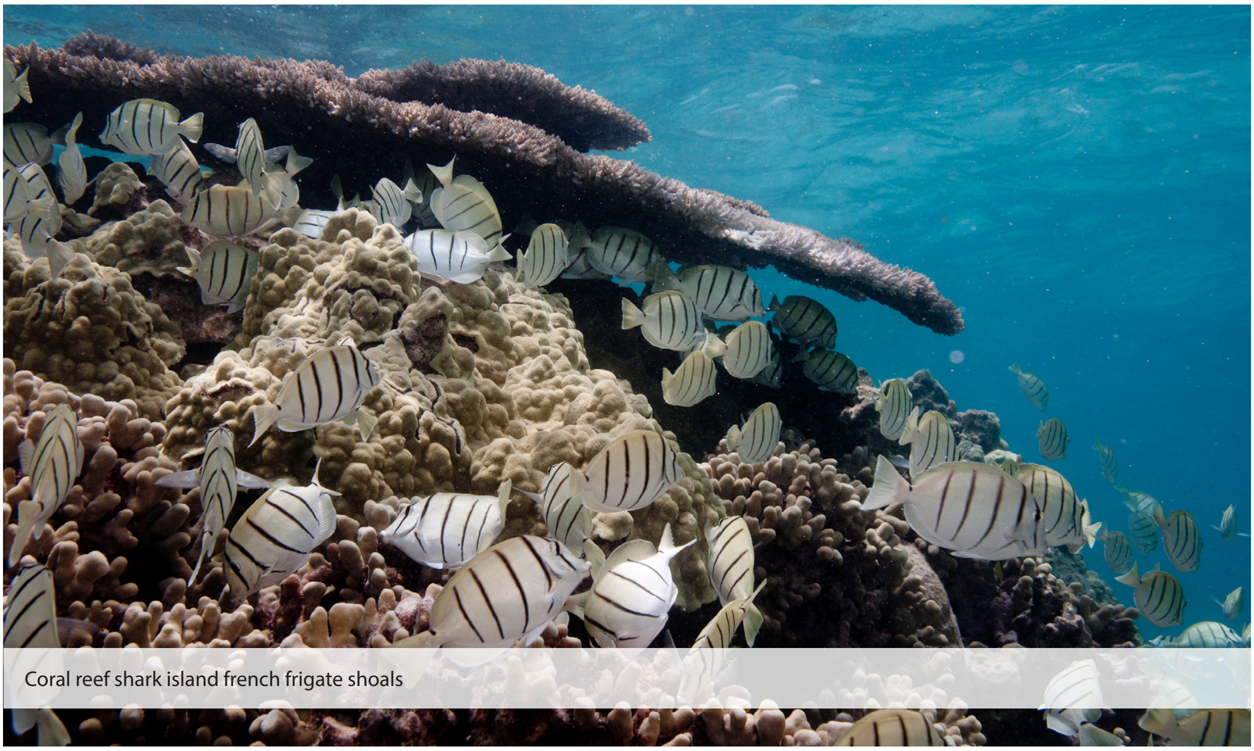
Recommendations

Managing high seas regions will benefit greatly from coordination with surrounding countries. For many issues, this will require agreements by UN member states on how to regulate areas beyond national jurisdiction (ABNJ). Because relatively few goals are relevant to or can be assessed in the high seas, the status of fisheries and biodiversity drive Index scores in these regions. As such, meaningful management aimed to improve overall ocean health needs to focus on improving fisheries management, particularly for migratory and wide-ranging stocks that influence fisheries scores for multiple high seas regions, and mitigating threats to biodiversity, in particular climate change. There is also urgent need to increase and improve monitoring of the high seas so that future assessments will be more comprehensive.

8.2.3 Notes on Methods

The OHI measures, on a scale from 0-100, the sustainable delivery now and in the future of 10 different goals for healthy oceans (Table 8.2). The current status of each goal is assessed against a reference point (see Samhouri et al. 2012; Halpern et al. 2012) that defines the maximum or optimal sustainable value of the goal, and the overall goal score is determined by combining the current status, recent trend, existing negative cumulative impacts on the goal, and governance and resilience measures in place (Halpern et al. 2012). Extensive details on how each goal is measured and which data are used to calculate the goal scores are provided elsewhere (Halpern et al. 2012, 2015; www.ohi-science.org).

Of the ten goals in the Index, only a subset is relevant to the high seas and has available data for an assessment. Goals and sub-goals that are currently not relevant and thus are not assessed include: mariculture (sub-goal of food provision), artisanal fishing opportunities, coastal protection, tourism and recreation, and coastal livelihoods and economies. Goals and sub-goals that could be relevant but do not currently have sufficient data to assess them globally include: natural products, lasting special places (sub-goal of sense of place), habitats (sub-goal of



Coral reef shark island french frigate shoals

biodiversity), and clean waters. For the clean waters goal, we had expected data to be available, but global marine debris data do not exist (although some regional data are available), human pathogens data is *likely* zero in the high seas but this is unknown (for example: ships *likely* dispose of waste in the high seas), and the spatial distribution of organic pollution is currently too coarse to be applicable to our assessments. Spatial data on atmospheric deposition of nitrogen do exist (GESAMP 2012) but we felt it was not appropriate to assess the clean waters goal (which is comprised of these 4 types of pollution) based on a single type of pollution. Emerging global data on pollution in the high seas should allow this goal to be included in future assessments. We considered including carbon storage in the assessment, but ultimately excluded the goal because pelagic carbon sequestration is currently not something that management can affect in any meaningful way, so its assessment would provide no policy value. Thus the assessment focused only on fisheries (sub-goal of food provision), iconic species (sub-goal of sense of place), and species diversity (sub-goal of biodiversity).

To assess the current condition of fisheries resources, we used data on all commercially exploited species whose catch was reported to the FAO. Many of these species are not monitored through formal stock assessments, so we calculated their status using a simplified assessment model based on the best currently available science in the field of 'data-limited' fisheries (described in detail in Halpern et al. 2015). Tests of various data-limited models using simulated data showed a modified catch- (MSY[41]) model, based on Martell and Froese (2012), as the most appropriate. The model was modified from its original formulation to obtain estimates of current population biomass relative to the biomass that yields maximum sustainable yield (B/B_{MSY}[42]; see Rosenberg et al. 2014).

41 Maximum Sustainable Yield
42 Where 'B' is current biomass, and 'B_{MSY}' is biomass at MSY. The ratio of these two values can indicate the status (sustainability) of the fishery.

One of the model parameters, the distribution of the prior (a value used to seed and constrain parameter space) for final population biomass, included a constraint based on historical peak to account for the fact that in many unregulated fisheries historical catch declines are due to overexploitation. Explorations suggested that this constraint caused the model to predict a decline in population biomass in several cases when the decline in catch was due to regulatory measures. For this reason, in cases where it could be reasonably assumed that the stock was being managed (for example: there was a Regional Fisheries Management Organization (RFMO), operating in the area that was formally charged to manage that stock) we replaced the prior on final biomass biomass (which includes constraints as a default) was replaced with a uniform distribution.

Iconic species and species biodiversity sub-goals were assessed using IUCN's Red List data on species' risk of extinction (Mace et al. 2008). The Red List categorizes species along a spectrum of extinction risk, from least concern (zero risk) to extinct, and includes assessments for 6080 species across a range of taxa. Of these species, 1820 are present in the high seas somewhere and 52 are iconic in at least one region.

The Index was calculated for the high seas portion of 15 different FAO major fishing areas (the three Antarctica FAO regions that include high seas areas were assessed together with coastal Antarctica as a single region, and the Mediterranean FAO region is completely subsumed within EEZ boundaries and so assessed for those EEZs). Because data and the best available science improved since development of the initial methodology (Halpern et al. 2012), methods for calculating several goals and the data used for them were updated (Halpern et al. 2015). For this high seas assessment, this only affected calculation of the fisheries sub-goal. Because this is the first time the high seas have been assessed, it was not possible to evaluate emerging trends in high seas scores across multiple years.

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