Reference metadata template for data reported on the Sustainable Development Goals (SDGs)

The purpose of this template is for international agencies to submit reference metadata on the agreed upon tier I and II global indicators and associated data for which they are responsible, in order to monitor the Sustainable Development Goals (SDGs) and targets in a consistent manner. In order to ensure coherence and consistency of the metadata that will be presented alongside the SDG indicator database, we are requesting uniform reference metadata on the global indicators and on associated data that you are reporting using this standard template.

While we realise this form is detailed, your willingness to provide this reference metadata in a standard format will be vital to users better understanding of the global indicators and associated data you have provided. We hope any metadata submitted previously can be copied and pasted into the relevant section of this form. Any metadata that was previously submitted to UNSD prior to July 2016 can be found at: http://unstats.un.org/sdgs/iaeg-sdgs/metadata-compilation/.

This form should be completed by the international agencies that provided their data for inclusion in the SDG progress report and associated database. Please replace the instruction text shaded in yellow with the appropriate text describing the reference metadata for that section (i.e. definition, rationale, etc.). Please try to make your responses as concise as possible while making sure to include all relevant information. For more detailed methodological information, a link can be included in the reference section (see page 4).

If there are any questions regarding SDG metadata or this form, please contact Zin Lin at lin@un.org.

Goal: 14
Target: 14.2
Indicator: Ocean Health Index (OHI)

Institutional information

Organization(s):
Ocean Health Index
National Center for Ecological Analysis & Synthesis
University of California, Santa Barbara
Santa Barbara, California, USA 93103

Contact person(s):
Ben Halpern, Ph.D.

Email address (for internal use only)
halpern@nceas.ucsb.edu

Concepts and definitions

Definition:
The Ocean Health Index (OHI) is the first and only ocean assessment tool that integrates key elements from all dimensions of the ocean's health (biological, physical, economic, and social), which is a significant advancement over conventional single-sector indicators. A healthy ocean is defined as one that sustainably delivers a range of benefits to humans now and in the future. The OHI focuses on ocean resources and services that people directly relate to and value, and it is calculated through modeling the best publicly available data with clearly defined, socially-accepted global reference point targets, resulting in scores on a unitless scale from 0-100. Yearly assessments starting in 2012 will continue to be updated annually, providing continuity of methods and data required to monitor progress of SDG targets.

Rationale:
Taken as a whole, the Ocean Health Index provides a comprehensive view of how well the marine system and the people who depend on it are faring. We define ocean health as the sustainable delivery of ten widely-held public goals for ocean ecosystems (see Concepts section below for more detail). These goals represent the full suite of sustainable benefits people derive from the ocean, including the traditional 'goods and services' people often consider (e.g., fish to eat, coastal protection from nearshore habitats) as well as benefits less commonly accounted for, such as cultural values and biodiversity. Within each region, scores, ranging from 0 to 100, are calculated for the 10 goals. This score is calculated based on current status, historical trend, and external pressures and resilience measures, all of which can be tracked and monitored through time. Each of these goals are framed to highlight the essential interactions between humans and their environments, emphasizing that sustainable use and conservation go hand-in-hand in achieving sustainable development priorities. By using the OHI lens to measure how healthy oceans are, we are able to track environmental sustainability and human community health in an integrated way, across time and space, and do so in a transparent way (i.e. all our code is open source publicly available for reuse github.com/ohi-science).

Of special note: While the focus of SDG Goal 14 is on the conservation and sustainable use of ocean resources for human development, the current targets outlined do not include several of the benefits provided by sustainable oceans. Many of these components are essential for not only knowing the status of marine ecosystems, but also the physical and social health of the people that depend on these ecosystems. For example, jobs and food are two essential foundations for healthy people, and the ocean provides these resources to people around the world. **The OHI would be an excellent overarching indicator for the entirety of SDG Goal 14 because of its specific emphasis on conservation as well as sustainable use of our oceans. The OHI would likewise serve as an excellent refinement and expansion of the indicators for SDG Target 14.2 specifically** because it not only measures the share of coastal and marine areas that are protected, but goes far beyond to also include how sustainably we are managing our coastal ecosystems to achieve healthy and productive oceans by incorporating the full suite of benefits that a sustainable ocean provides to people. **Benefits that a sustainable ocean provides to people are essential to include when considering the goal of sustainable management and protection of marine and coastal ecosystems as protection and sustainable use must go hand-in-hand if we are to truly achieve the goal of long-term sustainable, healthy, and productive oceans.** Using the OHI to monitor progress for SDG Target 14.2 would more comprehensively capture benefits provided to people through sustainable management of our oceans, and also provide information to more effectively focus conservation efforts to maintain our vital ocean and coastal ecosystems. The OHI also incorporates a suite of indicators specifically aimed at quantifying the resilience of ocean and coastal ecosystems which would additionally increase knowledge around how well we are collectively achieving Target 14.2.

Concepts:

Ocean Health Index concepts and terms in this section are identified in **bold**. The Ocean Health Index provides country-level scores that describe the health and sustainability of ten widely-held public **goals** for ocean ecosystems:

Food Provision: The sustainable harvest of seafood from wild-caught fisheries and mariculture

Artisanal Fishing Opportunity: The opportunity for small-scale fishers to supply catch for their families, members of their local communities, or sell in local markets

Natural Products: The natural resources that are sustainably extracted from living marine resources

Carbon Storage: The condition of coastal habitats that store and sequester atmospheric carbon

Coastal Livelihoods and Economies: Coastal and ocean-dependent livelihoods (job quantity and quality) and economies (revenues) produced by marine sectors

Tourism and Recreation: The value people have for experiencing and enjoying coastal areas through activities such as sailing, recreational fishing, beach-going, and bird watching

Sense of Place: The conservation status of iconic species (e.g., salmon, whales) and geographic locations that contribute to cultural identity

Clean Waters: The degree to which ocean regions are free of contaminants such as chemicals, eutrophication, disease pathogens, and trash

Biodiversity: The conservation status of native marine species and key habitats that serve as a proxy for the suite of species that depend upon them

Coastal Protection: The amount of protection provided by marine and coastal habitats serving as natural buffers against incoming waves

Scores are calculated for each goal based on a measure of **current status**, which is defined as the goal's performance relative to a socially-accepted global **reference point** target. Scores also incorporate a **likely future status** estimate that is based on recent changes in status (i.e., **trend**) as well as **pressure** and **resilience** dimensions that influence status. The role of resilience and pressure dimensions is to improve our predictions of near-term likely future status by incorporating additional information beyond that provided by the recent trend. Pressure or resilience measures that were in existence in the past may have a cumulative effect that has not yet manifested itself in trend (e.g., fishing pressure may have increasingly negative impacts as successive year classes of fish become increasingly less abundant; resilience due to establishment of a marine protected area (MPA) may require a number of years before its benefits become apparent). Both resilience and pressure dimensions are scaled from 0 to 1, and trend is constrained to $-1.0 \leq T \leq 1.0$ (i.e., values outside this range are clamped to range end values).

For a detailed description of each goal visit the OHI website here: http://ohi-science.org/ohi-global/goals
For a deeper dive into the data and methodologies used to calculate each goal score, go here: https://raw.githack.com/OHI-Science/ohi-global/published/global_supplement/Supplement.html

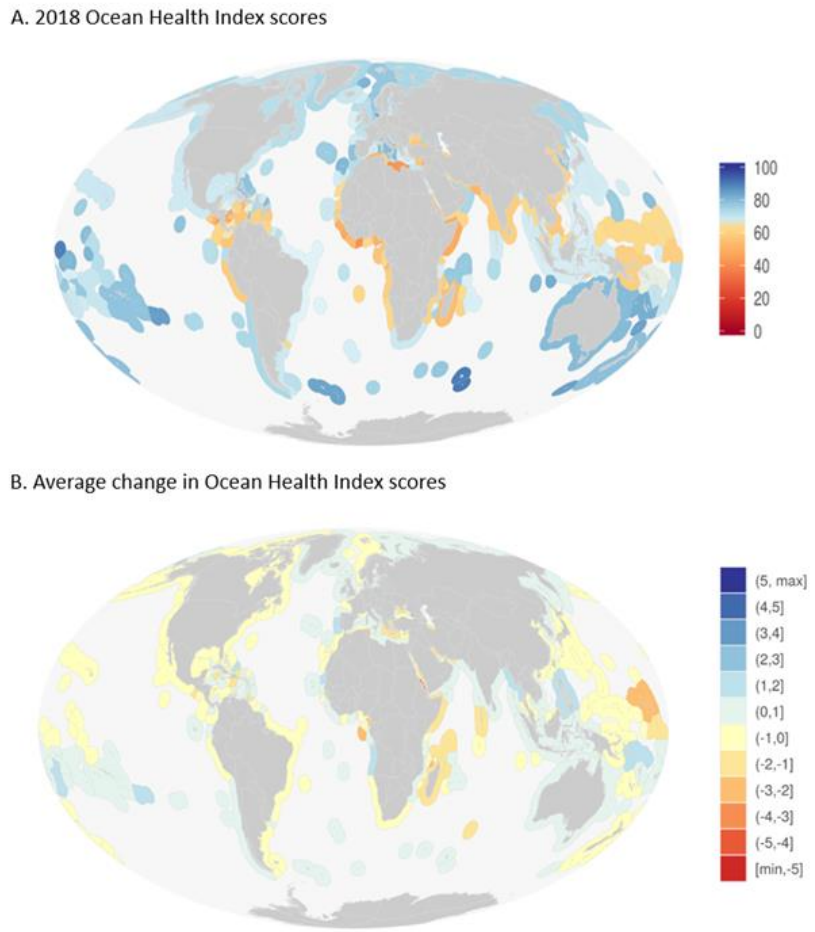

Figure 1. Ocean Health Index scores for 220 coastal regions, with scores from 0 (low health/sustainability) to 100 (high health/sustainability) (A). Average annual change in OHI scores. Annual change is estimated with a linear regression model of scores from 2012 to 2018 (B). Yellow to red regions indicate no change or decreasing Index scores. Source: http://ohi-science.org/ohi-global.

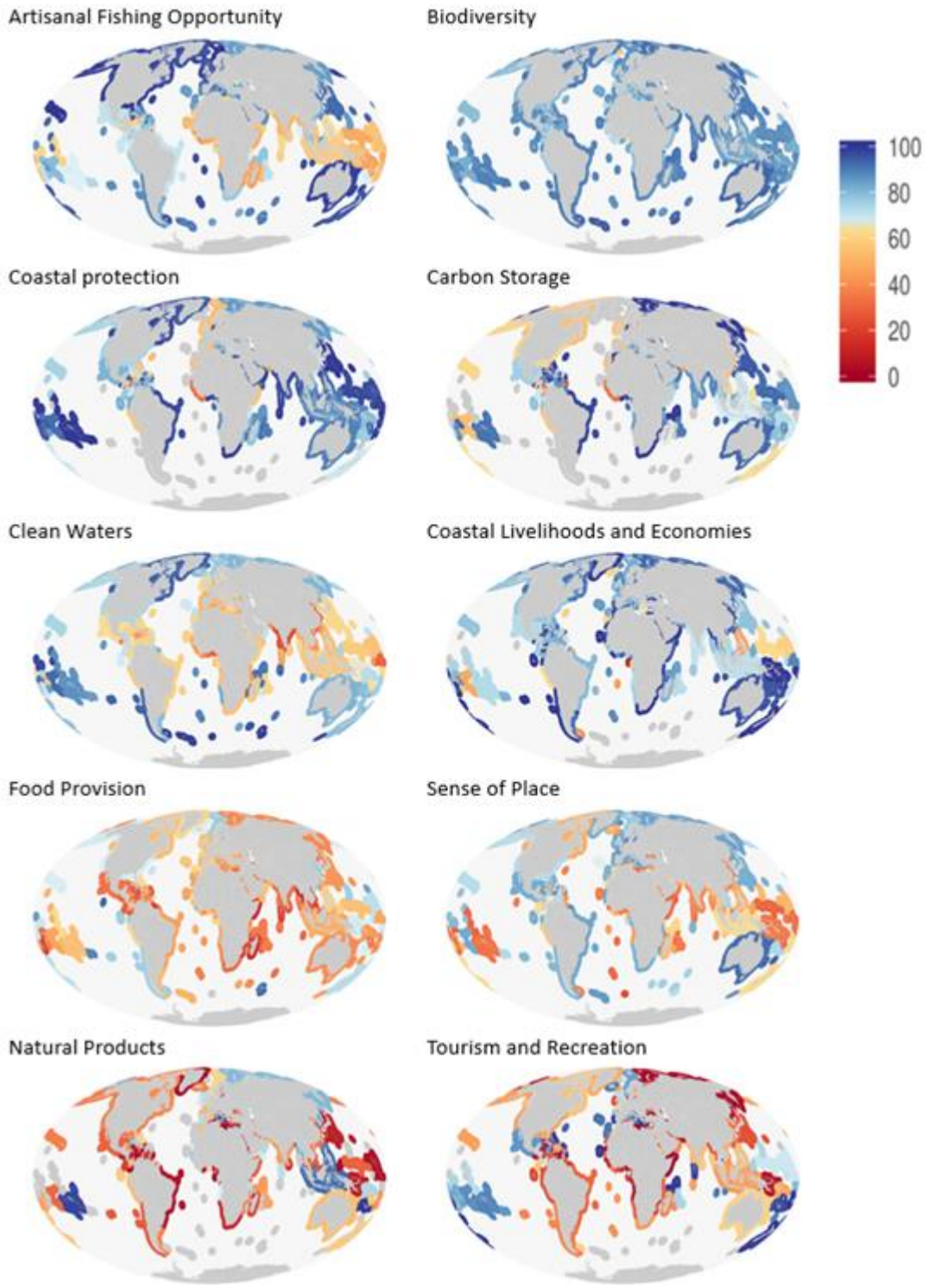

Figure 2. Global OHI scores for 10 sub-indicators for 220 coastal regions, with scores from 0 (low health/sustainability) to 100 (high health/sustainability). Source: http://ohi-science.org/ohi-global.

Comments and limitations:
The OHI framework and its accompanying open-source software is ready to use now, and is freely available online (ohi-science.org). The Index has been used – and improved upon – every year for the last seven years to assess global ocean health, and will continue to be used for global assessments into the future with minimal effort and cost.

The OHI is calculated annually, and 2019 marks the eighth year the OHI has been used to assess the ocean health of 220 coastal nations and territories. The OHI framework has not changed since its inception in 2012 (Halpern et al. 2012). However, the OHI has benefitted from continued evaluation and improvement, incorporating new knowledge and data and updating methods to better capture the health and sustainability of ocean resources (Halpern et al. 2015; 2017). When upgrades occur, previous years are back-calculated so all scores are comparable across time. Information for all assessment years is available from ohi-science.org/ohi-global/download.

OHI assessments are conducted in a transparent, collaborative way using the "OHI Toolbox", which leverages existing software and best practices from open science and data science, what we call open data science. The Toolbox is based in R, RStudio, and GitHub, and provides file structure, data, code, and instruction that are shared online for free (Lowndes et al. 2017). The "OHI Toolbox" allows anyone to build directly from previous OHI assessments, conceptually and practically, without reinventing the wheel. In addition to streamlining the global assessment, the OHI Toolbox has been used for over twenty independent assessments that are ongoing around the world, including in the Baltic Sea, Ecuador, and Canada (Lowndes et al. 2015; ohi-science.org).

The OHI global assessment will continue into the future, providing scores to track changes in ocean health through time. With the streamlining and automation of the Toolbox, annual global OHI assessments are achieved in less time and effort each year (Lowndes et al. 2017). In 2018, the OHI team piloted a model to complete annual assessments at lower cost by launching the OHI Fellows Program. The OHI team trains graduate student fellows in OHI methods and open data science tools so they can lead the annual global assessment. In addition to updating the scores, the Fellows learn skills to become valuable members to the global OHI community and beyond (ohi-science.org/ohi-global/fellows).

As an annual global indicator, the accessibility of publicly available data that is reported on a yearly basis is a limiting factor of OHI. We continue to calculate scores each year, combining the most recently available data, which means combining data from different years.

Methodology

Computation Method:
The computational methods for each component of the Ocean Health Index are described in detail below.

Goal Scores
In OHI, each goal score is the average of its current status and likely future status (Figure 3). The Index assesses the current status of each goal relative to a reference point. Likely future status is estimated

using: recent trends in current status; pressures that can stress the system and threaten future delivery of benefits; and resilience to such pressures, due to governance, institutional and ecological factors.

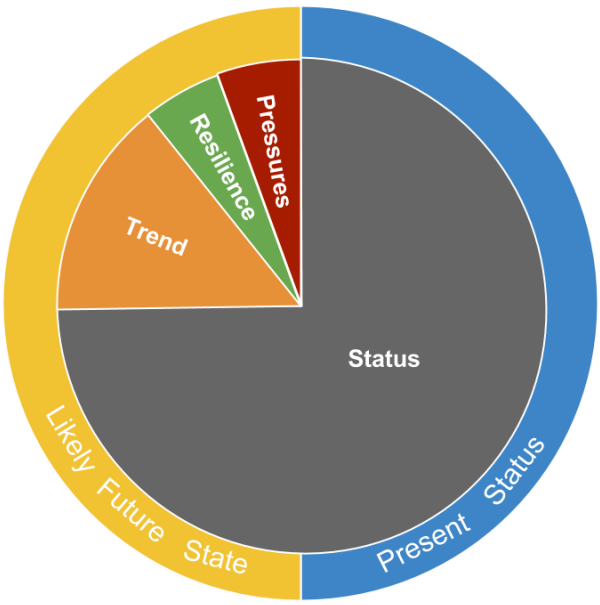

Figure 3. Pie chart describing the contribution of each dimension to the goal score

Each goal score, G, is the average of its present status, x, and its likely near-term future status, $\hat{x}_F$:

$$G = \frac{x + \hat{x}_F}{2}$$

The status of goal, x, is its present state, X, relative to a reference point, X_R, uniquely established for each goal:

$$x_i = \frac{X}{X_R}$$

The reference point, X_R, can be determined mechanistically using a production function (e.g., maximum sustainable yield, MSY, for fisheries), spatially by means of comparison with another region (e.g., country X represents the best possible known case), temporally using a past benchmark (e.g., historical habitat extent), or in some cases via known (e.g., zero pollution) or established (e.g., 30% of waters set aside in MPAs) targets. Past benchmarks can either be a fixed point in time or a moving target (e.g., five years prior to most current data). The type of reference point can have important implications for interpretations of how a goal is doing in any given country.

For each region, the estimate of a goal's likely near-term future status is a function of its present status, x modified by: recent trends, T, in status; current cumulative pressures, p, acting on the goal; and social and ecological resilience, r, to pressures given the governance and social institutions in place to protect or regulate the system and the ecological condition of the system:

$$\hat{x}_F = [1 + \beta T + (1 - \beta)(r - p)]x$$

where, β represents the relative importance of the trend versus the resilience and pressure terms in determining the likely trajectory of the goal status into the future. We assume $\beta = 0.67$, which makes trend twice as important as the pressure/resilience component. We chose this value because we believe

the direct measure of trend is a better indicator of future (i.e., in five years) condition than indirect measures of pressure and resilience.

The role of the resilience and pressure dimensions is to improve our understanding of the likely near-term future condition by incorporating additional information beyond that provided by the recent trend. Pressure or resilience measures that were in existence in the past may have a cumulative effect that has not yet manifested itself in trend (e.g., fishing pressure may have increasingly negative impacts as successive year classes of fish become increasingly less abundant; resilience due to establishment of a marine protected area (MPA) may require a number of years before its benefits become apparent). In addition, the recent trend does not capture the effect of current levels of resilience and pressures. The expectation of a likely future condition suggested by the trend will become more or less optimistic depending on the resilience and pressure dimensions. If the effects are equal they cancel each other out.

Both resilience and pressure dimensions are scaled from 0 to 1, and trend is constrained to $-1.0 \leq T \leq 1.0$ (i.e., values outside this range are clamped to range end values).

The likely future status cannot exceed the maximum possible value of the status for each goal, which is 1.0. In reality data are rarely perfect, creating potential situations where likely future condition exceeds 1.0. To address these cases, we implemented two rules. First, if current status = 1.0, then trend is set = 0.0, since any trend > 0.0 in those cases must be due to incomplete or imperfect data. Second, status and likely future status scores were constrained to maximum value of 1.

Likely future status dimensions

Three dimensions are used to calculate likely future status: trends, pressure, and resilience. This section describes the calculations underlying these three dimensions.

Trend

Trend is the proportional change in status predicted to occur in 5 years, based on recent status data. In most cases, this is calculated by estimating the yearly change in status using a linear regression model (i.e., slope estimate) of the five most recent years of status data and multiplying this value by 5 to estimate the change five years into the future. To determine proportional change, we divide the slope estimate by the status value of the earliest year of data used in the trend calculation.

Trends indicate proportional change in status, so they typically range from -100% to +100% (or, -1.0 to +1.0), therefore we constrained values to this range.

For all goals we include the trend estimate, even if the linear model is not statistically significant (i.e., $P<0.05$). We chose to include these values for two key reasons: 1) we are not trying to predict the future but instead only indicate likely condition. 2) in nearly all cases we do not have sufficient data to conduct more rigorous trend analyses.

In some cases, we are not able to estimate trend using status data due to data limitations. In these cases, we use alternative methods to estimate trend.

We recognize several possible shortcomings in using past trends to estimate likely future status. We assume a simple linear trend, but this is not always the case due to a variety of variables such as altered pressures and resilience responses, nonlinear patterns in system response, stochastic environmental and biological variability, and simple bounding conditions (status cannot go below zero or above 1.0, and so the trend must level off as it approaches these values). Also, it is important to note that the same trend value could reflect many different processes. For example, declines due to unsustainable harvest of a resource can look identical to declines due to restrictions placed on resource users to allow the resource to recover. It also may be too short a time frame to determine true trends or the causes of those trends, but the intent here is more about informing the likely near-term trajectory.

Pressure

The pressure score, p, describes the cumulative pressures acting on a goal which suppress the goal score. Pressure scores range from 0 to 1, and they are calculated for each goal and region and include both ecological (p_E) and social pressures (p_S) (Figure 4), such that:

$$p \quad = \quad \gamma * p_E \quad + \quad (1-\gamma) * p_S$$

where γ is the relative weight for ecological vs. social pressures and equals 0.5 for the global assessment. At global scales, little evidence exists to support unequal weighting of ecological and social pressures for most goals; furthermore, unequal weighting would require unique values for each goal and there is currently no empirical work to guide such decisions. At local or regional scales there may be clear evidence for unequal weights per goal and γ should be adjusted accordingly.

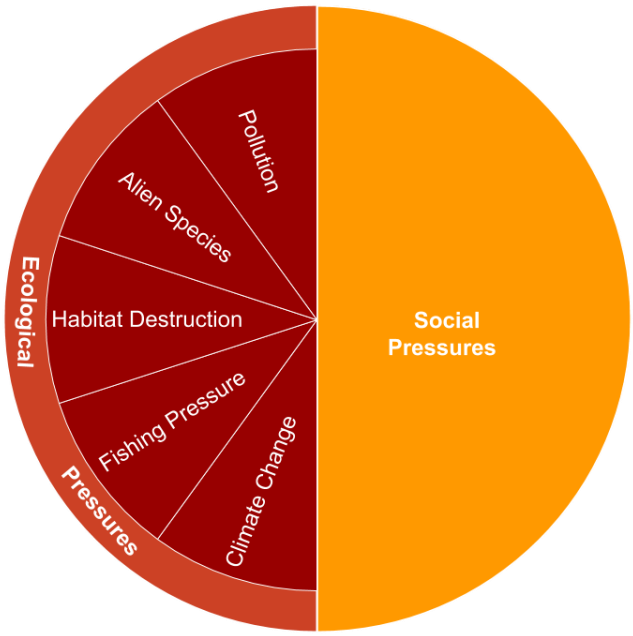

Figure 4. Pressure is calculated using both social and ecological pressures. Ecological pressures include 5 subcategories (fishing pressure, habitat destruction, climate change, water pollution, and species/genetic introductions).

Ecological pressure

We assess five broad, globally-relevant categories of ecological stressors: fishing pressure, habitat destruction, climate change (including ocean acidification), water pollution, and species introductions (invasive species and genetic escapes). The five categories are intended to capture known pressures to the social-ecological system associated with each goal. Each pressure category may include several stressors. The intensity of each stressor within each OHI region is scaled from 0 to 1, with 1 indicating the highest stress (e.g., example of one of these data layers is sea surface temperature).

We determine the rank sensitivity of each goal/subgoal to each stressor (or, when possible, an element of the goal, such as a specific habitat). We rank ecological pressures as having 'high' (score = 3), 'medium' (score = 2), 'low' (score = 1), or 'no' (score = NA) impact. Wherever possible we rely on peer-reviewed literature to establish these rankings, and rely on our collective expert judgment in cases with no available literature (Table S28 in Halpern et al. 2012). The pressure ranks are based on a rough estimate of the global average intensity and frequency of the stressor. We recognize that this will create over- and under-estimates for different places around the planet, but to address such variance in a meaningful way would require a separate weighting matrix for every single region on the planet, which is not feasible at this time.

To estimate the cumulative effect of the ecological pressures, P_E, we first determine the cumulative pressure, p, within each ecological category, i (e.g., pollution, fishing, etc.):

$$p_i = \frac{\sum_{i=1}^{N} w_i s_i}{3}$$

Where w_i is the sensitivity ranks describing the relative sensitivity of each goal to each stressor, and s_i is intensity of the stressor in each region on a scale of 0-1. We divide by the maximum weighted intensity that could be achieved by the worst stressor (max = 3.0).

If p_i > 1.0, we set the value equal to 1.0. This formulation assumes that any cumulative pressure load greater than the maximum intensity of the worst stressor is equivalent to maximum stressor intensity.

For the goals for which sensitivity ranks are assigned for specific habitats or livelihood sectors (i.e., goal elements), we calculate the weighted sum of the pressures for only those habitats or sectors that are present in the country.

The overall ecological pressure, p_E, acting on each goal and region is calculated as the weighted-average of the pressure scores, p, for each category, i, with weights set as the maximum rank in each pressure category (w_{i_max}) for each goal, such that:

$$p_E = \frac{\sum_{i=1}^{N} (w_{i_max} * p_i)}{\sum_{i=1}^{N} w_{i_max}}$$

Stressors that have no impact drop out rather than being assigned a rank of zero, which would affect the average score.

Social pressures

Social pressures describe the lack of effectiveness of government and social institutions. Social stressors are described for each region on a scale of 0 to 1 (with one indicating the highest pressure). Social pressure is then calculated as the average of the social stressors:

$$p_S = \frac{\sum_{i=1}^{N} z_i}{N}$$

where z_i are the social pressure measures specific to the goal. Unequal weighting may be appropriate in some cases but is difficult to assess currently, particularly at the global scale.

Caveats

There are a number of ecological pressures not included in the Ocean Health Index, including altered sediment regimes, noise and light pollution, toxic chemicals from point sources, nutrient pollution from atmospheric deposition and land-based sources other than fertilizer application to agricultural land. In all cases, global data do not exist in a format that would allow for adequate comparisons within and among countries. Future global or regional iterations of the Index could include these data as they become available.

The calculation of ecological pressures is sensitive to the number of stressors within each category (but not to the number of categories). Inclusion of additional stressors within categories would require careful calibration of ranks so that the cumulative effect of a larger number of stressors does not overestimate pressure.

A key assumption in our assessment of ecological pressures is that each goal has a linear and additive response to increases in intensity of the stressors. Clearly many ecosystems respond non-linearly to increased stressor intensity, exhibiting threshold responses, and there are likely nonlinear interactions among stressors. Unfortunately little is known about the nature of these types of nonlinearities and interactions so we could not include them in any meaningful way.

Resilience

To calculate resilience for each goal and region, r, we assess three resilience categories (Figure 5): ecological integrity, Y_E, regulatory efforts that address ecological pressures, Y_R, and social integrity, Y_S. The first two measures address ecological resilience while the third addresses social resilience. When all three aspects are relevant to a goal, resilience is calculated as:

$$r \quad = \quad \gamma * (\frac{Y_E + Y_R}{2}) + (1 - \gamma) * Y_S$$

We chose $\gamma = 0.5$ so the weight of resilience components that address ecological systems (ecosystem and regulatory) vs. social systems would be equivalent to the proportions used in the model to calculate pressure.

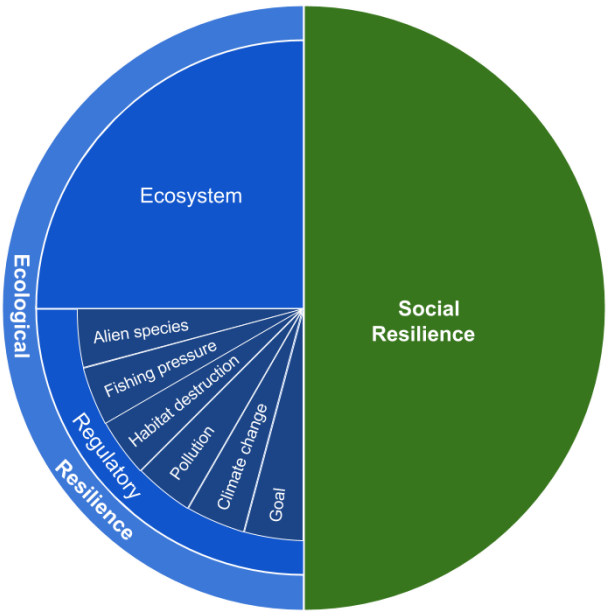

Figure 5. Resilience includes both ecological and social resilience categories. Ecological resilience includes an ecosystem and regulatory category. The regulatory category includes 5 subcategories that mirror the pressure categories (fishing pressure, habitat destruction, climate change, water pollution, and species/genetic introductions) as well as a goal-specific category.

Each resilience category is composed of 1 or more data layers with values scaled from 0-1, reflecting the magnitude of resilience, for each region (an example of one of these data layers describes tourism regulations that preserve biodiversity). Each resilience data layer is assigned a weight of 0.5 or 1 that is applied equally across all the goals (or, goal elements) influenced by the resilience layer (i.e., resilience matrix). This information is used to calculate a score for each resilience category. The weight reflects information about governance.

Ecological resilience

Ecosystem integrity

Ecosystem integrity, e.g., food web integrity, is measured as relative condition of assessed species in a given location (scores from the species subgoal were used to estimate ecosystem integrity). For some goals, there is little evidence that our index of ecosystem integrity directly affects the value of the goal (or subgoal). In these instances, ecological integrity falls out of the resilience model.

For the global assessments, we only have one data layer describing ecosystem integrity, however, if there were multiple layers the overall score for ecosystem integrity would be a weighted mean of all the data layers, i, that describe ecosystem integrity ($y_{E,i}$) and influence the goal:

$$Y_E = \frac{\sum_{i=1}^{N} w_i y_{E\,i}}{\sum_{i=1}^{N} w_i}$$

Regulatory resilience

Regulatory resilience (Y_R) describes the institutional measures (e.g., rules, regulations, and laws) designed to address ecological pressures. The regulatory resilience datasets are grouped into five categories that address the 5 pressure categories: fishing pressure, habitat destruction, climate change (including ocean acidification), water pollution, and species introductions (invasive species and genetic escapes). There is also an additional category for goal-specific regulations that apply to a goal or goals, but do not address a larger pressure category.

Weights are based effectiveness of governance. Governance is a function of 1) institutional structures that address the intended objective, 2) a clear process for implementing the institution is in place, and 3) whether the institution has been effective at meeting stated objectives. At global scales it is very difficult to assess these three elements; we usually only have information on whether institutions exist. However, in some cases we have detailed information on institutions that enable us to assess whether they would contribute to effective management, and thus, increased ocean health. In the latter cases, we give more weight to those measures.

For each region and goal, we calculate a score for each regulatory category, $y_{R,i}$, as a weighted mean of the resilience data layers, r_i, that influence the goal:

$$y_{R,i} = \frac{\sum_{i=1}^{N} w_i r_i}{\sum_{i=1}^{N} w_i}$$

where, w_i is the weight.

To calculate the overall regulatory resilience, Y_R, we average the scores for each regulatory category.

Social integrity resilience

Social integrity is intended to describe those processes internal to a community that affect its resilience. It is a function of a wide range of aspects of social structure. Social Integrity per goal for each region, Y_S, is therefore:

$$Y_S = \frac{\sum_{i=1}^{N} y_{S,i}}{N}$$

where $y_{S,i}$ are the social integrity measures specific to the goal.

Ideally, assessments of social resilience would include state and federal level rules and other relevant institutional mechanisms as well. However, such information is extremely difficult to access for every single country, and so we rely on global datasets that focus on international treaties and assessments. Another key gap is information on social norms and community (and other local-scale) institutions (such as tenure or use rights) that influence resource use and management in many settings. Information on these institutions is also extremely difficult to find at a global scale, although the World Governance Indicator (Kaufmann *et al.* 2010) partly measures their effectiveness through its inclusion of corruption indices.

Goal models and data

In this section we provide a general description of each goal. Please see our extensive online methods (https://raw.githack.com/OHI-Science/ohi-global/published/global_supplement/Supplement.html#601_tables_describing_data_layers_(table_61)_and_sources_(table_62) for data sources and models used to calculate each goal's status and trend as well

as the pressure and resilience variables used to calculate goal scores. Global OHI scores incorporate nearly 100 publicly available data sets.

Food provision

One of the most fundamental services the ocean provides people is the provision of seafood. From meeting the basic nutritional needs of over half of the world's population to being sold in high-end sushi restaurants, seafood is an important benefit of healthy oceans. This goal measures the amount of seafood sustainably harvested within an EEZ or region through any means for use primarily in human consumption. The status of the food provision goal is calculated as the mean of the fisheries and mariculture subgoals, weighted by their relative contribution in tonnes to food production for each region.

The fisheries component of the food provision goal assesses the amount of wild-caught seafood that can be sustainably harvested with penalties assigned for both over- and under-harvesting. As such, one must establish a reference point at which harvest is both maximal and sustainable. We assess food provision from wild caught fisheries by estimating population biomass relative to the biomass that can deliver maximum sustainable yield (B/B_{MSY}) for each stock. When available, we obtain B/B_{MSY} values from the RAM Legacy Stock Assessment Database (Ricard *et al.* 2012), which contains stock assessment information for a portion of global fish stocks. When RAM data are not available, we use data-limited approaches that have been developed to estimate B/B_{MSY} values using globally available catch data (Costello *et al.* 2012, 2016; Martell & Froese 2013; Thorson *et al.* 2013; Rosenberg *et al.* 2014). To calculate the status for each region and year, B/B_{MSY} values are converted to a stock status score between 0-1 that penalizes both over- and under-harvesting. To obtain the overall status for each region, the stock status scores for all the stocks within a region are averaged using a geometric mean weighted by the average catch (tonnes) of each stock.

The mariculture component of the food provision goal assesses each region's food production from sustainable mariculture harvest. Sustainable harvest data is adjusted for coastal population within a country given the assumption that production depends on the presence of coastal communities that can provide the labor force, infrastructure, and economic demand to support the development and economic viability of mariculture facilities. This assumes that mariculture development scales proportionally with coastal population. The status of the mariculture subgoal is based on the production of strictly marine taxa from both the marine and brackish water FAO categories, excluding species that were not used as a source of food for human consumption. Seaweeds are included, but the tonnes of harvest is multiplied by 0.2 to adjust for protein content relative to fish and shellfish mariculture. The reference point is based on a relative comparison of country performance, relative to other countries, of the harvested tonnes of seafood from sustainable mariculture practices per coastal inhabitant.

Artisanal fishing opportunities

Artisanal fishing, often called small-scale fishing, provides a critical source of food, nutrition, poverty alleviation and livelihood opportunities for many people around the world, in particular in developing nations. This goal measures whether people who need to fish on a small, local scale have the opportunity to do so. It has three sub-components: stock, access, and need. A score of 100 means the country or region is meeting the needs of artisanal fishermen or communities by implementing institutional supports, providing access to near-shore water, and maintaining the health of targeted species. The status of this goal is a function of need for artisanal fishing opportunities and whether or not the opportunity is permitted and/or encouraged institutionally and done sustainability. This *need* was measured by an analogous proxy: per capita gross domestic product (pcGDP) adjusted by the purchasing power parity (PPP), which translates the average annual income (pcGDP) into its local value (PPP). These data correlate with UN data on the percent of a population living below international poverty standard, which directly ties to this need for small-scale fishing. *The opportunity or ability to meet this need*, we used data from (Mora et al. 2009), which scores countries on the institutional measures that support or

facilitate artisanal and small-scale fishing. The reference point for this goal is when all demand for artisanal fishing is allowed and/or achieved and done in a sustainable manner.

Natural products

In many countries the harvest of non-food natural products is important for local economies and can also be traded internationally. The sustainable harvest of these products is therefore an important component of a healthy ocean. This goal assesses the ability of countries to maximize the sustainable harvest of living marine resources, such as corals, shells, seaweeds, and fish for the aquarium trade. It does not include bioprospecting which focuses on potential (and largely unknowable and potentially infinite) value rather than current realized value, or non-living products such as oil and gas or mining products which by definition are not sustainable.

The natural products goal model measures the sustainable harvest (in metric tons) of six natural ocean products: coral, ornamental fish, fish oil, inedible seaweeds and marine plants, shells, and sponges. Tonnes of harvest is adjusted using the *sustainability* of each product. The reference point is determined for each country based on the maximum harvest achieved within the country across years.

Carbon storage

Coastal wetland ecosystems store substantial amounts of carbon. They are also threatened by coastal development, but are amenable to restoration and conservation efforts. This goal captures the amount of carbon stored in three coastal habitats known to provide meaningful carbon storage: mangroves, seagrasses, and salt marshes. A score of 100 means all habitats that contribute to carbon removal within a country are still intact or have been restored and they can function to their full carbon burial potential. This goal model measures the current 'condition' of habitats relative to reference conditions, weighted by the relative contribution of each habitat type to total carbon sequestration. We generally considered the reference years to be between 1980-1995, although these varied by habitat due to data availability.

Coastal protection

This goal aims to assess the amount of protection provided by marine and coastal habitats against flooding and erosion to coastal areas that people value, both inhabited (homes and other structures) and uninhabited (parks, special places, etc.). This goal captures the degree of protection, relative to historical protection, provided by coastal habitats: mangroves, seagrasses, salt marshes, coral, and sea ice. A score of 100 means all habitats that contribute to coastal protection within a country are still intact or have been restored and they can function to their full potential. This goal model measures the current 'condition' of habitats relative to reference conditions, weighted by their area and protectiveness ability. A temporal reference point (ie. coverage data of a historical point) was used for each type of habitat. We generally considered the reference years to be between 1980-1995, although these varied by habitat due to data availability.

Tourism and recreation

Tourism and recreation in coastal areas is a major component of thriving coastal communities and a measure of how much people value ocean systems, i.e. by traveling to coastal and ocean areas. The objective of this goal is to capture the number of people, and the quality of their experience, visiting coastal and marine areas and attractions. As well as ensuring that this activity is sustainable. A score of 100 means a region uses its full recreational potential without harming the ecosystem. Because few non-economic indicators of tourism and recreation exist at the global scale, we use employment in the tourism sector as a reasonable proxy measure for the total number of people engaged in coastal tourism

and recreation activities. Employment within this sector should respond dynamically to the number of people participating in tourist activities, based on the assumption that the number of hotel employees, travel agents and employees of other affiliated professions will increase or decrease with changing tourism demand within different regions. The model also incorporates tourism competitiveness index (TTCI) from the World Economic Forum (WEF 2017) to capture the sustainability of the tourism industry. The reference point is based on a countries performance relative to other countries.

Livelihoods and economies

The jobs and revenue produced from marine-related industries are important to many people, even those who do not directly participate in the industries but value community identity, tax revenue, and indirect economic and social impacts of a stable coastal economy.

This goal is composed of two equally important sub-goals, livelihoods and economies, which are assessed across as many marine-related sectors as possible. Livelihoods includes two equally important sub-components, the number of jobs, which is a proxy for livelihood quantity, and the per capita average annual wages, which is a proxy for job quality. Economies is composed of a single component, revenue. We track the two halves of this goal separately because the number and quality of jobs and the amount of revenue produced are both of considerable interest to stakeholders and governments, and could show very different patterns in some cases (e.g., high revenue sectors do not necessarily provide large employment opportunities). The status of the livelihoods and economies goal is the average of the livelihoods and economies subgoals.

The jobs and revenue produced from marine-related industries are clearly of huge value to many people, even for those people who do not directly participate in marine-related industries. People value community identity, tax revenue, and indirect economic and social impacts of a stable coastal economy. This sub-goal Livelihood describes job quantity and quality for people living on the coast. Livelihoods includes two equally important sub-components, the number of jobs, which is a proxy for livelihood quantity, and the per capita average annual wages, which is a proxy for job quality.

The livelihood portion of this goal is based on job and wage data:

- jobs: the total number of jobs within marine sectors within a country, adjusted by sector- and development status-specific multipliers derived from the literature. The multipliers account not only for direct employment opportunities and revenue, but also indirect and induced economic effects, since activity in the direct industry stimulates additional jobs and revenue in related industries.
- average wages per job within each sector: adjusted for PPP (ie. purchasing power parity) to control for differences in the purchasing power of a dollar across countries with respect to a range of common goods.

The marine sectors included in this model are: tourism, commercial fishing, marine mammal watching, aquarium fishing, wave & tidal energy, mariculture, transportation & shipping, ports & harbors, ship & boatbuilding. Because there is no absolute reference point for jobs (i.e., a target number of jobs would be completely arbitrary), its reference point is calculated as a relative value on a moving baseline: the value in the current year (or most recent year) relative to the value in a recent moving reference period, defined as 5 years prior to the current year. This reflects an implicit goal of maintaining coastal livelihoods and economies on short time scales, allowing for decadal or generational shifts in what people want and expect for coastal livelihoods and economy. For wages we assumed the reference value for average annual wages is the highest value observed across all reporting units.

The economies portion of this goal is based on revenue from these marine sectors: tourism, commercial fishing, marine mammal watching, aquarium fishing, wave & tidal energy, mariculture, transportation & shipping, ports & harbors, ship & boatbuilding. Revenue is adjusted by sector- and development status-specific multipliers derived from the literature to account not only for direct revenue, but also indirect and induced economic effects, since activity in the direct industry stimulates additional jobs and revenue in related industries. Because there is no absolute reference point for revenue (i.e., a target number of revenue would be completely arbitrary), its reference point is calculated as a relative value on a moving baseline: the value in the current year (or most recent year) relative to the value in a recent moving reference period, defined as 5 years prior to the current year. This reflects an implicit goal of maintaining coastal livelihoods and economies on short time scales, allowing for decadal or generational shifts in what people want and expect for coastal livelihoods and economy.

Sense of place

The sense of place goal captures the aspects of the coastal and marine system that people value as part of their cultural identity. This definition includes people living near the ocean and those who live far from it but still derive a sense of identity or value from knowing particular places or species exist. This goal is calculated using two equally weighted subgoals: iconic species and lasting special places.

The iconic species portion of this goal evaluates the condition of species within a country that are relevant to local cultural identity through: 1) traditional activities such as fishing, hunting or commerce; 2) local ethnic or religious practices; 3) existence value; and 4) locally-recognized aesthetic value (e.g., touristic attractions/common subjects for art such as whales). The list of iconic species is from the World Wildlife Fund's global and regional lists for Priority Species (especially important to people for their health, livelihoods, and/or culture) and Flagship Species ('charismatic' and/or well-known). And condition is based on the IUCN status data for each species. The reference point is for all iconic species to have an IUCN status of Least Concern.

The lasting special places portion of this goal assesses the protection and conservation of geographic locations that hold particular value for aesthetic, spiritual, cultural, recreational or existence reasons. The model measures the percentage of protected area within 3nmi of shore and 1km inland. The reference point is protecting 30% of the coastal area.

Clean waters

People value marine waters that are free of pollution and debris for aesthetic and health reasons. Contamination of waters comes from oil spills, chemicals, eutrophication, algal blooms, disease pathogens (e.g., fecal coliform, viruses, and parasites from sewage outflow), floating trash, and mass kills of organisms due to pollution. People are sensitive to these phenomena occurring in areas that they access for recreation or other purposes as well as for simply knowing that clean waters exist. The Clean Water goal captures the degree to which local waters are unpolluted. The clean waters goal score is calculated as the geometric mean of its four components: eutrophication (nutrients), chemicals, pathogens and marine debris. Chemical pollution describes land-based organic and inorganic pollution from agricultural pesticide and herbicide use and runoff from impervious surfaces, and ocean-based pollution from commercial shipping and ports. Nutrient pollution describes nitrogen and phosphorus inputs from agricultural fertilizer inputs. To estimate pathogen pollution we determined the number of people in coastal areas without access to improved sanitation facilities. Trash pollution was estimated using globally-available plastics data. The reference point is zero pollution for all inputs.

Biodiversity

People value biodiversity, in particular, for its existence value. The risk of species extinction generates great emotional and moral concern for many people. As such, this goal assesses the conservation status of species based on the best available global data through two sub-goals: species and habitats. Species were assessed because they are what one typically thinks of in relation to biodiversity. Because only a small proportion of marine species worldwide have been mapped and assessed, we also assessed habitats as part of this goal, and considered them a proxy for condition of the broad suite of species that depend on them.

The species condition portion of the goal measures the average threat status, defined by the International Union for Conservation of Nature (IUCN), of species in each country, weighted by each species' area of distribution within the country's EEZ. The reference point is for all species to have a risk status of Least Concern. We also scaled the lower end of the goal to be 0 when 75% species are extinct, a level comparable to the five documented mass extinctions and would constitute a catastrophic loss of biodiversity.

The habitat conditions portion of the goal evaluates the condition of marine habitats in each country. We assessed all habitats for which at least some global data were available, specifically: mangroves, coral reefs, seagrass beds, salt marshes, sea ice edge, and subtidal soft-bottom habitats. Status was calculated as the average of the condition estimates for each habitat present in a region, measured as the loss of habitat and/or percent degradation of remaining habitat. A temporal reference point (ie. coverage data of a historical point) was used for each type of habitat. We generally considered the reference years to be between 1980-1995, although these varied by habitat due to data availability.

Disaggregation:

OHI scores can be disaggregated into ten goals (some of which have sub-goals), and then further into the status, trend, likely future status, pressures, and resilience. Figure 6 shows an OHI flower plot, which displays the overall Index score (center; described in following "regional aggregates" section) as well as each goal score separately. Each "petal" in the flower plot represents a goal, with length and color illustrating how close it is to a score of 100 (outer ring and dark blue, respectively). Petal widths illustrate each goal's contributing weight to the overall Index score. Weighting is currently equal across all 10 goals, with any subgoals contributing half of that weight; the exception is the food provision goal, which is weighted by catch of either mariculture or wild-caught fisheries.

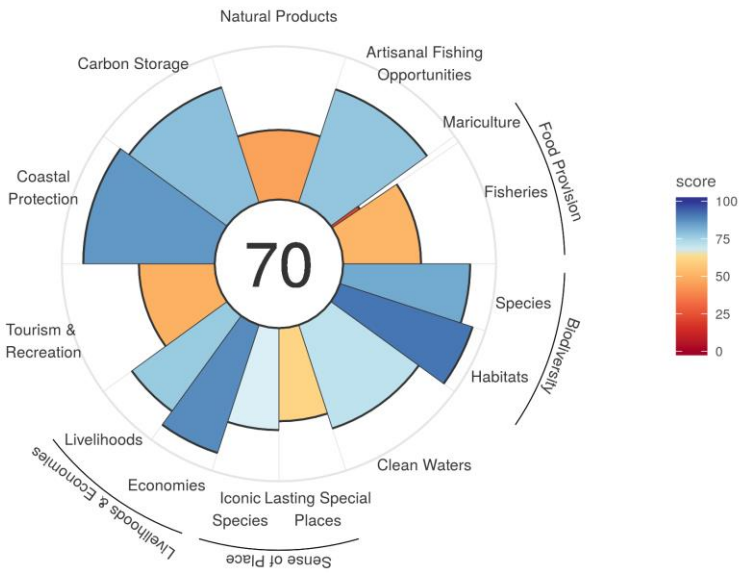

Figure 6. Global OHI scores for 2018 as a flower plot, which displays the overall Index score (center) as well as each goal score separately. Each "petal" in the flower plot represents a goal, with length and color illustrating how close it is to a score of 100 (outer ring and dark blue, respectively). Petal widths illustrate each goal's contributing weight to the overall Index score. Weighting is currently equal across all 10 goals, with any subgoals contributing half of that weight; the exception is the food provision goal, which is weighted by catch of either mariculture or wild-caught fisheries.

Treatment of missing values:

- At country level

For Index scores to be comparable, every country must have a value for each data layer included in the analysis, unless it is known to not be relevant to a region. In other words, missing data are not acceptable (Burgass *et al.* 2017). Adhering to this criterion is critical to avoid influencing the Index score simply because of inclusion (or absence) of a particular data layer for any reporting region.

Gaps in data are common; many developing countries lack the resources to gather detailed datasets, and even developed, data-rich countries have inevitable data gaps. We use a variety of methods to estimate missing data, including: averages of closely related groups (e.g., regions sharing ecological, spatial, political attributes; taxonomic groups; etc.), spatial or temporal interpolation (e.g., raster or time-series data), and predictive models (e.g., regression analysis, machine learning, etc.). Gapfilling is a major source of uncertainty, especially for certain goals and regions. Given how common gaps in data are, clear documentation of gapfilling is a critical step of index development because it provides a measure of the reliability of index scores.

One of the ongoing goals of the Ocean Health Index (OHI) has been to improve our approach to dealing with missing data, by quantifying the potential influence of gapfilled data on index scores, and developing effective methods of tracking, quantifying, and communicating this information (Frazier *et al.* 2016). The Ocean Health Index uses multiple gap-filling approaches to deal with missing data, including:

1. Regional means: One of the most common methods of estimating missing data is to use the average values of regions sharing ecological, spatial, and/or political attributes relevant to the dataset being gapfilled.
2. Raster interpolation: For datasets calculated using raster we interpolate missing raster data and calculate the percentage of gapfilled cells for each region.
3. Correlates: Often the dataset being gapfilled is correlated with other datasets, and missing data is estimated using predictive models, such as linear regression.
4. Zero-filled: For some datasets, we gapfill missing data with zero values if it seems reasonable to assume missing data indicates zero.
5. Temporal: For time series, we estimate missing years based on data from other years using regression models, or other techniques.
6. Taxonomic: When estimating missing data for organisms we use taxonomic averages.

- At regional and global levels

All gapfilling is done at the country level (see previous section) so higher level gapfilling at regional or global scales does not occur.

Regional aggregates:

The overall index score for each region (I_{region}) is calculated as a weighted average of all the scores (G), for each of the 10 goals (g) such that:

$$I_{region} = \frac{\sum_{g=1}^{N} w_g G_g}{\sum_{g=1}^{N} w_g}$$

where, w_g is the weight for each goal.

For the global assessment, the goal weights (w_g) were assumed to be equal, even though we know this assumption does not hold for most individuals or across individuals within communities. Ideally these weights would be derived empirically, but such an effort would require surveying a full spectrum of people from every single country. This was beyond the scope of this project, but may be possible in a future application of the Index. Weights are represented by “petal” widths Figure 6.

In many places certain goals are not relevant, for example, production-focused goals typically do not apply to uninhabited islands, and the coastal protection or carbon storage goals will not apply to regions without the relevant coastal ecosystems.

Sources of discrepancies:

The OHI does not use disparate, country-produced datasets, only internationally-available data are used to allow for unbiased comparison across all coastal nations and territories. When data are not available for specific countries, the gap-filling methods (see Methodology “treatment of missing values” section) are utilized, rather than defaulting to country-produced data that may use different, non-comparable methods or metrics. While some countries do lead their own independent assessments (ohi-science.org/projects/ohi-assessments), for SDGs only the global assessment that scores all 220 coastal nations and territories should be considered.

Methods and guidance available to countries for the compilation of the data at the national level:
Because the OHI does not rely on individual datasets from each country there is no need for tailored guidance for data aggregation to the national level. All datasets used to calculate the Ocean Health Index are globally comprehensive and, usually, publically available, having been compiled and submitted to entities such as the United Nations Food and Agriculture Organization (FAO), for example.

Quality assurance
All of our analyses are coded in open source software using version control and made publically available on GitHub (github.com/ohi-science). All code is reviewed by our team members annually. Intermediate and final results are compared to previous years to identify issues in code or source data. A standard operating procedure is followed by all team members to manage data and files (http://ohi-science.org/ohiprep_v2019/Reference/SOP_dataOrganization/dataOrganization_SOP.html).

Additionally, we are beginning to quantify uncertainty in the OHI. We have identified the proportion of gapfilled data used to calculate goal and country scores which provides a measure of uncertainty (Frazier et al. 2016). We have also estimated uncertainty in the food provision fisheries scores (Afflerbach et al. 2019).

Data Sources

Description:
We generate many datasets to incorporate into the OHI model (Table 1). We use existing datasets (Table 2) in the model but a good deal of work is involved in standardizing the data to the correct spatial and temporal scale as well as estimating missing data. The scripts and data outputs used to format these data are available at: https://github.com/ohi-Science/ohiprep_v2018

Table 1. A brief overview of all the data layers used to calculate the global OHI. See Table 3 for a description of the data sources used to create these data layers.

Layer	Description	References
Artisanal fisheries opportunity	The opportunity for artisanal and recreational fishing based on the quality of management of the small-scale fishing sector	Mora *et al.* (2009)
Economic need for artisanal fishing	Inverse of per capita purchasing power parity (PPP) adjusted gross domestic product (GDP): GDPpcPPP as a proxy for subsistence fishing need	World Bank (2017)
Habitat extent of coral	Area of coral habitat	Burke *et al.* (2011)
Habitat extent of seaice	Area of seaice (edge and shoreline) habitat	Cavalieri *et al.* (1996)

Habitat condition of coral	Current condition of coral habitat relative to historical condition	Bruno & Selig (2007); Schutte *et al.* (2010)
Habitat condition trend of coral	Estimated trend in coral condition	Bruno & Selig (2007); Schutte *et al.* (2010)
Habitat condition of seaice	Current condition of seaice habitat relative to historical condition	Cavalieri *et al.* (1996)
Habitat condition trend of seaice	Estimated trend in seaice condition	Cavalieri *et al.* (1996)
Habitat extent of mangrove	Area of mangrove habitat	Hamilton & Casey (2016)
Habitat extent of saltmarsh	Area of saltmarsh habitat	Bridgham *et al.* (2006); Dahl (2011); Eionet (2008); Joint Nature Conservation Committee (2004); New Zealand Ministry for the Environment (2007)
Habitat extent of seagrass	Area of seagrass habitat	UNEP-WCMC & Short (2005)
Habitat condition of mangrove	Current condition of mangrove habitat relative to historical condition	United Nations (2007)
Habitat condition trend of mangrove	Estimated trend in mangrove condition	Hamilton & Casey (2016)
Habitat condition of saltmarsh	Current condition of saltmarsh habitat relative to historical condition	Bridgham *et al.* (2006); Dahl (2011); Eionet (2008); Joint Nature Conservation Committee (2004); New Zealand Ministry for the Environment (2007)
Habitat condition trend of saltmarsh	Estimated trend in saltmarsh condition	Bridgham *et al.* (2006); Dahl (2011); Eionet (2008); Joint Nature Conservation Committee (2004); New Zealand Ministry for the Environment (2007)
Habitat condition of seagrass	Current condition of seagrass habitat relative to historical condition	Hemminga & Duarte (2000); Waycott *et al.* (2009)
Habitat condition trend of seagrass	Estimated trend in seagrass condition	Short *et al.* (2011); Waycott *et al.* (2009)
Chemical pollution trend	Trends in chemical pollution, based on commercial shipping traffic, ports and harbors, land-based pesticide use (organic pollution), and urban runoff (inorganic pollution) within EEZ	Halpern *et al.* (2008); Halpern *et al.* (2015a); Homer *et al.* (2004); United Nations (2016d)

Nutrient pollution trend	Trends in nutrient pollution, using fertilizer consumption as a proxy for nutrient pollution	Halpern *et al.* (2008); Halpern *et al.* (2015a); Homer *et al.* (2004); United Nations (2017)
Pathogen pollution trend	Trends in percent of population without access to improved sanitation facilities as a proxy for pathogen pollution	WHO-UNICEF (2017)
Plastic trash trends	Trends in trash estimated using improperly disposed of plastics	Jambeck *et al.* (2015)
Coastal chemical pollution	Modeled chemical pollution within 3nm of coastline from commercial shipping traffic, ports and harbors, land-based pesticide use (organic pollution), and urban runoff (inorganic pollution)	Halpern *et al.* (2008); Halpern *et al.* (2015a); Homer *et al.* (2004); United Nations (2016d)
Coastal nutrient pollution	Modeled nutrient pollution within EEZ based on fertilizer consumption	Halpern *et al.* (2008); Halpern *et al.* (2015a); Homer *et al.* (2004); United Nations (2017)
Pathogen pollution	Percent of population without access to improved sanitation facilities as a proxy for pathogen pollution	WHO-UNICEF (2017)
Marine plastics	Global marine plastic pollution	Eriksen *et al.* (2014)
Economic status scores	Calculated using corrected revenue data for several marine sectors (data not updated since 2013)	Kaufmann *et al.* (2010); O'Connor *et al.* (2009); United Nations (2013a); United Nations (2013b); United Nations (2013c); United Nations (2012); World Bank (2016)
Economic trend scores	Calculated using change in revenue for several marine sectors (data not updated since 2013)	Kaufmann *et al.* (2010); O'Connor *et al.* (2009); United Nations (2013a); United Nations (2013b); United Nations (2013c); United Nations (2012); World Bank (2014a); World Bank (2016)
Sectors in each region	Proportion of jobs within each marine sector	France (2011); O'Connor *et al.* (2009); Thorbourne (2011); United Nations personal communication (2011); WTTC (2013)

B/Bmsy estimates	The ratio of fish population abundance compared to the abundance required to deliver maximum sustainable yield (RAM and catch-MSY data)	Anderson (2018); Free (2017); Martell & Froese (2013); RAM (2017); Ricard *et al.* (2012); Rosenberg *et al.* (2014); Watson & Tidd (2018)
Fishery catch data	Mean commercial catch for each OHI region (averaged across years)	Watson & Tidd (2018)
Food provision weights	Proportion of wild caught fisheries relative to total food production (e.g., fisheries and mariculture)	United Nations (2018a); Watson & Tidd (2018)
Habitat condition of softbottom	Current condition of softbottom habitat, based on demersal destructive fishing practices (e.g., trawling)	Watson & Tidd (2018)
Habitat condition trend of softbottom	Estimated change in softbottom condition, based on trends in demersal destructive fishing practices (e.g., trawling)	Watson & Tidd (2018)
IUCN extinction risk	IUCN extinction risk category for iconic species located within each region	Halpern *et al.* (2012); IUCN (2018a)
Livelihood status scores	Calculated using adjusted job and wage data in several marine sectors (data not updated since 2013)	France (2011); Kaufmann *et al.* (2010); O'Connor *et al.* (2009); Oostendorp & Freeman (2012); Thorbourne (2011); United Nations personal communication (2011); World Bank (2017); World Bank (2014b); WTTC (2013); World Bank (2016)
Livelihood trend scores	Calculated using change in adjusted job and wage data in several marine sectors (data not updated since 2013)	France (2011); Kaufmann *et al.* (2010); O'Connor *et al.* (2009); Oostendorp & Freeman (2012); Thorbourne (2011); United Nations personal communication (2011); World Bank (2014b); World Bank (2014c); WTTC (2013); World Bank (2016)
Inland coastal protected areas	Protected areas located 1 km inland	Lewis *et al.* (2017); IUCN (2018)
Offshore coastal protected areas	Protected areas located 3nm offshore	Lewis *et al.* (2017); IUCN (2018)

Inland 1km area	Inland area of OHI regions within 1km of shoreline	Claus *et al.* (2012); ESRI (2010); Halpern *et al.* (2012); Halpern *et al.* (2015b)
Offshore 3nm area	Offshore area of OHI regions within 3nm of shoreline	Claus *et al.* (2012); ESRI (2010); Halpern *et al.* (2012); Halpern *et al.* (2015b)
Inland coastal population	Total coastal population within 25 miles of coast	Center For International Earth Science Information Network-CIESIN-Columbia University (2017)
Mariculture harvest	Tonnes of mariculture harvest	United Nations (2018a)
Mariculture sustainability score	Mariculture sustainability based on the Mariculture Sustainability Index (MSI)	Trujillo (2008)
Habitat extent of rocky reef	Area of rocky reef habitat	Halpern *et al.* (2008)
Blast fishing	Artisanal blast fishing	Burke *et al.* (2011)
Poison fishing	Artisanal poison (cyanide) fishing	Burke *et al.* (2011)
Relative natural product harvest value	Relative importance of six marine commodities (coral, fish oil, seaweed and plants, shells, sponges, ornamental fish) within each region determined by dividing the max USD value (determined across most recent 10 years of data) of each product and dividing by the sum of the max USD values of all products	United Nations (2017)
Natural product harvest	Yield in metric tonnes of six marine commodities (coral, fish oil, seaweed and plants, shells, sponges, ornamental fish)	United Nations (2017)
Relative natural product harvest tonnes	Tonnes of harvest of each commodity relative to maximum harvest (with 35% buffer) of the commodity within the region observed across years	United Nations (2017)
Ocean acidification	Pressure due to increasing ocean acidification, scaled using biological thresholds	Feely *et al.* (2009)
Sea level rise	Pressure due to rising mean sea level	AVISO (2018)

Sea surface temperature	Pressure due to increasing extreme sea surface temperature events	NOAA (2018)
UV radiation	Pressure due to increasing frequency of UV anomalies	Hovila *et al.* (2013)
High bycatch due to artisanal fishing	Pressure due to artisanal high bycatch fishing identified by discard tonnes and standardized by NPP	Behrenfeld & Falkowski (1997); O'Malley; Watson & Tidd (2018)
Low bycatch due to artisanal fishing	Pressure due to artisanal low bycatch fishing identified by reported and IUU tonnes and standardized by NPP	Behrenfeld & Falkowski (1997); O'Malley; Watson & Tidd (2018)
High bycatch due to commercial fishing	Pressure due to industrial high bycatch fishing identified by discard tonnes and standardized by NPP	Behrenfeld & Falkowski (1997); O'Malley; Watson & Tidd (2018)
Low bycatch due to commercial fishing	Pressure due to industrial low bycatch fishing identified by reported and IUU tonnes and standardized by NPP	Behrenfeld & Falkowski (1997); O'Malley; Watson & Tidd (2018)
Targeted harvest of cetaceans and marine turtles	Targeted harvest of cetaceans and marine turtles	United Nations (2018b)
Intertidal habitat destruction	Coastal population density (25 mi from shore) as a proxy for intertidal habitat destruction	Center For International Earth Science Information Network-CIESIN-Columbia University (2017)
Subtidal hardbottom habitat destruction	Presence of blast fishing as an estimate of subtidal hard bottom habitat destruction	Burke *et al.* (2011)
Subtidal soft bottom habitat destruction	Pressure on soft-bottom habitats due to demersal destructive commercial fishing practices (e.g., trawling)	Halpern *et al.* (2008); Watson & Tidd (2018)
Chemical pollution	Modeled chemical pollution within EEZ from commercial shipping traffic, ports and harbors, land-based pesticide use (organic pollution), and urban runoff (inorganic pollution)	Halpern *et al.* (2008); Halpern *et al.* (2015a); Homer *et al.* (2004); United Nations (2016d)
Nutrient pollution	Modeled nutrient pollution within 3nm of coastline based on fertilizer consumption	Halpern *et al.* (2008); Halpern *et al.* (2015a); Homer *et al.* (2004); United Nations (2017)
Nonindigenous species	Measure of harmful invasive species	Molnar *et al.* (2008)
Genetic escapes	Introduced mariculture species (Mariculture Sustainability Index) as a proxy for genetic escapes	Trujillo (2008)
Weakness of social progress	Inverse of Social Progress Index scores	Index; Stern *et al.* (2018)

Weakness of governance	Inverse of World Governance Indicators (WGI) six combined scores	Kaufmann *et al.* (2010); World Bank (2018)
Management of habitat to protect fisheries biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: habitat related questions	Convention on Biological Diversity (2005)
Commercial fishing management	Country scale regulations and management of commerical fishing	Mora *et al.* (2009)
Artisanal fisheries management effectiveness	Quality of management of small-scale fishing for artisanal and recreational purposes	Mora *et al.* (2009)
Coastal protected marine areas (fishing preservation)	Protected marine areas within 3nm of coastline (lasting special places goal status score)	Lewis *et al.* (2017); IUCN (2018)
EEZ protected marine areas (fishing preservation)	Protected marine areas within EEZ (lasting special places calculation applied to the entire EEZ)	Lewis *et al.* (2017); IUCN (2018)
CITES signatories	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) signatories	CITES (2015)
Management of mariculture to preserve biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: mariculture related questions (data prep)	Convention on Biological Diversity (2005)
Mariculture Sustainability Index	Mariculture practice assessment criteria from the Mariculture Sustainability Index (MSI)	Trujillo (2008)
Management of tourism to preserve biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: tourism related questions	Convention on Biological Diversity (2005)
Management of habitat to protect habitat biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: habitat related questions	Convention on Biological Diversity (2005)
Coastal protected marine areas (habitat preservation)	Protected marine areas within 3nm of coastline (lasting special places goal status score)	Lewis *et al.* (2017); IUCN (2018)

EEZ protected marine areas (habitat preservation)	Protected marine areas within EEZ (lasting special places calculation applied to the entire EEZ)	Lewis *et al.* (2017); IUCN (2018)
Global Competitiveness Index (GCI)	Competitiveness in achieving sustained economic prosperity	Schwab (2017a)
Economic diversity	Sector evenness based on Shannon's Diversity Index calculated on the proportion of jobs in each sector as a measure of economic diversity	France (2011); O'Connor *et al.* (2009); Thorbourne (2011); WTTC (2013); United Nations personal communication (2011)
Management of waters to preserve biodiversity	Survey responses by country to the Convention on Biological Diversity (CBD) Third National Report: clean water management related questions	Convention on Biological Diversity (2005)
Social Progress Index	Social Progress Index scores	Index; Stern *et al.* (2018)
Measure of coastal ecological integrity	Marine species condition (same calculation and data as the species subgoal status score) calculated within 3 nm of shoreline as a proxy for ecological integrity	IUCN (2018b); IUCN (2018a); ('Bird species distribution maps of the world. Version 7.0.' 2017)
Measure of ecological integrity	Marine species condition (species subgoal status score) as a proxy for ecological integrity	IUCN (2018b); IUCN (2018a); ('Bird species distribution maps of the world. Version 7.0.' 2017)
Strength of governance	World Governance Indicators (WGI) six combined scores	Kaufmann *et al.* (2010)
Region areas based on EEZ boundaries	Area of Ocean Health Index regions modified from exclusive economic zones, weights used to calculate global score	Claus *et al.* (2012); ESRI (2010); Halpern *et al.* (2012); Halpern *et al.* (2015b)
OHI region id	Subset of regions that are not deleted or disputed	Claus *et al.* (2012); ESRI (2010); Halpern *et al.* (2012); Halpern *et al.* (2015b)
Regions	Regions by type (eez, subocean, unclaimed)	Claus *et al.* (2012); ESRI (2010); Halpern *et al.* (2012); Halpern *et al.* (2015b)
Uninhabited regions	Regions with low and no number of inhabitants (also identifies Southern Islands)	Wikipedia
Average species condition	Overall measure of species condition based on IUCN status of species within each region	IUCN (2018b); IUCN (2018a); ('Bird species distribution maps of the world. Version 7.0.' 2017)

Average species condition trend	Overall measure of species condition trends based on change in IUCN status of species within each region	IUCN (2018b); IUCN (2018a); ('Bird species distribution maps of the world. Version 7.0.' 2017)
Percent direct employment in tourism	Percent direct employment in tourism	WTTC (2017)
Tourism sustainability index	Tourism Competitiveness Index (TTCI)	Schwab (2017b)
US State Department travel warnings	US State Department travel warnings	State (2018)
Coastal protection weights	Habitat extent multiplied by habitat protection rank for: coral, mangrove (offshore and inland 1km), saltmarsh, sea ice (shoreline), and seagrass (empty dataframe filled by functions.R in ohi-global)	Tallis *et al.* (2011)
Carbon storage weights	Habitat extent multiplied by carbon storage capacity for: mangrove, saltmarsh, and seagrass (empty dataframe filled by functions.R in ohi-global)	Laffoley & Grimsditch (2009)
Habitat presence/absence	List of habitats in each region (empty dataframe filled by functions.R in ohi-global)	

Collection process:
The Index does not aggregate data from individual countries. All data layers used in the calculation of the Ocean Health Index are globally comprehensive and, usually, publically available. The few datasets that are not publically available are retrieved by Ocean Health Index scientists each year and integrated into the index.

Data Availability

Description:
Ocean Health Index scores are calculated for 220 coastal countries and territories worldwide (Figure 7, Table 2). Regions are based on Exclusive Economic Zone boundaries (EEZ). However, we aggregate some EEZ regions to the level of country (e.g., Hawaii is estimated as part of the larger U.S.). We have also modified some boundaries (Halpern *et al.* 2012, 2015b). We do not estimate OHI values for disputed or unclaimed areas.

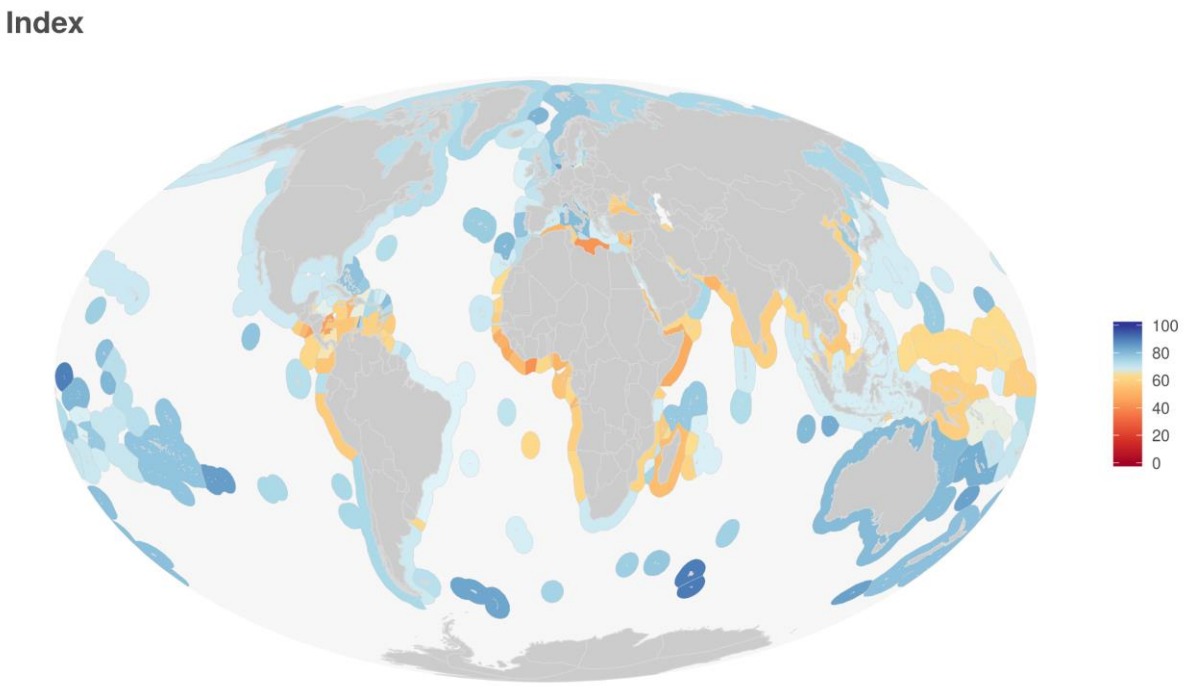

Figure 7: Global Ocean Health Index scores for 2018

Table 2. Global regions assessed by the OHI.

region	ISO code	type	administrative country
Albania	ALB	country	
Algeria	DZA	country	
American Samoa	ASM	territory	United States
Amsterdam Island and Saint Paul Island	ATF	territory	France
Andaman and Nicobar	IND	territory	India
Angola	AGO	country	
Anguilla	AIA	territory	United Kingdom
Antigua and Barbuda	ATG	country	
Argentina	ARG	country	
Aruba	AW	territory	Netherlands
Ascension	ASC	territory	United Kingdom
Australia	AUS	country	

Azores	PRT	territory	Portugal
Bahamas	BHS	country	
Bahrain	BHR	country	
Bangladesh	BGD	country	
Barbados	BRB	country	
Bassas da India	ATF	territory	France
Belgium	BEL	country	
Belize	BLZ	country	
Benin	BEN	country	
Bermuda	BMU	territory	United Kingdom
Bonaire	BQ	territory	Netherlands
Bosnia and Herzegovina	BIH	country	
Bouvet Island	BVT	territory	Norway
Brazil	BRA	country	
British Indian Ocean Territory	IOT	territory	United Kingdom
British Virgin Islands	VGB	territory	United Kingdom
Brunei	BRN	country	
Bulgaria	BGR	country	
Cambodia	KHM	country	
Cameroon	CMR	country	
Canada	CAN	country	
Canary Islands	ESP	territory	Spain
Cape Verde	CPV	country	
Cayman Islands	CYM	territory	United Kingdom
Chile	CHL	country	
China	CHN	country	
Christmas Island	CXR	territory	Australia
Clipperton Island	CPT	territory	France
Cocos Islands	CCK	territory	Australia
Colombia	COL	country	

Comoro Islands	COM	country	
Cook Islands	COK	territory	New Zealand
Costa Rica	CRI	country	
Croatia	HRV	country	
Crozet Islands	ATF	territory	France
Cuba	CUB	country	
Curacao	CW	territory	Netherlands
Cyprus	CYP	country	
Democratic Republic of the Congo	COD	country	
Denmark	DNK	country	
Djibouti	DJI	country	
Dominica	DMA	country	
Dominican Republic	DOM	country	
East Timor	TLS	country	
Ecuador	ECU	country	
Egypt	EGY	country	
El Salvador	SLV	country	
Equatorial Guinea	GNQ	country	
Eritrea	ERI	country	
Estonia	EST	country	
Faeroe Islands	FRO	territory	Denmark
Falkland Islands	FLK	territory	United Kingdom
Fiji	FJI	country	
Finland	FIN	country	
France	FRA	country	
French Guiana	GUF	territory	France
French Polynesia	PYF	territory	France
Gabon	GAB	country	
Gambia	GMB	country	
Georgia	GEO	country	

Germany	DEU	country	
Ghana	GHA	country	
Gibraltar	GIB	territory	United Kingdom
Glorioso Islands	ATF	territory	France
Greece	GRC	country	
Greenland	GRL	territory	Denmark
Grenada	GRD	country	
Guadeloupe and Martinique	GP-MQ	territory	France
Guatemala	GTM	country	
Guernsey	GGY	territory	United Kingdom
Guinea	GIN	country	
Guinea Bissau	GNB	country	
Guyana	GUY	country	
Haiti	HTI	country	
Heard and McDonald Islands	HMD	territory	Australia
Honduras	HND	country	
Howland Island and Baker Island	UMI	territory	United States
Iceland	ISL	country	
Ile Europa	ATF	territory	France
Ile Tromelin	ATF	territory	France
India	IND	country	
Indonesia	IDN	country	
Iran	IRN	country	
Iraq	IRQ	country	
Ireland	IRL	country	
Israel	ISR	country	
Italy	ITA	country	
Ivory Coast	CIV	country	
Jamaica	JAM	country	
Jan Mayen	SJM	territory	Norway

Japan	JPN	country	
Jarvis Island	UMI	territory	United States
Jersey	JEY	territory	United Kingdom
Johnston Atoll	UMI	territory	United States
Jordan	JOR	country	
Juan de Nova Island	ATF	territory	France
Kenya	KEN	country	
Kerguelen Islands	ATF	territory	France
Kiribati	KIR	country	
Kuwait	KWT	country	
Latvia	LVA	country	
Lebanon	LBN	country	
Liberia	LBR	country	
Libya	LBY	country	
Line Group	KIR	territory	Kiribati
Lithuania	LTU	country	
Macquarie Island	AUS	territory	Australia
Madagascar	MDG	country	
Madeira	PRT	territory	Portugal
Malaysia	MYS	country	
Maldives	MDV	country	
Malta	MLT	country	
Marshall Islands	MHL	country	
Mauritania	MRT	country	
Mauritius	MUS	country	
Mayotte	MYT	territory	France
Mexico	MEX	country	
Micronesia	FSM	country	
Monaco	MCO	country	
Montenegro	MNE	country	
Montserrat	MSR	territory	United Kingdom

Morocco	MAR	country	
Mozambique	MOZ	country	
Myanmar	MMR	country	
Namibia	NAM	country	
Nauru	NRU	country	
Netherlands	NLD	country	
New Caledonia	NCL	territory	France
New Zealand	NZL	country	
Nicaragua	NIC	country	
Nigeria	NGA	country	
Niue	NIU	territory	New Zealand
Norfolk Island	NFK	territory	Australia
North Korea	PRK	country	
Northern Mariana Islands and Guam	MNP	territory	United States
Northern Saint-Martin	MAF	territory	France
Norway	NOR	country	
Oecussi Ambeno	TLS	territory	East Timor
Oman	OMN	country	
Pakistan	PAK	country	
Palau	PLW	country	
Palmyra Atoll	UMI	territory	United States
Panama	PAN	country	
Papua New Guinea	PNG	country	
Peru	PER	country	
Philippines	PHL	country	
Phoenix Group	KIR	territory	Kiribati
Pitcairn	PCN	territory	United Kingdom
Poland	POL	country	
Portugal	PRT	country	
Prince Edward Islands	ZAF	territory	South Africa

Puerto Rico and Virgin Islands of the United States	PRI	territory	United States
Qatar	QAT	country	
Republique du Congo	COG	territory	R_publique du Congo
Reunion	REU	territory	France
Romania	ROU	country	
Russia	RUS	country	
Saba	BES	territory	Netherlands
Saint Helena	SHN	territory	United Kingdom
Saint Kitts and Nevis	KNA	country	
Saint Lucia	LCA	country	
Saint Pierre and Miquelon	SPM	territory	France
Saint Vincent and the Grenadines	VCT	country	
Samoa	WSM	country	
Sao Tome and Principe	STP	country	
Saudi Arabia	SAU	country	
Senegal	SEN	country	
Seychelles	SYC	country	
Sierra Leone	SLE	country	
Singapore	SGP	country	
Sint Eustatius	ANT	territory	Netherlands
Sint Maarten	SXM	territory	Netherlands
Slovenia	SVN	country	
Solomon Islands	SLB	country	
Somalia	SOM	country	
South Africa	ZAF	country	
South Georgia and the South Sandwich Islands	SGS	territory	United Kingdom

South Korea	KOR	country	
Spain	ESP	country	
Sri Lanka	LKA	country	
Sudan	SDN	country	
Suriname	SUR	country	
Sweden	SWE	country	
Syria	SYR	country	
Taiwan	TWN	country	
Tanzania	TZA	country	
Thailand	THA	country	
Togo	TGO	country	
Tokelau	TKL	territory	New Zealand
Tonga	TON	country	
Trinidad and Tobago	TTO	country	
Tristan da Cunha	TAA	territory	United Kingdom
Tunisia	TUN	country	
Turkey	TUR	country	
Turks and Caicos Islands	TCA	territory	United Kingdom
Tuvalu	TUV	country	
Ukraine	UKR	country	
United Arab Emirates	ARE	country	
United Kingdom	GBR	country	
United States	USA	country	
Uruguay	URY	country	
Vanuatu	VUT	country	
Venezuela	VEN	country	
Vietnam	VNM	country	
Wake Island	UMI	territory	United States
Wallis and Futuna	WLF	territory	France
Western Sahara	ESH	territory	Morocco

Yemen	YEM	country	

Time series:
Ocean Health Index scores are currently available from 2012 through 2018.

Calendar

Data collection:
Data for the Ocean Health Index is collected on an annual basis.

Data release:
The 2019 Ocean Health Index assessment will be completed by December 2019.

Data providers

The following can be found as Table 6.2 in our methods documentation:
https://raw.githack.com/OHI-Science/ohi-global/published/global_supplement/Supplement.html#601_tables_describing_data_layers_(table_61)_and_sources_(table_62)

Table 3. A brief overview of the data sources used to calculate the global OHI.

Reference	Description	Years	Resolution
Anderson (2018)	Methods: Data-limited stocks assessments		
AVISO (2018)	Net change in sea level during the time series	1993-2017	0.25 deg
Behrenfeld & Falkowski (1997)	Net Primary Productivity paper		
Bridgham et al. (2006)	Global salt marsh habitat extent and condition	1975-2007	National
Bruno & Selig (2007)	Global coral habitat extent and change in condition	2002,1980-2009,2006	0.5 km; 1 km; Sites (points)
Burke et al. (2011)	Presence of artisanal blast and poison (cyanide) fishing practices	2009	10 km
Burke et al. (2011)	Global coral habitat extent and change in condition	2002,1980-2009,2006	0.5 km; 1 km; Sites (points)

Cavalieri et al. (1996)	Sea ice change in extent, both edge and shoreline metrics	1979-2017	25 km
Center For International Earth Science Information Network-CIESIN-Columbia University (2017)	Raster data of human population	2005-2020	30 arcsec
CITES (2015)	Countries that signed the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	2017	National
Claus et al. (2012)	Land and ocean areas for OHI land and eez regions	2013	1 km
Convention on Biological Diversity (2005)	Convention on Biological Diversity: Data from Third National Report for regulation of alien species, habitat, mariculture, tourism, and water to preserve biodiversity	2005	National
Schwab (2017b)	Sustainability of the travel and tourism industry	2017	National
Dahl (2011)	Global salt marsh habitat extent and condition	1975-2007	National
France (2011)	La Rance (France) and Annapolis (Canada) tidal plants employment data	2003-2010	Points (sites)
Eionet (2008)	Global salt marsh habitat extent and condition	1975-2007	National
Eriksen et al. (2014)	Plastic trash pollution in ocean	2014	0.2 deg
ESRI (2010)	Land and ocean areas for OHI land and eez regions	2013	1 km
Feely et al. (2009)	Change in aragonite saturation state (ASS) levels	2005-2020	1 deg
Free (2017)	Maps of fish stock boundaries for the original RAM Myers stock-recruit database	2017	Stock
Halpern et al. (2008)	Modeled pollution from urban runoff from impervious surfaces	2000	1 km
Halpern et al. (2008)	Modeled pollution from pesticides	1990-2013	1 km (FAO data is National)
Halpern et al. (2008)	Modeled pollution from shipping and ports	2003/2011	1 km

Halpern et al. (2008)	Modeled N input from fertilizer use as a proxy for nutrient pollution	1990-2013	1 km (FAO data is National)
Halpern et al. (2008)	Global rocky reef habitat extent	2005	2 arcmin; Points
Halpern et al. (2008)	Global soft-bottom subtidal habitat extent	2001-2005	0.5 deg
Halpern et al. (2012)	WWF Priority and Flagship Species Lists	2011	Global; National
Halpern et al. (2012)	Land and ocean areas for OHI land and eez regions	2013	1 km
Halpern et al. (2015b)	Land and ocean areas for OHI land and eez regions	2013	1 km
Halpern et al. (2015a)	Modeled pollution from shipping and ports	2003/2011	1 km
Hamilton & Casey (2016)	Global mangrove habitat extent, from remote sensing and assessments	2000-2012	30m2, summarized to 500m2
Hemminga & Duarte (2000)	Seagrass geographical regions	2010	County
Homer et al. (2004)	Modeled pollution from urban runoff from impervious surfaces	2000	1 km
Hovila et al. (2013)	Anomalies in intensity of ultraviolet (UV) radiation	2005-2017	1 deg
('Bird species distribution maps of the world. Version 7.0.' 2017)	Status of marine bird species	2017	National
IUCN (2018a)	IUCN Red List of threatened species by category; sub-population status for iconic species	1965-2018	National
IUCN (2018b)	IUCN spatial distribution	2018	Polygons rasterized to 0.5 deg
Jambeck et al. (2015)	Trends in mismanaged plastic waste for 2010 and projected for 2025 as a proxy for trash trends	2010-2025 (projected)	National
Joint Nature Conservation Committee (2004)	Global salt marsh habitat extent and condition	1975-2007	National

Kaufmann et al. (2010)	Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption		
Laffoley & Grimsditch (2009)	Carbon sequestration by habitat	2009	habitat
Lewis et al. (2017)	Location and area of marine and terrestrial protected areas manual		
Molnar et al. (2008)	The number and type of invasive and harmful invasive species in each marine ecoregion	2008	Ecoregion (sensu Spalding et al., 2007)
Mora et al. (2009)	Management effectiveness of the world's marine fisheries	2009	National
Mora et al. (2009)	Management effectiveness of artisanal fisheries	2009	National
New Zealand Ministry for the Environment (2007)	Global salt marsh habitat extent and condition	1975-2007	National
NOAA (2018)	Sea surface temperature anomalies	1982-2017	4 km
Index	Index measuring quality of life indicators	2014-2017	National
RAM (2017)	Stock assesment scores data	1950-2016	Stock
O'Connor et al. (2009)	Jobs based on number of whale watchers in a country and a regional average number of whale watchers per employee. Includes all marine mammal watching.	1998-2008	National
O'Connor et al. (2009)	Total revenue from marine mammal watching	1998-2008	National
O'Malley	Net Primary Productivity website	2003-2015	0.083 deg
Oostendorp & Freeman (2012)	Occupations within commercial fishing, ports and harbors, ship and boat building, tourism, and transportation and shipping	1989-2008	National
Ricard et al. (2012)	Stock assessment RAM data, paper		
Schutte et al. (2010)	Global coral habitat extent and change in condition	2002,1980-2009,2006	0.5 km; 1 km; Sites (points)
Schwab (2017a)	Composite measure of 12 aspects of economic competitiveness	2007-2017	National

Short et al. (2011)	Global seagrass habitat extent and change in condition	1975-2010	1 km, National
Stern et al. (2018)	Methods: Index measuring quality of life indicators		
Tallis et al. (2011)	Ranks of coastal protection provided by habitats	2011	habitat
Thorbourne (2011)	La Rance (France) and Annapolis (Canada) tidal plants employment data	2003-2010	Points (sites)
Trujillo (2008)	Mariculture Sustainability Index (MSI): traceability and code of practice, fishmeal use, waste treatment, and seed and larvae origin indicators	1994-2003	National
IUCN (2018)	Location and area of marine and terrestrial protected areas data	1819-2018	Shapefile
UNEP-WCMC & Short (2005)	Global seagrass habitat extent and change in condition	1975-2010	1 km, National
United Nations (2013a)	Total revenue from commercial marine fishing	1997-2007	National
United Nations (2013c)	Revenue of Aquarium Trade Fishing derived from commodities database	1984-2009	National
United Nations (2013b)	Total revenue from mariculture production of marine species	1977-2011	National
United Nations (2016d)	Modeled pollution from pesticides	1990-2013	1 km (FAO data is National)
United Nations (2016d)	Modeled N input from fertilizer use as a proxy for nutrient pollution	1990-2013	1 km (FAO data is National)
United Nations (2017)	Export tonnes and value (US dollars) and of coral, ornamental fish, fish oil, sponges, shells, and seaweeds and plants	1976-2015	National
United Nations (2018b)	Catch statistics for cetaceans and marine turtles	1950-2016	National
United Nations (2018a)	Production of finfish and invertebrates	1950-2016	National
United Nations personal communication (2011)	Global Number of Fishers, commercial fishing	1990-2008	National

United Nations personal communication (2011)	Global Number of Fishers, aquaculture	1993-2008	National
United Nations (2012)	Total revenue from marine renewable energy	1990/2001-2010/2008	National
United Nations (2007)	Mangrove condition	1980/1990/2000/2005	Country
State (2018)	Travel warnings issued by the US State Department	2015-2018	National
Watson & Tidd (2018)	Fisheries catch by species and gear type (tonnes/km2)	1950-2015	0.5 deg
Waycott et al. (2009)	Global seagrass habitat extent and change in condition	1975-2010	1 km, National
WHO-UNICEF (2017)	Percent population without access to improved sanitation facilities	2000-2015	National
World Bank (2014a)	Gross Domestic Product; Adjustment to all revenue data layers to factor out global economic fluctuations, in 2012 $USD	1960-2012	National
World Bank (2017)	Per capita purchasing power parity (PPP) adjusted gross domestic product (GDP): GDPpcPPP	1990-2017	National
World Bank (2014b)	Number of people aged 15 and older who could contribute to the production of goods and services	1990-2011	National
World Bank (2016)	Census populations for countries	1990-2012	National
World Bank (2014c)	Percent of the labor force unemployed but able to and looking for work	1990-2011	National
World Bank (2018)	Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption	1996-2016	National
WTTC (2013)	Total contribution of tourism to employment	1988-2012	National
WTTC (2013)	Total tourism revenue by country, adjusted by country's relative proportion of coastal area	1998-2012	National
WTTC (2017)	Employment directly linked to travel and tourism sectors (hotels, transportation, services)	1988-2017	National

Martell & Froese (2013)	Methods: Data-limited stocks assessments		
Rosenberg et al. (2014)	Methods: Data-limited stocks assessments		
Wikipedia	Population by region	2018	National

Data compilers

The Ocean Health Index is compiled by the OHI science team at the National Center for Ecological Analysis and Synthesis at the University of California at Santa Barbara, USA.

References

The following references are for data providers, whose data and methods are incorporated into OHI calculations and scores (see a table view by data set: http://ohi-science.org/ohi-global/layers_table.html). Following this list of references is an additional list of peer-reviewed publications.

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Below are peer-reviewed scientific publications about the construction and use of the global Ocean Health Index (a complete list is available at (ohi-science.org/publications):

- Halpern et al. 2017, *PLoS ONE**. Drivers and implications of change in global ocean health over the past 5 years. (website with interactive figures and maps)
- Halpern et al. 2015, *PLoS ONE**. Patterns and emerging trends in global ocean health. (2013 and updated 2012 global data)
- Halpern et al. 2012, *Nature*. An index to assess the health and benefits of the global ocean. (original 2012 global data)
- Lowndes et al. 2017, *Nature Ecology & Evolution**. Our path to better science in less time using open data science tools. (website with resources and media links)
- Lowndes et al. 2015, *PeerJ**. Best practices for assessing ocean health in multiple contexts using tailorable frameworks.

- Afflerbach et al. 2019, *Fish and Fisheries*. Quantifying uncertainty in the wild-caught fisheries goal of the Ocean Health Index.
- Anderson et al. 2017, *Fish and Fisheries*. Improving estimates of population status and trend with superensemble models. (datalimited R package for catch only models)
- Kleisner et al. 2013, *AMBIO*. Exploring patterns of seafood provision revealed in the global Ocean Health Index.
- O'Hara et al. 2019, *Conservation Letters**. Mapping status and conservation of global at-risk marine biodiversity.
- O'Hara et al. 2017, *PLoS ONE**. Aligning marine species range data to better serve science and conservation. (website with interactive figures and maps)
- Selig et al. 2013, *PLoS ONE**. Assessing global marine biodiversity status within a coupled socio-ecological perspective.
- Samhouri et al. 2012, *Ecosphere*. Sea Sick? Setting targets to assess ocean health and ecosystem services.
- Frazier et al. 2016, *PLoS ONE**. Mapping Uncertainty Due to Missing Data in the Global Ocean Health Index.
- Burgass et al. 2018, *Regional Environmental Change**. A pan-Arctic assessment of the status of marine social-ecological systems.

Related indicators

The Clean Waters goal of the Ocean Health Index has been selected as an indicator for target 14.1.

Goal 14/Indicator 14.1.1: Index of coastal eutrophication and floating plastic debris density

Nearly all countries have room to improve their coastal water quality; however, water quality concerns are most acute for some equatorial regions, with particularly low scores in parts of Asia, Africa, and Central America (Figure 1). Improvements in coastal water quality are achievable, as demonstrated by the nearly 50% of coastal regions (104 of 220) that improved their coastal water quality during an 8 year period from 2012 to 2018 (Figure 2). Improvements to coastal water quality will require policy commitments at the country scale to improve access to wastewater treatment and to reduce chemical and nutrient runoff from agricultural sources as well as global commitments to reduce plastic debris which can reduce water quality in areas far from the source.

Figure 1. Clean water scores for 220 coastal regions. Clean water is assessed on a scale of 0 (very polluted) to 100 (clean).

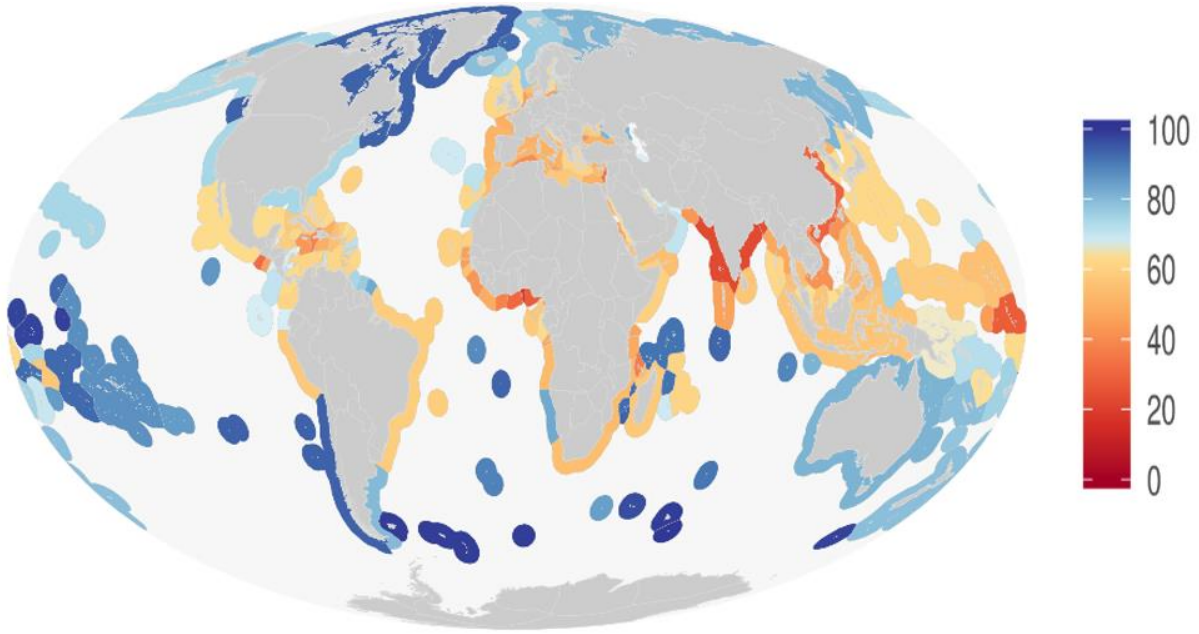
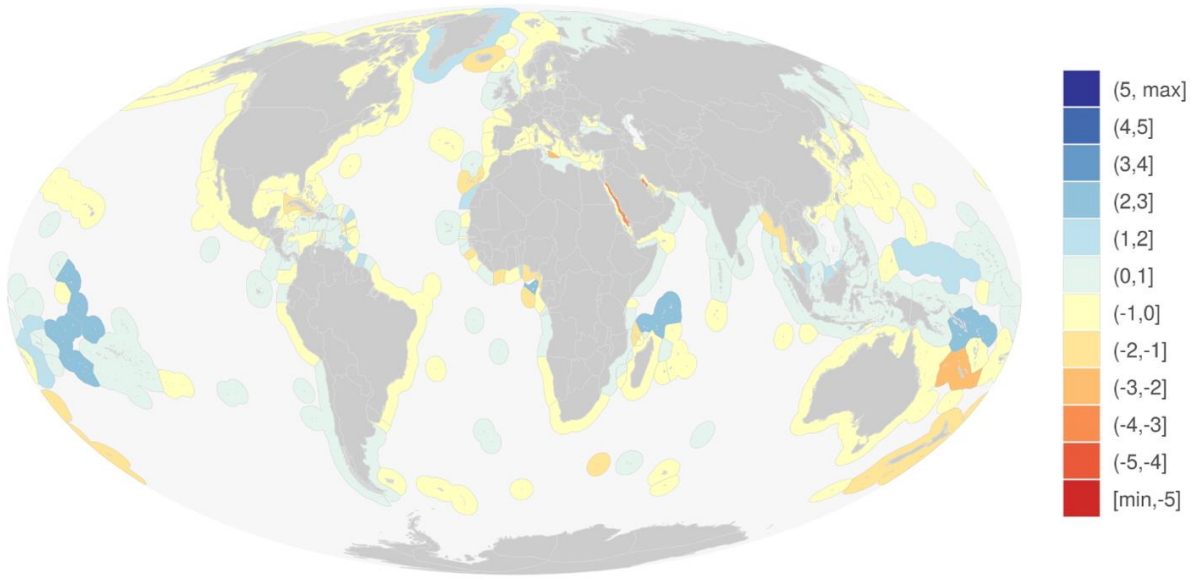


Figure 2. Average annual change in clean water scores. Annual change is estimated with a linear regression model of clean water scores from 2012 to 2018. Yellow regions indicate no change or decreasing water quality.



Additional information and resources

The clean water indicator is a component of the Ocean Health Index (Halpern et al. 2012) that describes the degree to which coastal waters are unpolluted. Scores are calculated from 0 to 100, with a 100 score indicating no pollution. The score is calculated as the geometric mean of four categories of pollution:

- Land-based nutrient pollution
- Land-based chemical pollution
- Pathogen contamination

- Marine debris

Visit the OHI website (http://ohi-science.org/ohi-global/goals#clean_waters) for information about the data and methods used to calculate Clean Water scores.