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Reflection

Building on a Decade of the Ocean Health Index

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With oceans under increasing pressure from human activities, sustainable development and conservation efforts are working to set meaningful targets for healthy oceans. Determining whether those targets are achieved requires indicators that measure status and progress. Here, I reflect upon lessons learned from a decade of developing and calculating the Ocean Health Index.

Introduction

The increasing concern that our planet is approaching a tipping point in sustainability, beyond which lies an uncertain future that is most likely far less hospitable,[1] is galvanizing efforts within the international community to shift our global trajectory toward one that allows for thriving human and natural systems. Embedded in these efforts is the need for targets that define success in achieving this outcome. The constellation of sustainability targets is growing and includes the UN Sustainable Development Goals (SDGs), Aichi biodiversity targets, and targets for protected-area extent, among many others. Underlying these efforts is the assumption that these objectives and targets will help achieve healthy ecosystems.

Measuring progress toward meeting any target for ecosystem health requires indicators, as well as the monitoring and data necessary to inform those indicators. This need has led to a proliferation of indicators, almost too many to count. Just over a decade ago, the Ocean Health Index (OHI) project was launched to address multiple needs: help set targets for healthy oceans, develop indicators to measure the status of ocean health, and do so in a way that reduces and combines the number of indicators into an efficient but informative set and is repeatable and comparable through time. A decade later, with eight annual global OHI assessments completed[2–4] and over 20 regional (OHI+) assessments conducted or underway,[4] I offer a few reflections on what I have learned in leading the OHI project in the hopes that they help inform priorities for ocean monitoring and assessment and accelerate progress in other efforts to define targets and develop indicators.

Defining Ocean Health

I underestimated the challenge in defining ocean health—not from within the team of 50+ researchers engaged in developing the OHI but from the broader scientific community, at least some of whom define ocean health differently than we do for the OHI. The vast majority of policy documents from around the world clearly define a healthy ocean as one that has both nature and people thriving.[5] The burgeoning scientific literature on ecosystem-based management in the oceans similarly defines healthy ecosystems as coupled human-natural systems.[6] Consequently, we structured OHI goals as coupled measures (Figure 1) and called our indicator the Ocean Health Index. However, during scientific peer review we had reviewers vehemently object to the name by saying that it was misleading to what the index measures—they defined healthy oceans as pristine oceans—and insisted the paper be rejected unless we changed the name (the published paper does not use the term Ocean Health Index). We continue to hear similar frustration with the name and the premise upon which it rests, although increasingly less often. Underlying this disagreement is a strong difference in values for what people want the ocean to be.

Defining Reference Points

Defining what people want the ocean to be is an act of defining reference points or targets. To be useful to an indicator, targets need to be measurable and, for the OHI, measurable in a quantitative way. The targets can be aspirational by defining a world that might not yet exist or historical by harkening to a world that used to be. Setting a reference point might appear straightforward, but it is profoundly challenging. Legitimate differences exist in what people want the ocean to be (Figure 2), and there are both scientific uncertainties and data-quality issues that confound efforts to define and measure targets.[7] People inherently have reference points that they assume or expect. The OHI makes these explicit (Figure 1).

Biodiversity is a useful example for illustrating these challenges. In the OHI, we measure biodiversity directly through the status of species and indirectly through the status of habitats. From a perspective of maximizing biodiversity, one would want zero impact to species, including from fishing, but zero impact is neither possible nor desirable given the importance of fisheries for food and livelihoods. But how much impact on species from fishing and other stressors is allowable for "healthy" biodiversity? We use the International Union for Conservation of Nature's definition of species in least-concern status as a reference point and set a target of all species' being at this status, but that condition is far from pristine. Equally challenging, we have to define what a score of zero means, and a planet with zero species on it is meaningless. We used the average species loss of the great mass extinctions (~75% of all species lost) to set this lower reference point, but clearly there is room for debate about this value as a reference point.

For habitats, the reference point is necessarily historical, yet we have very little data on where habitats used to be earlier than about 1980, and a world affected by nearly 8 billion people (and growing) cannot feasibly return to the state of a preindustrial world of fewer

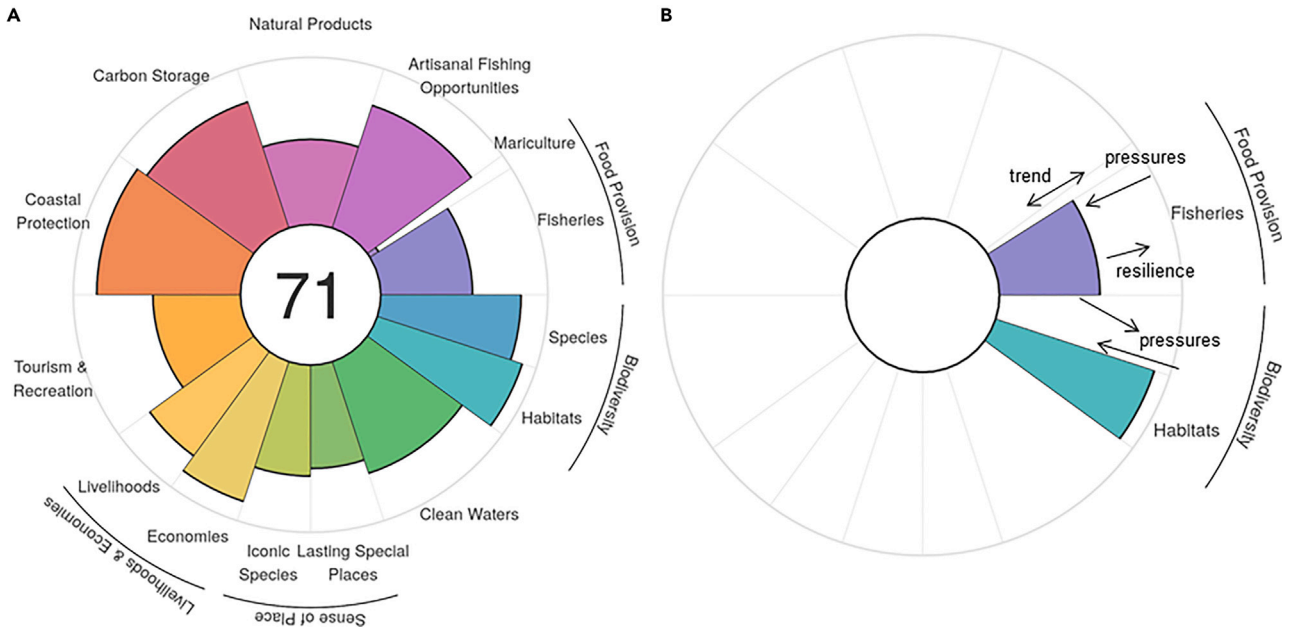

Figure 1. Anatomy of the Ocean Health Index Petal Plot

This visualization shows (A) the overall index score (central number), the contribution of multiple goals to overall ocean health (each petal) and their relative importance (petal width), and the role of targets in defining the score for each goal (petal length). Within each "petal," scores are determined by (B) the goal's status as well as trends in that status, pressures to the goal, and resilience measures that help mitigate pressures. Arrows indicate the direction of change from these variables, and activities supporting one goal can create pressures to another goal. This petal plot shows scores for the world's ocean in 2019.

than 1 billion people. But how far back should we set a reference point for what habitat extent should be? This decision is inherently subjective. The OHI is transparent in these targets and is able to change them if better information becomes available.

All target-driven indicators face this challenge of explicitly setting a reference point or target. A key strength of conducting OHI assessments is the ability to tailor reference points to a region in a transparent way across all goals in the OHI. Determining reference points for all aspects of ocean health at the same time rather than setting one reference point at a time also requires confronting the inherent tradeoffs and interactions that exist in multi-objective ocean health.

Interactions and Tradeoffs Are Everywhere

The complexity of the ocean as a social-ecological system means that individual indicators cannot capture more than a thin slice of ocean health, and none are independent of the others. These inherent interactions mean that changes in one indicator will often lead to changes in other indicators, sometimes in a similar direction but often in the opposite direction, creating tradeoffs in management decisions and outcomes. The OHI builds as many of these interactions as possible into the structure of the index (Figure 1B), for example, by having increases in activities lead to both improvement in the status of one goal (e.g., higher levels of sustainable fishing) and changes in associated pressures to other goals (e.g., increased impact on biodiversity from fishing).

Most indicator efforts do not account for interactions, at least not explicitly. They instead provide dozens or hundreds of indicators, none of which interact with the other indicators, and people are left to combine and interpret them in an *ad hoc* way. Such "mental models" are both more subjective and less transparent, making it more difficult to know why someone thinks ocean health is getting better or worse. Using a conceptual framework to help structure the combination of indicators helps overcome this subjectivity.

The Power of a Conceptual Framework

Developing a conceptual framework for combining indicators requires understanding the system and the types of attributes and interactions that define that system and *then* seeking data that can be used to indicate those attributes.[8] Too often the development of indicators starts with the identification of available data and then an attempt to find a use for them, which can unnecessarily limit the scope and potential of the indicators. An important aspect of the OHI is that goals are defined first, and then the best available data for measuring targets are selected. This approach could lead to the discovery that the ideal dataset does not exist, requiring the use of proxy data.

Importantly, basing the OHI on a conceptual framework has allowed the index to be flexible and scalable to different contexts. The framework guides the process for adapting indicators to the local context and types of data that are needed.

A Long and Iterative Process

Developing and maintaining an indicator that uses the best available science and is adaptable to different contexts takes a lot of work. It took us nearly 3 years to develop the OHI framework; identify, gather, and process all necessary data; and conduct the first global assessment. It took us many more years to streamline

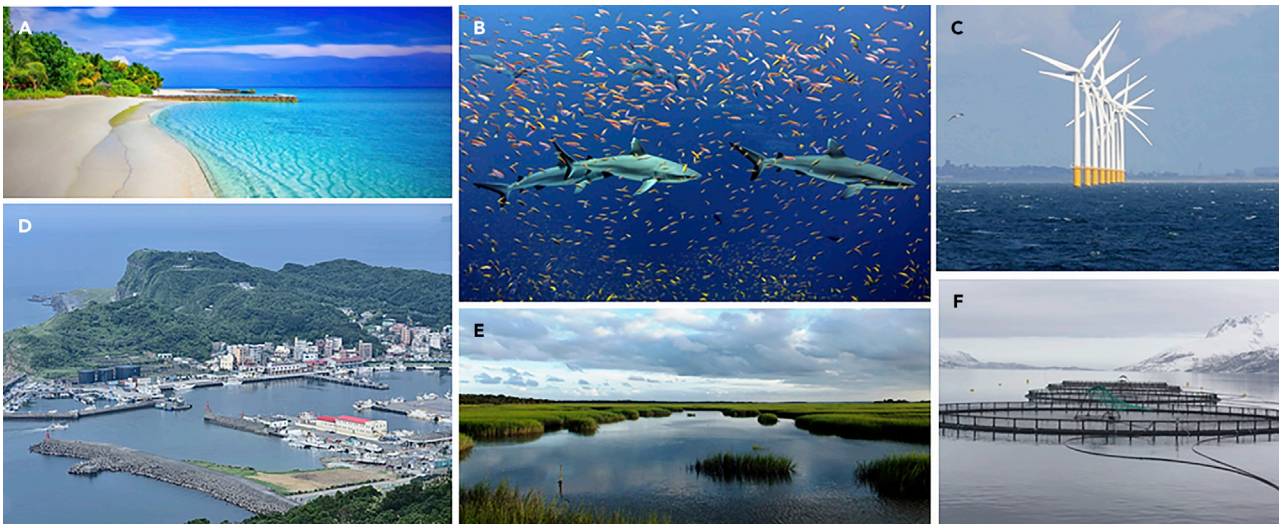

Figure 2. Different Views of a Healthy Ocean
Each of these images could be seen as healthy or unhealthy according to a person's values and perspective: (A) crystal-clear blue water but without any fish, (B) a shark-filled ocean that has abundant top predators but is very scary to many, (C) offshore wind farms that produce sustainable energy but disrupt benthic habitat, (D) a thriving fishing port but destroyed nearshore habitats, (E) a salt marsh that is healthy but buggy and smelly to many, and (F) aquaculture farms that produce healthy seafood but pollute coastal waters.

the process and make it repeatable,[9] and we continue to make annual improvements through this iterative process. If updates are not made, indicators can become "stale" by relying on old science and data that are no longer the best available. The decision to develop new indicators should be made carefully to ensure that resources exist for their longevity.

Confronting Expectations

People often have preconceived ideas of how healthy the ocean is according to media coverage, what their friends and family tell them, or their personal experience with a particular patch of coast or ocean. The OHI scores rarely match these expectations. When we launched the first global assessment in 2012, representatives from many countries stated that their scores were too low, but just as many felt they were too high. This pattern of split opinion has held in nearly every regional assessment we have conducted.

This cognitive dissonance between perception and OHI scores seems to arise from two factors. Most people base their impression of ocean health on a few key attributes, or indictors, or just the places they know (e.g., Figure 2). They see trash on the beach, fewer fish in their nets, or a plume of runoff at a river mouth and perceive the ocean as sick. Or they see some brightly colored coral reef fish while diving, a thriving coastal tourism industry, or water that looks crystal blue from the surface and perceive the ocean as healthy. They are, one could say, not seeing the forest for the trees. Because the OHI is a composite index, it combines multiple indicators across multiple scales in a way that rarely matches the status of any individual indicator or any specific place. However, by allowing people to dig into the individual indicators composing the index, our hope is that people will begin to see how their perspective fits into the larger community represented by the scores.

Equally common, specific indicators might be insufficient proxies of the actual attribute of ocean health that they are intended to assess, or the data used for measuring the indicator are of poor quality. If people's perceptions of ocean health are correct, then these critiques of OHI scores help identify where improvements are needed. The OHI is built on the philosophy that measuring something is better than leaving it unassessed (and thus unactionable) and that some data are better than no data. Importantly, making everything in the OHI fully transparent lays these deficiencies bare and invites improvement.

The Value of Transparency

The ability to peek under the hood of an indicator helps build trust and understanding. No one likes a "black box" that hides what was done or masks the provenance of data. Despite the underlying complexity of how the OHI is calculated, all code and data are made freely available (https://ohi-science.org/ and https://github.com/ohi-science) and can be interrogated at any time, and we clearly communicate where data gaps exist and might create uncertainty in scores.[10] Commitment to open-science practices invites scrutiny, and that input helps improve how the OHI is calculated. As the OHI team has written elsewhere,[9] the adoption of open-science methods has been essential for us to easily and robustly repeat our own assessments.

The Path Forward

Composite indicators such as the OHI continue to face the critique that they are too complicated and opaque for management,[11] yet greater liabilities to effective management are both the inability for collections of individual indicators to deal with interactions and the opaqueness and subjectivity of how these collections are combined to describe the bigger picture of ocean health. In general, people are comfortable with composite indicators in other realms, most notably gross domestic product as a measure of economic health. Perhaps we just need time and familiarity to get used to composite indicators for ocean health.

The coming decades are likely to see increased uses of, and pressures to, the ocean. The increasing push for a "blue economy" from many countries around the world suggests that these uses will accumulate and accelerate faster than during the previous few decades. So that we can understand the implications and opportunities from this growth, the need for good indicators of ocean health is ever more pressing.

This need is confronted by two challenges: (1) given the continued proliferation of indicators, how do we prioritize which are most useful; and (2) with the increasing demand for data to inform all of these indicators, how do we prioritize which monitoring and data-collection efforts need to continue or begin anew? The OHI highlights which data are critical to understanding the status and changes in ocean health and also provides a gap analysis of which missing data would be most useful for the start of collection. It also can help prioritize where actions should be taken to improve ocean health. For example, many countries in Africa and Central America consistently score relatively low[3,4] and could benefit from particular attention during the upcoming UN Decade of Ocean Science for Sustainable Development.

The OHI was not perfect when first launched in 2012, and it is not perfect now. We continue to update and improve the OHI according to internal and external feedback and leverage the amazing monitoring and assessment work of others. Yet the ability to complete these assessments rests on continuity of funding for the underlying monitoring data, as well as calculation of the index itself. Funding agencies and philanthropists strongly favor "new" science, but sometimes the most important information comes from long-term maintenance of existing assets.

The adage that "you cannot manage what you do not measure" is equally relevant for ocean health. It is one thing to claim and articulate a need to achieve healthy oceans; it is quite another to make such aspirations concrete, attainable, and measurable. The OHI provides a means of achieving these policy goals.

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