NEWS & VIEWS

ENVIRONMENTAL SCIENCE

Scorecard for the seas

An index assessing the health of the oceans gives a global score of 60 out of 100. But the idea that a single number can encompass both environmental status and the benefits that the oceans provide for humans may prove controversial. SEE ARTICLE P.615

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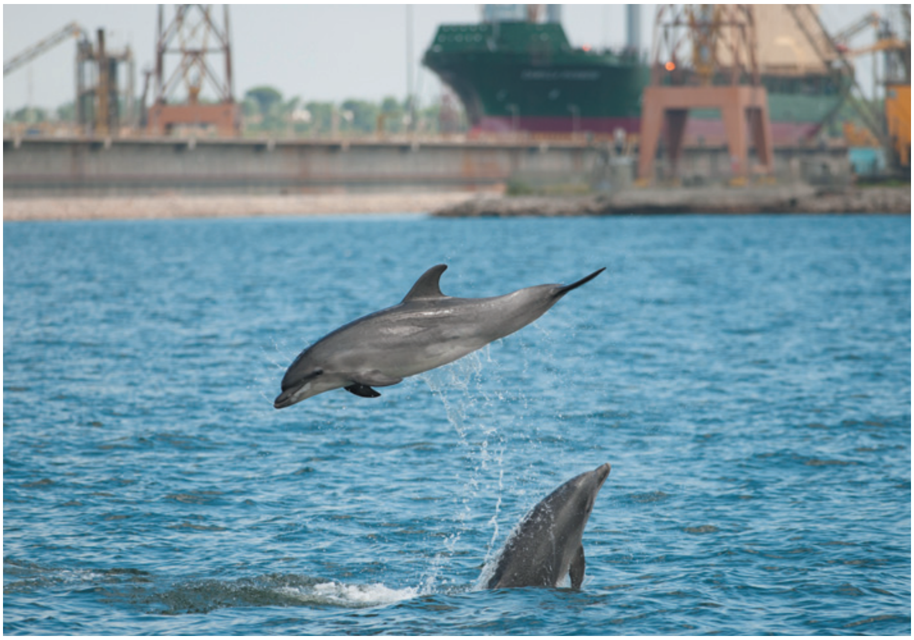

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Figure 1 | The ocean's bounty. To develop a single index to define the health of the oceans, Halpern and colleagues[1] assessed ten goals that encompass the ecological integrity of the marine realm and the goods, services and benefits that the oceans provide for humans.

Just like the business pages of many newspapers at present, reports about the state of our oceans all too often read like a scandal sheet. However, according to research published by Halpern *et al.*[1] on page 615 of this issue, residents of Germany or Seychelles may have something to cheer about — with a score of 73 out of 100, they are among the top of the class for inhabited countries in an index that provides a score of the overall condition of marine ecosystems. But 32% of coastal nations receive a score of less than 50.

Although broad-scale ecosystem indicators are not novel[2], the one that Halpern and colleagues describe is noteworthy for several reasons. The authors fuse markedly different goals into a single composite index that not only consists of measures of ocean health, but also takes into account the goods, services and benefits that the oceans provide for humans. Furthermore, their index is spatially explicit, being calculated for each country (see Fig. 2 of the paper[1]) that has a marine exclusive economic zone (waters up to 322 kilometres offshore). This provides a yardstick against which management of the oceans can be compared, and thereby creates a 'league table' of national stewardship of marine resources.

The authors began by defining ten goals (and eight sub-goals) that describe both a sustainable marine realm and what the ocean can provide for people. These range from extractive uses, such as food provision, to ecological attributes, such as biodiversity, and also include less tangible benefits, such as carbon storage and 'sense of place' (Fig. 1). The researchers quantified each goal in terms of its current status (against a defined reference point); its recent trend; the pressures likely to affect it in the future; and its resilience. The goals were then synthesized into a single index of ocean health and benefits to give a value between 0 and 100. Thus, the index provides a numerical representation of the fine line between maintaining ocean ecosystems and extracting from them resources, economic benefits and livelihoods for humans.

There is no single objective way to amalgamate the ten disparate goals used in this index. The default scheme that Halpern and colleagues present is to weight each goal equally. Canada, for example, scores highly on artisanal (small-scale) fishing opportunities, coastal protection and biodiversity, low on mariculture, tourism and recreation and 'lasting special places', and moderately on the remaining goals and sub-goals. With equal weighting, these individual grades give an overall index score of 70. However, the authors also present schemes in which the goals are weighted according to different sets of values — from conservationist or utilitarian perspectives, for example — thereby allowing different users to choose the scheme most appropriate for their needs.

There also remains unavoidable subjectivity in the choice of goals and reference points for the index. For example, the authors' decision to set the reference point for fisheries to 75% of multi-species maximum sustainable yield, or that for mariculture to China's yield (the maximum observed), are judgement calls with which some may disagree. In addition, some of the data they use seem to be less reliable proxies of their goal than others (international arrivals as a measure of ocean-related tourism, for example). The authors acknowledge these data disparities, but point out that their study provides an opportunity to identify areas in which additional data collection may prove fruitful.

Some of Halpern and colleagues' results may raise eyebrows in the marine community. The authors' global index value of 60 seems high, given the extensive evidence for our detrimental and accelerating impact on ocean ecosystems. The value of 83 for the global-biodiversity goal also seems remarkably optimistic in light of the voluminous literature that catalogues the changes humans have wrought on the oceans[3,4] — research to which many of the authors of the current paper have contributed.

However, such dissonance can be reconciled through a recalibration of expectations — away from an index that measures the pristineness or ecological integrity of the marine realm, and towards one that quantifies an integrated system in which humans and the non-human ecosystem are considered equally important parts. In such a system, appropriate use of extractive resources or substantial mariculture production will result in a higher index score. Whether or not this is the right approach depends on your opinion about the role the oceans should fulfil for humans. But there is a genuine concern that improvements in human-related indices (such as tourism and recreation, or coastal economies) may mask deterioration in the fundamental ecological health underpinning the marine environment — and may provide excuses for inaction on this front.

An additional consideration is that the principle of distilling such complex and nuanced information down to a single value may sit uneasily with some people. An alternative strategy that might avoid conflating opposing ideas about what constitutes a healthy ocean would be to separate this single index into two — one that measures the provision of goods and benefits for humans and another that evaluates the health of the ocean as the distance to a 'more pristine' state. But this would lack the simplicity of a single, easily interpretable number by which performance can be benchmarked, and which can act as both a carrot and a stick. A single index allows the oceans to be assessed and compared in a similar way to, for example, the use of gross domestic product as an indicator of a country's standard of living, and brings with it similar benefits and limitations.

The debate about whether a single index is a reasonable goal to aim for is certainly worth having, and one could argue incessantly about the best way to construct such a metric. But as Voltaire's aphorism says, the perfect is the enemy of the good, and to have something on the table is certainly better than nothing. Halpern *et al.* have synthesized an extraordinary diversity of data in their work towards this laudable goal. A single index that can be communicated, plotted, monitored over time and transparently compared between countries, regions and oceans may help to bring ocean management into greater prominence in the media, and in a more readily interpretable format. Although scepticism remains as to whether efforts such as that of Halpern and colleagues will spur governments and regulatory bodies to further action, they will at least enable us to monitor the future progress or, perhaps more likely, the deterioration of our oceans. ■

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IMMUNOLOGY

Licensed in the lungs

In multiple sclerosis, the body's own immune cells attack the brain and spinal cord. But how they get there from peripheral tissues has been a mystery. Surprisingly, the lungs might be a key transit point. SEE LETTER P.675

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The immune system has one cardinal function: to protect the body against pathogens. To accomplish this task, immune cells develop in such a way that they are activated only by foreign structures. This discrimination is imperfect, however, and when it goes wrong, our bodies can suffer autoimmune inflammation and disease. In many cases, this inflammation is largely or entirely limited to a single organ — multiple sclerosis, for example, affects the brain, optic nerves and spinal cord of the central nervous system (CNS). Understanding how autoimmune cells migrate to and accumulate within an affected organ is vital to developing effective treatment strategies. On page 675 of this issue, Odoardi and colleagues[1] use a rat model of multiple sclerosis to show that, before their entry into the CNS, inflammatory autoimmune cells transiently settle in the lungs — an organ not previously associated with immune-cell trafficking to the CNS.

Multiple sclerosis affects around 2.5 million people worldwide. The disease targets myelin, a membranous sheath that wraps around the axon fibres of nerve cells. Damage to myelin leads to myriad symptoms, including sensory disturbance, impaired balance and difficulty thinking. To study multiple sclerosis, researchers have developed several animal models, one of which is called adoptive-transfer experimental autoimmune encephalomyelitis (EAE). In this model, rats are first immunized with myelin basic protein (MBP), a major component of myelin. The immunization activates certain immune cells (T cells) that are specific for MBP, and induces them to proliferate. These T cells can then be collected from the immunized rats and injected into other rats, where they act as autoimmune cells and cause inflammation that centres on the spinal cord. Because these 'encephalitogenic' T cells specifically attack myelin, and not other CNS structures[2], the rat disease closely mimics certain aspects of the human condition.

However, researchers have been puzzled by the fact that it takes four to five days following transfer of the encephalitogenic T cells for rats to develop disease, despite the cells being activated *in vitro* before transfer. The research group presenting the current paper also previously reported another strange phenomenon of the model: the T cells must be infused into the recipient rat's circulation to induce EAE; direct administration into the cerebrospinal fluid, which bathes the CNS, not only fails to hasten disease onset but is in fact ineffective in inducing the disease[3].

In this earlier study, the authors showed that the injected T cells migrate from the bloodstream to immune-system organs, including lymph nodes and the spleen, and that the gene-expression pattern of the cells changes during this time: a sharp reduction in the expression of activation- and proliferation-related genes is accompanied by a striking increase in the expression of genes involved in cell migration[3] (Fig. 1). Then, at the onset of disease, millions of T cells accumulate abruptly and simultaneously in the CNS[3]; the same research group has also characterized the events taking place at this time of CNS entry[4]. So the first steps following T-cell infusion, and the events immediately preceding disease onset, had both been established — but what happens to the T cells between those time points remained unclear.

Odoardi and colleagues set out to clarify this 'black box'. They used encephalitogenic T cells that express green fluorescent protein, which allows the cells to be tracked, and they developed the ability to image these fluorescent cells in the spinal cord of living animals using a technique called two-photon microscopy[5], an advance that has also been made by other research groups. Imaging of the intact brain is likewise possible[6,7], and together these methods have revolutionized our understanding of the processes by which immune cells gain entry to the CNS during disease and immune responses[8].

The authors first asked whether the injection of activated encephalitogenic T cells could itself result in systemic inflammation that might affect the CNS or its associated vasculature, so as to induce chemical signals that attract the T cells to that region. To assess this possibility, the researchers conducted an experiment in which they joined the circulatory systems of two rats, one of which had received