Attaining Aichi Target 11:
How well are marine ecosystem services covered by protected areas?

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The policy challenge

The spatial coverage of marine and coastal protected areas worldwide has shown a rapid increase in recent years. Over 32% of the world's coral reefs and over 36% of the world's mangrove forests now fall within protected areas. However, simple measures of extent are insufficient for assessing progress toward achieving global targets. Notably, the CBD Aichi Target 11 calls for 'at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, **especially areas of particular importance for biodiversity and ecosystem services**' to be protected. There is, therefore, an urgent need to assess how well protected areas cover these areas of importance for ecosystem services.

Why is it important to conserve marine ecosystem services?

Modern conservation agreements have often stressed the important connection between natural resources and human well-being. However, Aichi Target 11 aims to strengthen that connection through the establishment of protected areas by encouraging countries to protect important areas for ecosystem services, as well as biodiversity.

Despite the importance of marine ecosystem services to human well-being, incorporating their values into protected area planning and implementation remains a considerable challenge. For example, there has been little progress in global-scale mapping of marine ecosystem services and, even at local scales, the mapping and quantification of ecosystem services remain non-trivial tasks. Consequently, although some protected areas have been established to improve fishery benefits, or to safeguard popular (and profitable) recreation destinations, there has been no systematic targeting of ecosystem services for MPA designation to date, as called for in Aichi Target 11.

What does ecosystem service mapping tell us?

It is now possible to measure how well protected areas cover ecosystem services, even at global scales. Such map-based approaches could be used to help future protected area network planning globally and locally, as well as enhance delivery of the ecosystem approach through marine spatial planning, integrated coastal zone management and climate change adaptation initiatives. Ensuring that protected areas safeguard marine ecosystem services will not only support the delivery of international CBD targets, but will also foster increasing support from local communities, direct users and industry bodies in support of marine conservation efforts.

A collaboration between The Nature Conservancy (TNC), UNEP World Conservation Monitoring Centre (UNEP-WCMC), BirdLife International and the University of Cambridge has now produced preliminary global maps of estimated marine ecosystem service values derived from mangroves and coral reefs, and calculated the proportion of these ecosystems covered by protected areas.

Preliminary results show the considerable spatial variation in potential service value, driven by a combination of natural environmental factors, habitat condition, and socio-economic factors associated with the distribution of human populations, infrastructure and markets.

Coral reef fisheries: Coral reefs play a key role in supporting fisheries and, thus, those people who depend on fisheries for their livelihoods and as sources of protein. We have mapped estimated catch of coral reef fish, using spatial data on reef conditions, fishing effort, and the distribution of coastal human populations and markets.

Coral reef tourism: Tourism is a major source of revenue for coral reef nations, often in places where there are few alternative livelihoods. We have produced a global map of estimated coral reef tourism values based on estimated spending by international and domestic visitors. While particularly high benefits are associated with diving and snorkelling, the map also incorporates the value of indirect benefits (such as sand generation, provision of calm waters, and scenic views), which help to attract non-diving visitors.

Coastal protection by coral reefs: Coral reefs are huge physical ramparts that defend many coasts from damage from erosion and wave action during storms. We have produced a global map of estimated coral reef coastal protection values based on proximity of reefs to the shore, storm likelihood, and the value of adjacent coastal resources based on population and infrastructure.

Carbon storage by mangroves: Mangrove forests play an important role in global climate regulation. In some places, they have extremely high biomass, with carbon storage values equivalent to or greater than tropical lowland rainforests. However, the spatial variation in mangrove biomass is also considerable. Avoiding mangrove deforestation can contribute to slowing CO_2 emissions, but the value of avoided deforestation will depend very much on where it occurs. We have produced a map plotting potential mangrove above-ground biomass, as a surrogate for carbon storage values, for all mangrove forests using a climate-based model.

Mangrove fisheries: Mangrove forests are 'fish factories,' supporting high levels of fish production that underpin coastal fisheries, providing jobs, income and food security to many coastal human populations. We have created a map showing estimated current catch levels based on modelled potential productivity and modelled fishing intensity (influenced primarily by the distribution of coastal human populations and proximity to markets).

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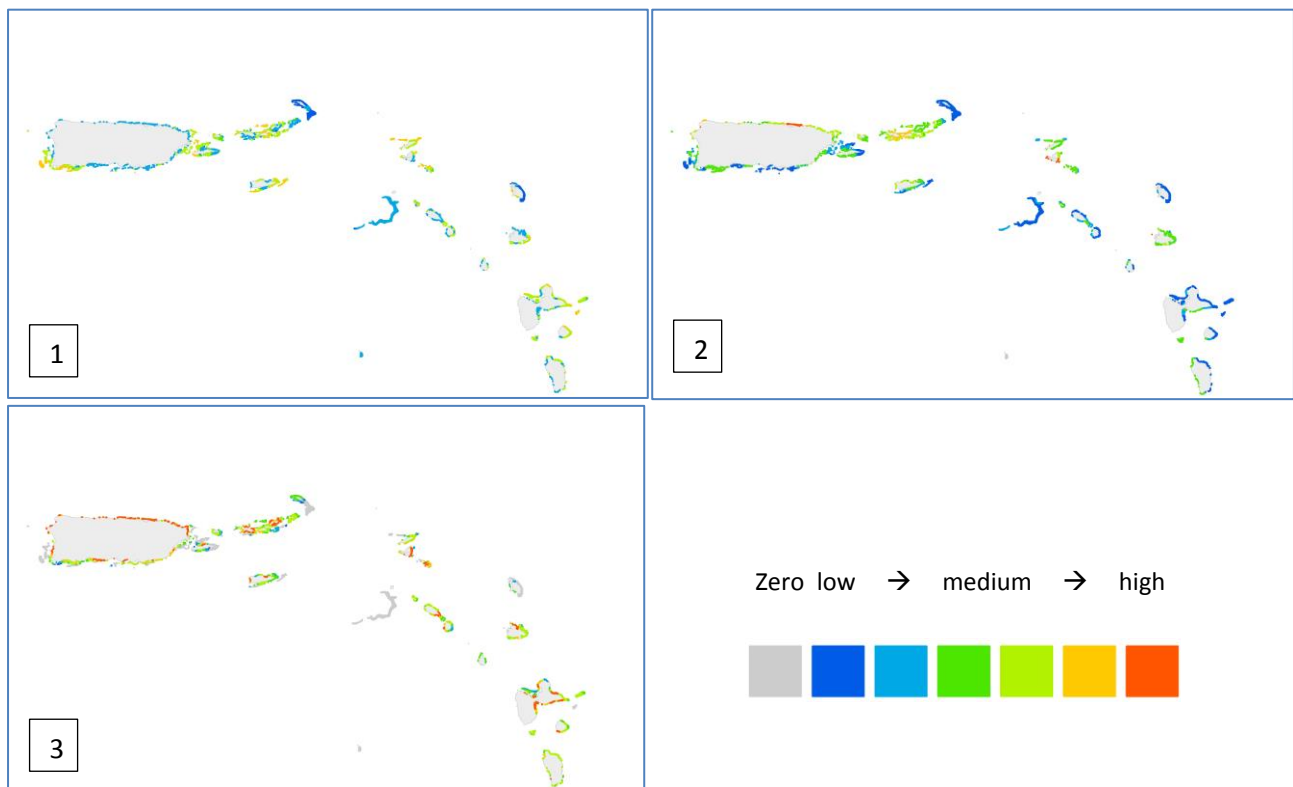
Maps 1-3: Sample details of the coral reef ecosystem service maps showing the distribution of estimated values for the islands of north-eastern Caribbean Islands (Puerto Rico in the west to Dominica in the south-east). 1 - weight of fish caught on coral reefs; 2 - reef-related tourism revenue generation; 3 - assets protected by coral reefs.
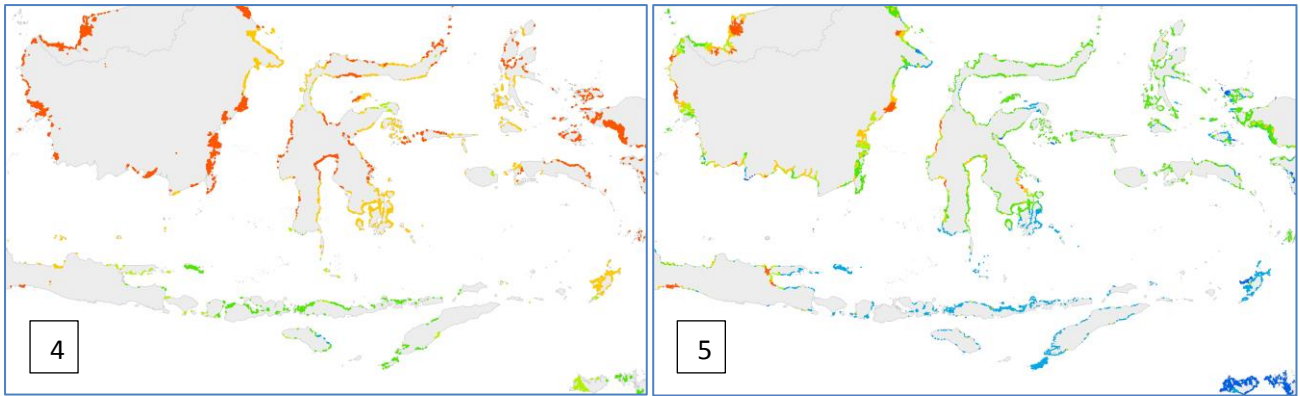
Maps 4-5: Sample details of the mangrove ecosystem service maps showing the distribution of estimated values for the islands of central Indonesia. 4 - carbon storage (above-ground biomass) by mangroves; and 5 - weight of fish caught in mangroves.

## How well are ecosystem services covered by protected areas?

These preliminary maps allow us to quantify the proportion of the value of these ecosystem services covered by protected areas.

For coral reef fisheries, we accounted for the fact that some marine protected areas are designed to enhance or maintain fisheries through no-take areas (NTAs) that prohibit all fishing. These generate fisheries values not *within* their boundaries but outside through adult spill-over and increased larval supply to surrounding areas. We modelled these benefits in surrounding waters and the resulting enhanced values were used, alongside values in non-NTA sites, to estimate the proportion of coral reef fisheries values associated with protected areas.

Coral reefs

About 32% of the world's coral reefs are found in protected areas. Preliminary results suggest that these protected areas support:

- 17% of the global coastal protection value of coral reefs;
- 36% of the global tourism value of coral reefs; and
- 27% of the global fisheries value of coral reefs.
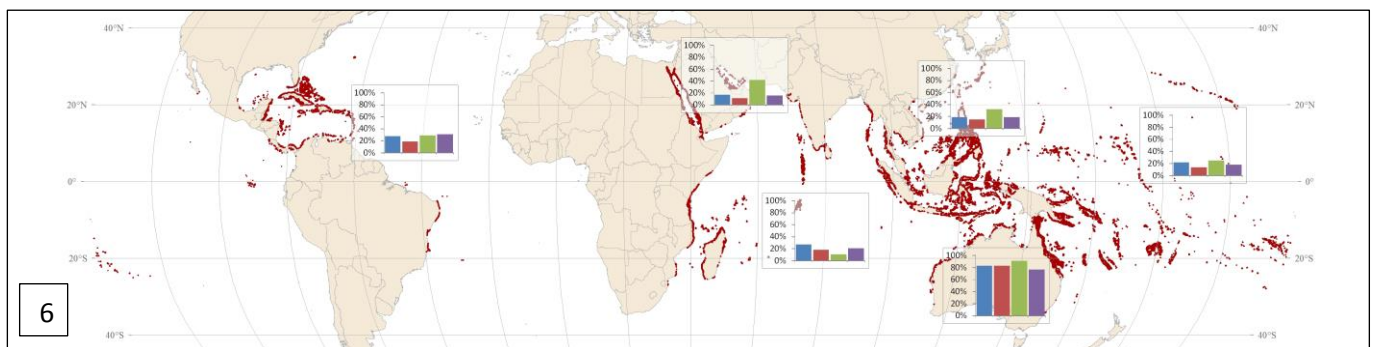
Map 6: Coral reefs of the world with regional charts showing the proportion of total area of reefs (blue), and the proportion of each ecosystem service contained within protected areas (red – coastal protection; green – tourism; and purple – fish catch). Charts are for Atlantic, Middle East, Indian Ocean, Southeast Asia, Australia, and Pacific Islands.

Coastal protection values of coral reefs are poorly represented in protected areas in most regions. While 32% of reefs are protected, only 17% of their coastal protection value is included, a shortfall that is notable in all regions other than Australia. Within regions, major coral reef nations also reflect this discrepancy (protection of reefs vs. coastal protection values: Indonesia: 29% vs. 19%; Egypt: 60% vs. 27%; Hawaii 88% vs. 15%).

Coral reef tourism values are moderately well represented in protected areas. East and Southeast Asia have included a large proportion of their reef tourism value within protected areas (protection of reefs vs. tourism values: Indonesia: 29% vs. 47%; Malaysia: 6% vs. 16%). A different picture appears in the Indian Ocean region where, despite 27% of reefs falling within marine protected areas, only 11% of tourism value is captured. This pattern is also visible at the country level in other areas (protection of reefs vs. tourism values: US Hawaii 88% vs. 22%; US continental: 58% vs. 22%; Brazil: 71% vs. 31%; Tanzania: 47% vs. 20%).

Coral reef fisheries values show a mixed regional pattern of representation in protected areas. Both Indian and Pacific Ocean fisheries are less well covered than the protected area extent statistics would suggest. This is largely due to extensive reef areas in very large MPAs in both regions, which raise the spatial coverage but do not include areas of very high fisheries value. NTAs contributed to only 2% of the marine protected area related fish catch, but rose to over 10% in countries like Kenya and Bermuda where a network of multiple NTAs are interspersed with areas where fishing is likely to be enhanced.

The relatively high proportion of tourism values within protected areas is perhaps not surprising given the direct and tangible economic values associated with this service. Similarly, the poor level of coastal protection benefits in protected areas may be understandable—reefs close to population centers are often in poor condition, and may not be a natural target for conservation prioritization. Even in a degraded condition, however, they can greatly reduce wave impacts and provide natural protection from storms. Protected area status could benefit such coral reefs, helping to protect against further declines in reef extent and/or condition, or perhaps even supporting recovery towards a healthy condition where coastal protection benefits might be further enhanced with positive effect on recreation and local livelihoods.

Mangroves

About 36% of the world's mangrove forests are found in protected areas, with preliminary results suggesting that PAs cover:
- 33% of global mangrove biomass
- 30% of mangrove fishery value
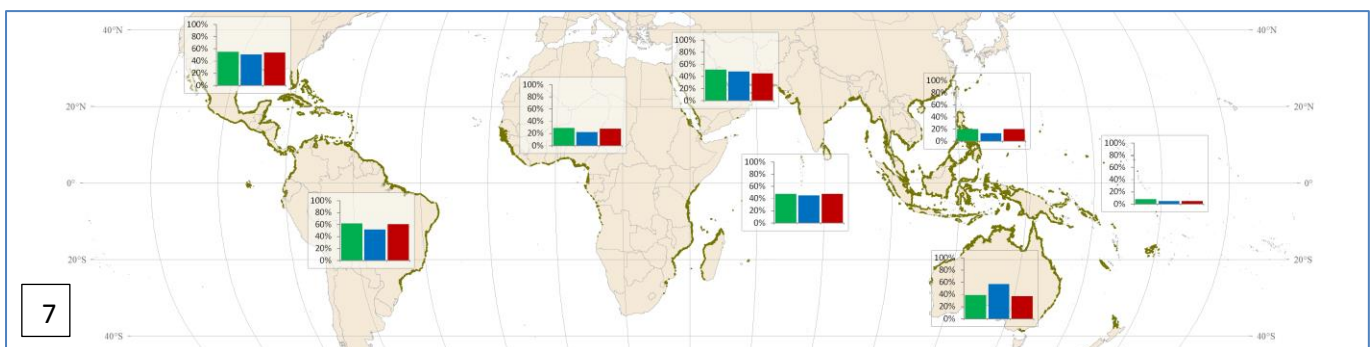
Map 7: Coral reefs of the world with regional charts showing the proportion of total area of mangrove forests (green), and the proportion of each ecosystem service contained within protected areas (blue – fish catch; red - carbon). Charts are for North and Central America, South America, West Africa, Middle East, Indian Ocean, Southeast Asia, Australia and New Zealand, and Pacific Islands.

For mangrove fisheries, protected area coverage was low in many regions. While the East and Southeast Asia region has 20% of its mangroves in protected areas, only 13% of its fisheries value is protected. This pattern also holds true at the country level (protection of mangroves vs. mangrove fisheries values: Indonesia: 20% vs. 10%; Nigeria: 11% vs. 6%; Bahamas: 9% vs. 2%; Philippines: 19% vs. 11%; mainland USA: 78% vs. 28%). In stark contrast, Australia shows a clear focus towards the protection of fisheries (40% vs. 64%).

Mangrove potential biomass values show a broadly even coverage in almost every region and are very similar to the spatial extents of mangroves protected. Only the Middle East and Pacific Ocean regions appear to show a slight deviation, with protected areas targeting lower mangrove biomass areas.
One recent trend in marine protected area development has been the rapid growth of very large sites (VLMPAs). Such sites have been variously defined, but there are eight sites larger than 100,000 km^2, which, when combined, include 52% of the coral reefs in protected areas. Such sites have the potential to be particularly important for biodiversity conservation—their extensive coverage potentially enables protection of large-scale ecosystem processes, often in relatively un-impacted settings. In some cases, they also provide value for tourism and recreation, but overall their coverage of ecosystem service benefits is more limited: they cover 17% of the world's coral reefs, less than 2% of the global coastal protection value; less than 8% of the world's coral reef tourism value; and 10% of fish catch.

Key recommendations

The quantification and mapping of ecosystem services is a rapidly advancing science. We have shown that generalized maps of estimated ecosystem service values can now be developed at global and regional scales. Preliminary results show individual ecosystem services with unique spatial patterns, often linked to the distribution of human populations and markets.

While greater detail is needed (and is already being developed) for modelling and mapping ecosystems services at local scales to inform conservation actions on the ground, these large-scale maps can be used to inform and prioritise broader conservation and development efforts. Ongoing work will assess how well protected areas cover locations with the highest ecosystem service values, relevant to the commitment in Aichi Target 11 to conserve areas of importance for ecosystem services.

While there are many ecosystem services, we have chosen to focus on provisioning and regulating marine services, which have clear and widely recognized direct benefits.

- As they play a critical role in supporting human well-being, **marine ecosystem services need greater and more systematic representation within protected areas.** This should be achieved alongside, rather than as an alternative to, improved coverage and greater representation of biodiversity (at the level of species, important sites, and ecoregions), and should be integrated into ongoing efforts to optimize protected area network expansion,
- **Measures of marine ecosystem services need to be more widely available for protected area planning and management.** The global conservation community should support this by developing guidelines on how to estimate and utilize such measures. The identification and mapping of important areas for ecosystem services will form an important part of this.
- **Effective protected areas that secure and enhance ecosystem services should be recognized and their benefits to society be well documented to build powerful new support and constituencies for protected areas.**

Acknowledgements

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