

INTO THE BLUE

Securing a Sustainable Future for Kelp Forests





Executive summary

The term “kelp” is commonly used to refer to just over 100 species of large brown seaweeds that represent some of the most productive and diverse habitats on Earth. Kelp dominate approximately one quarter of the world’s coastlines, throughout polar and temperate regions, making them the most extensive marine vegetated ecosystem in the world. Kelp create complex and three-dimensional underwater forests rich in biodiversity. These unique coastal environments provide nursery habitat, shelter and foraging grounds for a wide range of marine organisms, including fish species of commercial importance, such as cod and pollack, and other species such as crab, octopus and lobster. Kelp forests can mitigate carbon emissions by storing carbon in standing biomass and by facilitating the long-term removal of carbon dioxide (CO₂) through the export and burial of kelp carbon in the deep sea. Indigenous and coastal people have used kelp as medicine, food and material for generations, with kelp forming part of their identities and fostering the development of a sense of place and connectedness with nature.

However, kelp have been declining globally over the past 50 years. As cool-water species, kelp are stressed by ocean warming, marine heatwaves and other climate-related extremes, with extensive losses recorded at their warm range-edges. Overfishing, reduced water quality from excess nutrients, pollution and sedimentation, and unregulated and unsustainable kelp harvesting also pose major threats to kelp forests. This global synthesis report is the most comprehensive knowledge review on kelp to date, revealing the state of science on the world’s kelp forests and providing recommended actions to build the recovery of the world’s kelp forests through increased public awareness and institutional support for advancing conservation, management and restoration. The report also provides a range of policy and management interventions and options that can be used to maintain these remarkable ecosystems now and in the future and to support the people and economies that have depended on them for generations.

The state of kelp forests, their values and key challenges

Kelp is the most extensive marine vegetated ecosystem in the world. Kelp are predominantly cool-water species of large brown seaweeds that are found growing on rocky reefs throughout temperate, Arctic and sub-Antarctic regions, along 25–30 per cent of the world’s coastlines. They cover 1.5–2 million km², an area up to five times greater than that of coral reefs.

Kelp forests are threatened by both local and global stressors. Kelp have suffered widespread losses across much of their range, at a global rate of decline of 1.8 per

cent per year. The trajectories of change across regions are variable, reflecting the variety of factors affecting kelp ecosystems. Over the past 50 years, 40–60 per cent of kelp forests have been degraded, with climate change, poor water quality and overfishing being the prominent causes. In severe cases, these stressors can cause full-scale shifts to ecosystems that are difficult to reverse, turning kelp forests from complex habitats to structurally simple turf-dominated reefs or sea urchin barrens.

Climate change is a major threat to kelp forests and requires urgent action. Projections for climate change impacts on kelp forests reveal extensive losses in temperate regions. A key strategy for climate change adaptation would include addressing all other stressors that can be managed locally or regionally, such as by improving water quality and controlling overfishing, in order to reduce multiple pressures acting simultaneously and cumulatively and increase kelp resilience.

Kelp forests are among the most diverse and productive ecosystems in the world and provide many valuable ecosystem services. These ecosystem services include supporting coastal fisheries, providing food, medicine and materials, mitigating climate change, protecting biodiversity, buffering ocean acidification, improving water quality and providing a range of cultural services such as recreation and support for traditional identities.

Kelp can provide important nature-based solutions to tackle climate change. Kelp forests are essential contributors to the carbon cycle; they can take up CO₂ and convert it into organic biomass for short-term storage. Kelp carbon that is not grazed, consumed or decomposed can be buried in sea floor sediments or transported to the deep ocean, thus facilitating long-term carbon removal.

Kelp provide services with economic and existence values. Economic frameworks, such as the total economic value or cost-benefit analysis, can be applied to reveal the different types of economic values that kelp provide and to support management decisions. Although these economic tools are useful, many services linked to traditional uses, spiritual practices, support for identities and broader ecological function cannot easily be monetized. Economic tools should therefore be coupled with general biophysical data on ecological function and sociocultural knowledge in order to acknowledge the full breadth of values associated with kelp ecosystems.

Kelp forests can help countries achieve several global goals in terms of climate, biodiversity and sustainable development. These forests are at the core of delivering Sustainable Development Goal (SDG) 14 Life below Water,

while the conservation and sustainable use of kelp forests align with many other SDGs, including SDG 1 No Poverty, SDG 2 Zero Hunger, SDG 6 Clean Water and Sanitation, SDG 8 Decent Work and Economic Growth, SDG 12 Responsible Consumption and Production and SDG 13 Climate Action.

Kelp have received little attention in ocean governance.

To date, no global legal or policy instruments have focused explicitly on kelp. This lack of attention has perhaps resulted in limited protection of kelp forests, and vice versa, with an approximate first-order estimate of less than one third of known distribution falling within marine protected areas. There are, however, many international frameworks and national laws and policies in place that could, in principle, support the conservation and effective management of kelp.

Demand for kelp for human consumption and for industry is growing. In recent decades, demand for kelp for human consumption, alginate production, aquaculture feed and potentially biofuel has increased, and will almost certainly continue to grow. Growing demand for kelp globally has mainly been met by cultivation, which now delivers 27 times more than harvesting of wild kelp. Kelp and seaweed farming has become the fastest-growing aquaculture industry globally, with an increase of 6.2 per cent per year over the last two decades.

Opportunities and recommendations

Knowledge and data generation

Invest in mapping and systematic and long-term monitoring of the world's kelp forests. The most comprehensive study of historical trends in kelp abundance covers only about one third of the world's regions where kelp forests exist, as data within these regions are spatially and temporally sparse. Assessing the trends and condition of kelp forests – especially in the many unmonitored regions – is key to evaluating the need for management actions.

Support the development of a coordinated network of global kelp observations and a data-sharing platform. Improved information on, and understanding of, kelp forests may in turn support the development of transformative policies, which are often a prerequisite to effective management and investment.

Invest in further understanding and prediction of individual stressors and their combined effects on kelp abundance and distribution. Extreme events (including marine heatwaves and storms), overfishing leading to outbreaks of grazers, eutrophication, coastal darkening and invasive species can all affect multiple life-history stages of kelp and interact to reduce their growth and survival. It is critical to understand how these drivers interact in order to predict future kelp abundance and distribution and make informed management decisions.

Quantify the ecosystem functions and services provided by kelp, and understand how these will be affected by climate change and human activities. Most data on ecosystem services – both the biophysical measures and their value – are limited to a few well-studied regions and direct-use benefits, but every kelp habitat can function differently. It is therefore critical to have specific knowledge for different ecosystems.

Incentivize kelp protection and restoration through their carbon value. One promising tool to protect and restore kelp could be the use of kelp forest “blue carbon” credits. However, operationalizing such credits would require improved scientific estimates and tools to measure kelp carbon sequestration, as well as changes to carbon market policies and frameworks.

Develop a toolbox of management interventions.

By compiling examples of best practice, a toolbox of management interventions and their effectiveness (e.g. the 2022 Global Kelp Restoration Guidebook) could be developed, which could then be tailored to the needs of individual nations and local scales.

Management and policy responses

Take immediate and global action to address climate change. Increasingly warm waters have driven, both directly and indirectly, the majority of recent kelp loss. The long-term provision of services and benefits by kelp forests depends on ocean warming being held in check. Global action to tackle climate change is therefore needed to mitigate the effects of ocean warming on kelp forests and ensure their resilience in the coming decades.

Follow an ecosystem-based approach to sustainably manage kelp forests. Ecosystem-based management can act as an “umbrella” framework, whereby a number of different management approaches are applied and integrated, including initiatives for addressing individual pressures, area-based management such as marine spatial planning and marine protected areas, and sustainable management of harvesting of kelp and associated species.

Ensure an explicit focus on kelp when designating management measures and setting targets. As kelp can be affected by both land-based and sea-based human activities, managing for the cumulative impacts from various uses and users calls for a holistic approach, whereby kelp is registered as an “ecosystem in focus”, and for strategic plans to address current and future stressors through appropriate regulations.

Ensure capacity-building and sustained investment for kelp management at national and local scales.

Well-intentioned initiatives may not be effective if their implementation remains underfunded and inadequately managed. For management plans to be effective and for

kelp-specific goals and targets to be achieved, continuous funding and sufficient technical expertise and human resources are needed for implementation and monitoring of activities.

Assess harvesting practices regularly and adapt as needed. In many countries, kelp harvesting is managed through a combination of domestic and regionalized approaches. To ensure regrowth of kelp and kelp ecosystem resilience, obtaining regular and accurate information on kelp standing stock, monitoring harvest levels and assessing harvest impacts are critical to mitigating impacts on kelp populations and associated communities. In light of significant uncertainty around impacts on kelp forests and associated ecosystem recovery (e.g. the lack of a systematic evaluation of the effectiveness of approaches to manage kelp harvesting), it is necessary to apply an adaptive and learning approach.

Combine sociocultural knowledge with economic valuations to strengthen the case for devoting resources to the conservation, sustainable management and restoration of kelp. Economic frameworks are important to identify which kelp conservation or restoration projects are likely to deliver benefits overall and how those benefits are distributed. Decision-making should also consider sociocultural frameworks that take into account whether the distribution of resources is fair and equitable, particularly when minority groups are identified as being negatively impacted by kelp management practices.

Use existing global frameworks more effectively. Existing international law could be more widely utilized to recognize kelp forests and address threats to them. Kelp could also be better acknowledged and recognized within

World Heritage Sites, the Ramsar Convention, the Sendai Framework for Disaster Risk Reduction, the Convention on Biological Diversity, national biodiversity strategies and national action plans. Within the framework of the Paris Agreement and nationally determined contributions, there is also potential to catalyse the protection and restoration of kelp forests in the context of blue carbon and nature-based solutions to climate change mitigation and adaptation. Kelp restoration also provides countries with opportunities to achieve their pledges as part of the United Nations Decade on Ecosystem Restoration.

Expand partnerships and ensure stakeholder engagement and involvement. Many stakeholders have interests in kelp forests, including governments, non-governmental organizations, local and indigenous communities, local women representatives and women's groups, and businesses. Good governance requires the engagement and involvement of all relevant stakeholders. In particular, the integration of local and traditional knowledge, respect for indigenous customary laws and practices, community-based management, and formal recognition of traditional governance institutions that are empowered to make rules for local communities are all important.

Support the development of a global alliance among kelp nations. Such an alliance could raise the profile of kelp ecosystems and provide a platform for sharing best practices, discussing concerns and gathering legal, policy and management solutions at all governance levels. Similar to alliances for mangrove and coral reef ecosystems, a global alliance among kelp nations could work to provide greater visibility and commitments for kelp ecosystems in multilateral environmental fora, including the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change.

