



EGER ET AL. 2023. A ROADMAP FOR PROTECTING AND RESTORING 4 MILLION HECTARES OF KELP FORESTS BY 2040. KELP FOREST ALLIANCE, SYDNEY, AUSTRALIA



A roadmap for protecting and restoring 4 million hectares of kelp forests by 2040

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EXECUTIVE SUMMARY

Essential for healthy oceans, coastal communities, fisheries, economies, and marine biodiversity from the subtropics to the polar regions, kelp forests are an integral and threatened ocean ecosystem. Their benefits are connected to over 740 million people who live beside a kelp forest, and their economic potential is valued at least 500 billion USD per year.

Despite the ever-growing and increasingly prominent threats to the ocean’s largest biological ecosystem and the loss of their associated benefits, kelp forest conservation has lagged behind conservation efforts in other terrestrial and marine environments. The Kelp Forest Challenge aims to address this disparity and accelerate investment and action for kelp forest ecosystems by promoting the restoration and protection of 4 million hectares of kelp forests, globally, by 2040.

This roadmap is a detailed strategy for how businesses, governments, communities, universities, content creators, and anyone else with an interest can help meet the Kelp Forest Challenge. To save our kelp forests, we will need substantial investment, collaboration, and innovation across different sectors, countries, and philosophies; equitable and large-scale success for kelp forests will only be achieved by bringing together the diversity of solutions outlined here and creating a sustainable ocean for everyone.

As such, the key recommendations of this roadmap are as follows:

Stressor Management:

There is an imperative to identify and mitigate external pressures on kelp ecosystems. This includes addressing climate change, pollution, and invasive species threats; there must also be an implementation of robust monitoring and response mechanisms.

Active Restoration:

Degraded kelp forests need direct rehabilitation efforts, with an emphasis on techniques such as seeding, pest-species removal, and leveraging technological advancements to increase the scale and efficiency of restoration initiatives.

Conservation Finance:

This involves the exploration of innovative financial mechanisms and incentives to fund kelp conservation projects in order to ensure sustainable, long-term financing solutions.

Policy Changes:

We must advocate for revised, stronger policies that prioritise kelp forest conservation and management. This includes pushing for legal protections, incorporating kelp conservation into broader marine conservation strategies, and setting clear, actionable restoration and protection targets.

Indigenous Land and Sea Management:

It is critical, in the building of earnest, genuine partnerships, that projects recognise and collaborate with Indigenous communities to incorporate their values and conservation practices. Such engagements provide an invaluable perspective and can lead to more effective and inclusive conservation outcomes.

CITATION

Eger et al. 2023. A roadmap for protecting and restoring 4 million hectares of kelp forests by 2040. Kelp Forest Alliance, Sydney, Australia - [Author List](#)



Business Opportunities:

There is great value in encouraging the private sector to engage with kelp forests not just as an ecological asset but also as a potential economic one. This might involve promoting kelp-based products or services, sustainable aquaculture, or eco-tourism ventures.

Increasing Awareness:

We will elevate the profile of kelp forests among the general public through art, food, education, media, and community engagement. The power of storytelling and experiential learning can help us to foster emotional connections and a sense of stewardship, both of which will encourage care of these vital ecosystems by current and future generations.

Research and Development:

There is great value in investing in scientific research to enhance our understanding of kelp ecosystems; we also hope to develop cutting-edge tools for their conservation. New tools should prioritize ways to map and monitor kelp forests, engage community scientists, and generate sharable knowledge documents.

Partnerships and Collaboration:

It is vital that we forge alliances among academia, government, industry, communities, and NGOs. Initiatives such as the Kelp Forest Alliance can act as hubs, bringing together diverse stakeholders to achieve our common conservation goals and celebrate kelp forest ecosystems.

The Kelp Forest Challenge was created to illustrate *what needs to happen* to save our kelp forests as opposed to what is currently happening. Although it’s ambitious, the goal is achievable, but it will require advances in policy, funding, technical capacity, and societal interest.

The Kelp Forest Challenge was created to illustrate what needs to happen to save our kelp forests as opposed to what is currently happening. Although it's ambitious, the goal is achievable, but it will require advances in policy, funding, technical capacity, and reconnections to the sea.



PARTNERSHIPS AND COLLABORATION

Forge new and innovative partnerships among academia, government, industry, communities, and NGOs. Initiatives such as the Kelp Forest Alliance can act as hubs.



INCREASING CONNECTION

Create and grow people's connections to kelp forests through art, food, education, media, and community engagement.

CONSERVATION FINANCE

Explore innovative finance mechanisms and incentives to fund kelp conservation projects.



BUSINESS OPPORTUNITIES

Encourage businesses to engage in kelp conservation with innovative practices.

Promoting kelp-based products or services, sustainable aquaculture, or eco-tourism ventures.

RESEARCH AND DEVELOPMENT

Prioritize new research into kelp mapping, management tools, and autonomous technologies, to lower costs and increase scale of conservation.

ACTIVE RESTORATION

Develop and advance new active kelp restoration methods.

Seeding, pest-species removal, and leveraging technological advancements.

POLICY CHANGES

Create new and more powerful policies specific to kelp forest conservation from the local to the international level.

INDIGENOUS LAND AND SEA MANAGEMENT

The building of earnest, genuine partnerships, that recognise, empower, and collaborate with Indigenous communities to incorporate their values and conservation practices.

STRESSOR MANAGEMENT

Enable healthy kelp forests by creating healthy oceans and mitigating large scale pressures.



740 MILLION PEOPLE

US\$500 BILLION / YEAR

- Kelp forests are essential for healthy oceans, coastal communities, fisheries, economies, and marine biodiversity.
- Their benefits are connected to over 740 million people.
- Their economic potential is valued at least 500 billion USD per year.



4 MILLION HECTARES

The Kelp Forest Challenge aims to accelerate investment and action for kelp forest ecosystems by promoting the restoration and protection of 4 million hectares of kelp forests, globally, by 2040.



2040



CREATING A GLOBAL MOVEMENT

To save our kelp forests, we will need substantial investment, collaboration, and innovation across different sectors, countries, and philosophies; equitable and large-scale success for kelp forests will only be achieved by bringing together the diversity of solutions outlined here and creating a sustainable ocean for everyone.



Re-wilding the world became my full-time passion three decades ago, when I left my decades-long position as CEO of the Patagonia clothing company to join my soon-to-be husband Douglas Tompkins as we set about preserving land, later creating national parks and restoring ecosystems in a roadless area of Patagonia.

I now know that we can't begin to contemplate a landscape until we understand what's missing. And so, it became our mission to not only protect these special places but also to restore them.

We now know that in the last half-century, almost half of kelp forests have disappeared globally. It's an unseen tragedy. Fortunately, in the coastal waters of the southern tip of South America, there remain pockets of giant kelp, a fast-growing organism that, per square meter, captures ten times more carbon than tropical forests. These underwater forests are the foundation of marine communities on many shallow rocky coasts of the world's cold-water marine habitats. Teeming with life, they constitute one of the most diverse and productive ecosystems on the planet.

Protecting these ecosystems should be a global priority. Together, with many regional activists and local and international NGOs in Argentina's Tierra del Fuego Province, we celebrated the legislature's creation of Peninsula Mitre Natural Protected Area, a half-a-million acre area of coastal waters that is home to 30% of Argentina's kelp forest. This protection sets the path for the region to build a more robust nature-based economy based on ecotourism, wildlife watching, and artisan fisheries.

This is why I am energized by the prospect of protecting and restoring 4 million acres of kelp forest by 2040. At Patagonia, where I am still a board member, we have always been firmly rooted in the words of David Brower, "there is no business to be done on a dead planet." In the temperate and Arctic waters of our world, that means saving our kelp forests.

Blue businesses have a potentially huge role to play, as helping the kelp can be good for business and many businesses have the resources to make a big impact. It's a moral obligation that starts with sheer willpower.

I am convinced that businesses cannot do it alone--their leadership needs to seek advice and expertise about how to best support conservation initiatives and even play an active role in the projects themselves. So I applaud this roadmap for outlining how business and conservation will work together to achieve win-win scenarios. In the absence of these guidelines, it's difficult for us to imagine doing what's absolutely necessary. We will only meet the goals of the Kelp Forest Challenge and sustain our blue economy by creating a new approach to conservation, one that integrates the business community with activists and scientists. . We must be driven by the fact that not acting means abdicating our future.

Kris Tompkins
Conservationist and former Patagonia CEO





For thousands of years local communities have recognised the role and value of kelp forests for supporting fisheries and providing food and fertiliser.

Increasingly there is awareness and appreciation of kelp forests as assets of regional and global significance - for nutrient removal, carbon sequestration and as vital habitats for species of economic, social and cultural importance.

A key driver of this increased awareness, even as we better understand their many values, is the dramatic degradation and decline of these ecosystems in many parts of the world. It is a sad fact that so often we begin to value these ecosystems only as we lose them.

We are fortunate that there are many who are taking action to protect and restore these vital ecosystems. The Kelp Forest Alliance has grown into a global network of researchers, conservation agencies and organisations, users and beneficiaries who depend on healthy kelp forests, and ecosystem restorers who have developed the knowledge and approaches for kelp re-establishment and protection.

This Alliance has developed the Kelp Forest Challenge to motivate and drive the global effort to protect and restore kelp forests. A global restoration target of protecting and restoring four million hectares of kelp forests will help drive the effort necessary to reverse kelp decline.

I commend this roadmap and the Alliance members who have produced it to guide this work and meet this Challenge.

International targets and alliances have been critical in helping the world come together, share viewpoints and resources, and collaborate to address the big problems facing our society. With global issues, we need global solutions.

And the decline of our world's kelp forests is truly a global issue. These ecosystems cover over 1/3 of our world's coastlines, occur within 50 km of 740 M people, and have supported cultures and economies for thousands of years.

Today these marine ecosystems are under immense threats with 40-60% of kelps forests being degraded in the last 50 years and some regions seeing them nearly disappear in living memory. As kelp forests decline, we lose a bit of our connection to the sea, a sobering fact that is particularly true for the local communities and Indigenous populations that are most linked to these marine forests.

Luckily, there is a growing movement of people from different backgrounds, countries, and motivations coming together to stop these losses and restore the damages that were done. The Kelp Forest Alliance has planted the seeds of the global collaboration that is needed to save our kelp forests and outlined what is needed with the Kelp Forest Challenge. Collectively, they have targeted 4 M ha of kelp forests for protection and restoration by 2040.

This roadmap outlines the actions that are needed to achieve this goal and I hope that once again, the global community can come together and meet this challenge.

Razan Al Mubarak
President of IUCN





What if your favorite forest was clearcut of all its trees? There would be outrage. In fact, many places have outlawed such practices on land. However, since kelp forests are mostly underwater and out of sight, they rarely stimulate the outcry necessary for actions to protect or restore the lost forests.

What is at stake is more than just the loss of the large brown algae we call "kelp". We lose habitat for a diversity of other algae and animals - we lose nursery habitats and food for myriad fisheries species.

My subtidal research began in 1974 in the nearshore Gulf of Maine. There, kelp was only found in the shallows with urchins dominating the deeper waters. I thought this was the natural state, until a decade later I began studying a deep reef 130 km offshore. There, I saw a different world of abundant kelp, large predatory fish, but no sea urchins. Then, I started putting the pieces of the puzzle together. Healthy kelp forests were reliant on healthy food webs with abundant predators to limit sea urchin numbers. Such predators were lost from coastal Maine a long time ago.

To restore healthy kelp forests, we need healthy oceans and food webs. When the balance is restored, as was the case in the early 1990s when a sea urchin fishery extirpated urchins in Maine, USA, kelp forests returned remarkably quickly. But restoring kelp forests requires more than sea urchin fisheries, we must work to protect and restore the whole ecosystem. This challenge is only achievable with a strong scientific basis and robust collaboration between scientists and management.

Globally, kelp forests suffer from warming oceans and altered food webs. These threats mean that it is up to scientists, managers, and policy makers to first diagnose and when possible, mitigate the cause of kelp declines and to take steps to restore or protect the kelp forests of the future. This is the Kelp Forest Challenge we face and the focus of the Kelp Forest Alliance.

Professor Bob Steneck
University of Maine





Kelp forests (Orders Laminariales, Tilopteridales, and Fucales) are essential for healthy oceans, coastal communities, fisheries, economies, and marine biodiversity from the [subtropics to the polar regions](#). As nearly [740 million people](#) (~10% of the global population) live within 50 kilometres of a (Laminarian) kelp forest, these vital marine ecosystems provide many benefits not just for the oceans, but for people too. They are connected to countless [cultures and peoples](#) across the globe, and their potential global economic value is estimated to be at least [USD 500 billion per year](#). In addition, their environmental role is increasingly necessary in our warming world, as kelp forests grow incredibly quickly, play an important role in the marine carbon cycle, and help to sequester [CO₂](#) from the ocean and atmosphere. Due to their wide distribution and associated benefits, kelp forests are

one of the most important marine habitats on the planet. However, like many marine ecosystems, they are increasingly threatened by [warming seawater](#) temperatures, [habitat destruction](#), increased [pollution, sedimentation](#), overfishing of [marine food webs](#), [invasive species](#), and [combinations of these stressors](#). As a result, it is estimated that [40 to 60% of kelp forests](#) have been degraded within the last five decades, with mounting losses in recent years. Given the ever-growing threats to these crucial underwater ecosystems and increasing recognition of their importance, there is an emerging movement to [protect](#) and [restore](#) them.

ACKNOWLEDGEMENT OF COUNTRY

The Kelp Forest Alliance acknowledges the Gadigal people of the Eora Nation, the Traditional Custodians of the land where we are based, and we pay our respects to Elders both past and present. We also extend these respects to Indigenous people and organisations around the world. In addition to the explicit consideration stated in this document, we acknowledge that all conservation works involving the traditional lands and seas of Indigenous people must be co-developed, create space for leadership, and integrate Traditional Ecological Knowledge into the decision-making process. We kindly invite any person or group to contact us to provide comments on this document and/or develop new kelp conservation programs.

ACKNOWLEDGEMENT OF FUNDING





01 OVERVIEW OF KELP RESTORATION AND PROTECTION TO DATE

Kelp forest restoration began approximately 300 years ago in northern Japan, but it had a modern revival starting in California, The United States of America (USA) in the 1960s. The practice has since [spread across the globe](#) to most countries whose territorial waters contain kelp forests. Today, governments, natural resource agencies, and coastal communities around the world actively manage kelp forests and maintain a keen interest in protecting and restoring them as a [nature-based solution](#) to repair the world's marine ecosystems, and kelp forest restoration is expected to expand rapidly over the [next 10 years](#) as public interest and government capacity increase. There is also a great hope that, as restoration projects move beyond small-scale research programs and pilot projects to a more general, universal practice, the motivations

for restoration will also evolve. The expected aim of future restoration projects will be to repair or restore [entire ecosystems](#), their functioning, and the benefits they provide to coastal communities while also adapting those ecosystems to future environmental conditions. But as current efforts have only just begun to restore [past losses](#), and only [approximately 15,000](#) hectares of kelp forests — most of which are in South Korea — have been restored worldwide, society must scale up its efforts to regenerate lost kelp forest ecosystems and conserve remaining ones in order to generate meaningful social and ecological benefits.

While restoration is an important action to regenerate degraded ecosystems, it is also of paramount importance that we safeguard and protect existing kelp forest habitats. The first kelp forests to be included in marine reserves are in the USA and New Zealand. This commenced with the creation of [Matlahuayl State Marine Reserve](#) in California, USA in 1970, followed by [Cape Rodney-Okakari Point Marine Reserve](#) in New Zealand in

1975, and then the nationally recognised [Channel Islands National Marine Sanctuary](#) in California, USA in 1980. Since then, important reserves have been created in [South Africa](#), [Australia](#), the [United Kingdom](#) and [New Zealand](#). Notably however, marine protected areas like these are rarely created with the principal intent of preserving kelp forest ecosystems, and so very few management plans have focused explicitly on that preservation as a goal. For example, current estimates for the USA suggest that [less than 5%](#) of the country's kelp forests are currently under some form of marine protection.

With the signing of [Kunming-Montreal Global Biodiversity Framework](#) in December 2022, 198 countries have now committed to protecting at least 30% of their marine habitats and restoring at least an additional 30% of all degraded habitats by 2030, i.e., 30x30. But for these goals to be met for kelp ecosystem conservation, additional [public and private investment](#) for additional research and innovation will be required. Such support would bolster the technical

capacity for large-scale success as seen in [saltmarsh](#), [mangrove](#), and [seagrass](#) ecosystems.

With the exception of the [Bern Convention](#) — which covers most *Cystoseira* species — there are currently no international treaties or agreements for kelp forest restoration or protection. However, there has been significant growth in the broader field of kelp conservation. This includes initiatives such as the launch of [international](#) and regional collaborations or alliances in [California](#), [British Columbia](#), [the Pacific Northwest](#), and [Oregon](#); the first global evaluations of the [economic value](#) of kelp forests; [trans boundary](#) habitat assessments; the establishment of [businesses dedicated to restoring kelp](#); increased [public awareness](#) and [campaigns](#) to protect our kelp forests; and emergent [new funding](#) into kelp forest research, protection, and restoration.



The [Kelp Forest Challenge](#) is the first global kelp conservation initiative. Its primary aim is to expand the percentage of the world's kelp forests under protection and restoration while also increasing awareness and appreciation for these ecosystems.

Open to participation from any organisation, the Kelp Forest Challenge is led by the [Kelp Forest Alliance](#), a research-driven, non-profit entity that hosts a global community of over 500 people in 27 countries and 200 organisations dedicated to protecting and restoring kelp forests. The Challenge aligns with existing initiatives such as the Global Biodiversity Framework's "[30x30](#)" target and with local mandates for conservation. Approximately 250 people from non-governmental organisations (NGOs),

resource agencies, universities, research institutes, community groups and businesses met for extensive consultation over nine multi-national meetings to create the Kelp Forest Challenge, and its targets were designed based on existing estimates of the global kelp forest ecosystem (~10 M ha), decadal rates of decline (1-2% per year), the ability to scale up restoration technology and practices, the funding available for conservation, and the indicators as framed in the Kunming-Montreal Framework. The Kelp Forest Challenge was created to illustrate what **needs** to happen to save our kelp forests as opposed to what is currently happening. Although it's ambitious, the goal is achievable, but it will require advances in policy, funding, technical capacity, and societal interest.

The Kelp Forest Challenge is the first global kelp conservation initiative. Its primary aim is to expand the percentage of the world's kelp forests under protection and restoration while also increasing awareness and appreciation for these ecosystems.

The Kelp Forest Challenge is a call for everyone to contribute to the protection and restoration of four million hectares of kelp forest by 2040. Of this figure, three million hectares are for protection, and one million hectares are for restoration: numbers that roughly align with the 30x30 targets. Permissible activities within the Kelp Forest Challenge are established by the [IUCN typology on kelp forest restoration and protection](#) and include natural and artificial regeneration, protection and management of land and sea, and the management of invasive or problematic species.

The Kelp Forest Alliance is now calling upon society to commit to protecting and restoring kelp forests in their respective jurisdictions, in part through the Kelp Forest Challenge. Furthermore, the Kelp Forest Challenge also allows for pledges to be made for non-area-based activities, such as donors providing funding, professionals offering expertise (legal, media, accounting, fundraising, etc.), projects to raise awareness, or any other activity that enables the protection or restoration of kelp forests.



CREATING

The Kelp Forest Challenge



02

LAUNCH AND WORKSHOP

The Kelp Forest Challenge was launched online and in person at the [24th International Seaweed Symposium](#) on 19th February 2023 in Hobart, Australia. The workshop aimed to develop a shared strategy and roadmap to achieve the Challenge’s goals. Workshop attendees reviewed the structure of the Kelp Forest Challenge and heard presentations — from businesses, academia, and NGOs — about how they too could contribute. Participants also engaged in a series of breakout group discussions that supported the conceptualisation of this roadmap.

Discussion topics

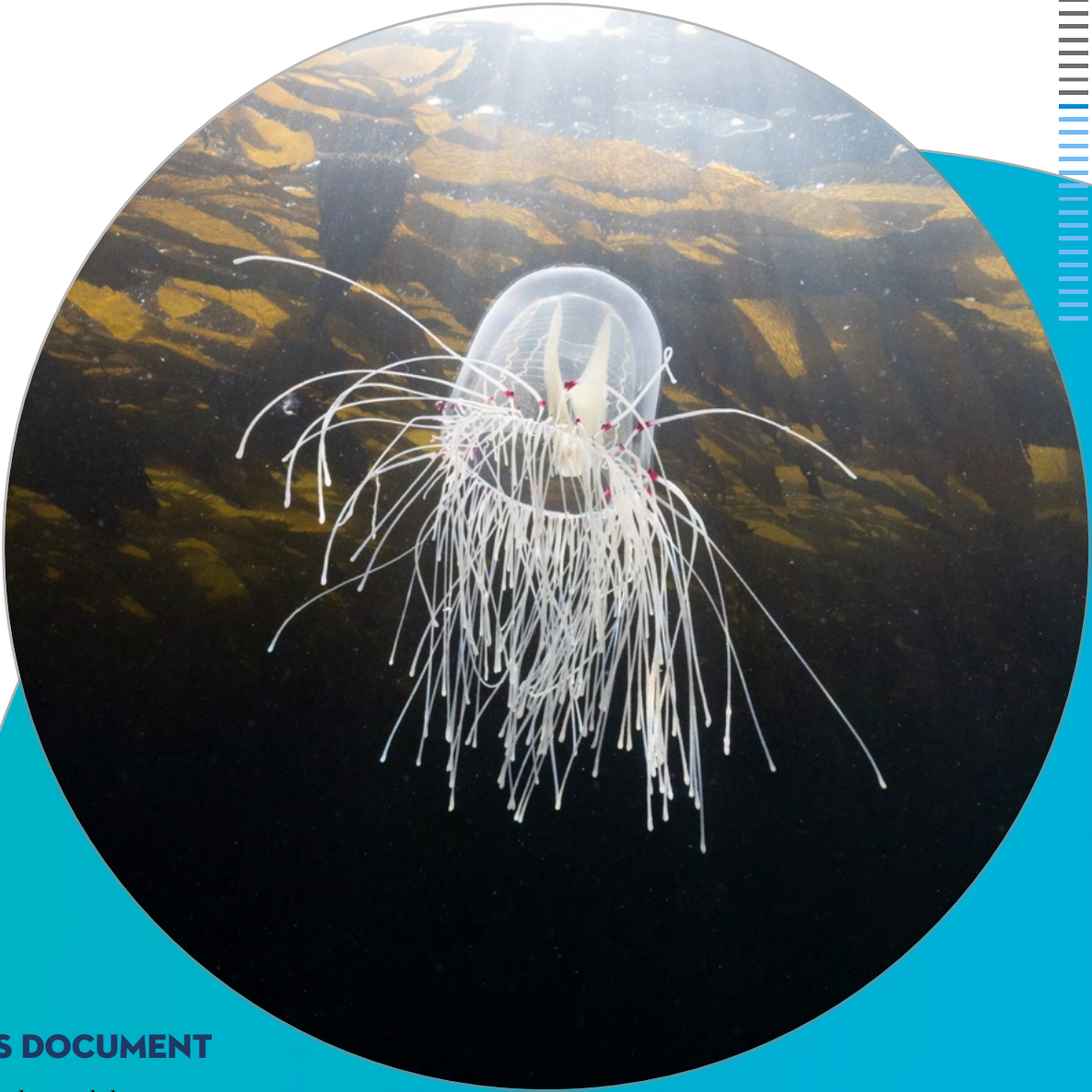
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|------------------------------------|---|
| ● Stressor Management | ● Indigenous Land and Sea Management |
| ● Active Restoration Methodologies | ● Business Opportunities |
| ● Conservation Finance | ● Art, Media, and Communication |
| ● Policy Changes | ● Research, Monitoring, and Technological Development |

These discussions focussed first on the broad ideas and concepts required to advance global kelp forest conservation, and participants then defined specific actions and identified the related actors needed to achieve those goals. Finally, they voted on the actions they thought would be most impactful and beneficial to kelp forest conservation (priority actions).

PURPOSE OF THIS DOCUMENT

This document summarises the workshop outputs and outlines the actions required to achieve the kelp forest protection and restoration targets outlined above. While it ascribes actions to particular sectors of society, it does not articulate particular governments or organisations, as the intention is to provide general advice to stakeholders worldwide, irrespective of language or context differences. Similarly, it does not provide a detailed action plan for each recommendation, because such plans often depend on local specificities and circumstances.

The actions detailed below are those recommended by workshop participants and include recommendations that may or may not be appropriate to the situation and capacity of different people and organisations; we encourage interested parties to seek out those recommendations that best suit their needs. Some recommendations are project specific, and not all recommendations are applicable to all projects, and above all, it is expected that all actions will be carried out within the principles of the Kelp Forest Challenge.



ROADMAP
For Achieving
The Kelp Forest
Challenge



03

STRESSOR MANAGEMENT

Kelp forests — whether natural, protected, or restored — require a healthy marine environment with low anthropogenic and biogenic stressors to thrive. Human-induced rising seawater temperatures are one of the foremost stressors threatening kelp forests, but overabundant herbivore populations, biodiversity loss, habitat destruction, commercial overharvesting, nutrient pollution, and toxin pollution (e.g., heavy metals) are other [stressors](#) threatening kelp forests. Any conservation effort that does not initially remove, mitigate, or address these stressors is [unlikely to succeed](#), but the achievement of suitable environmental conditions will require input and coordination from a diverse range of groups. As such, many of the decisions that need to be made and actions that need to be taken to achieve success are beyond the scope of restoration project teams. And as restoration projects may fail if the stressor returns, any attempts to ameliorate these stressors must be sustainable, so many of the recommendations given below are aimed at changing policy, addressing these issues upstream, and creating a healthier marine environment.

Climate action

Increased greenhouse gas emissions over recent decades have contributed unequivocally to warming seawater temperatures. As such, slowing and reducing these emissions is one of the most impactful things that can be done to protect existing kelp forests and enable the restoration of others. Recommendations for achieving global climate targets are beyond the scope of this document, but all projects and participants must consider their role in mitigating the impacts of a warming climate.

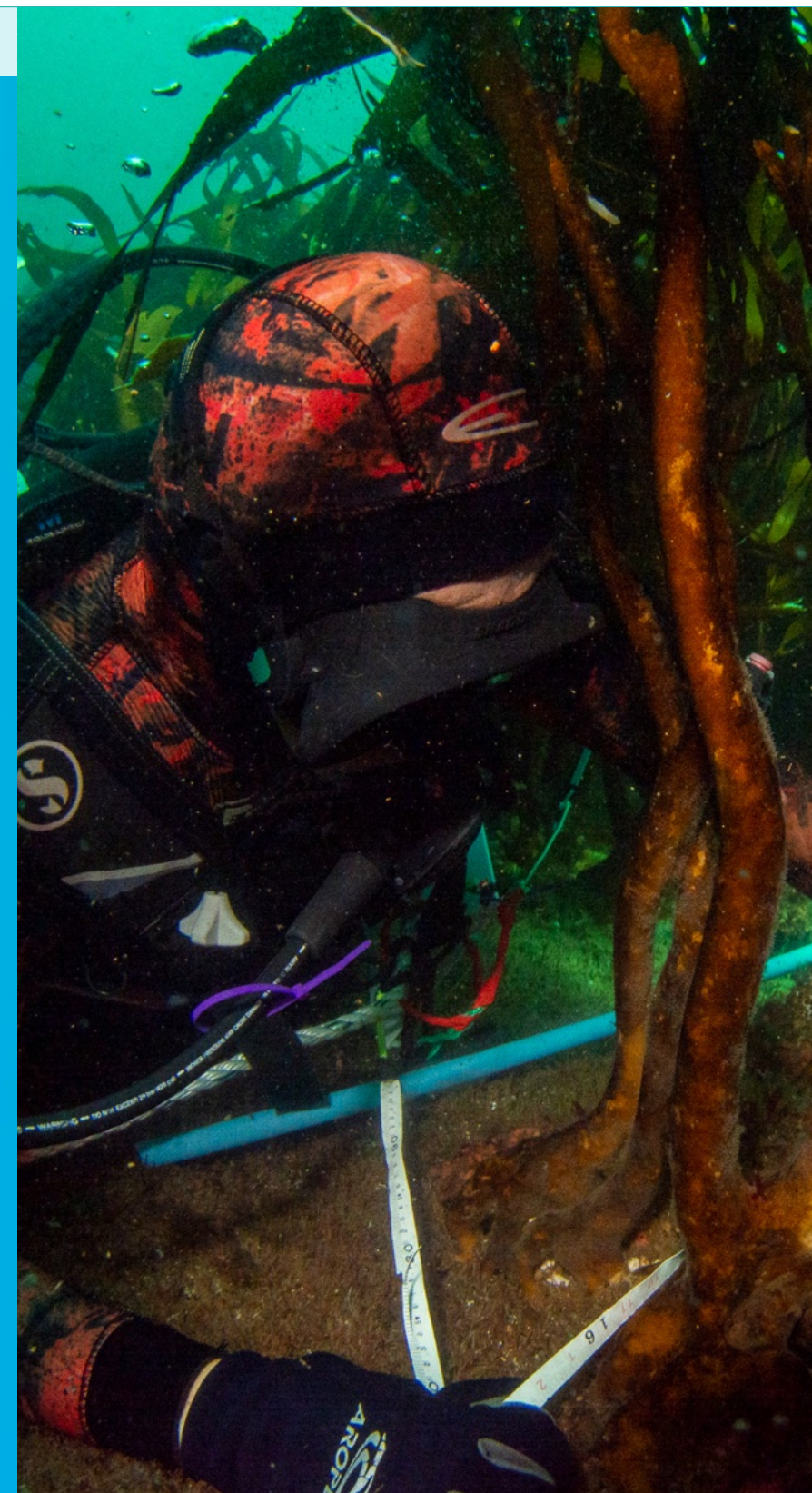
● **Local and international climate action should be taken to reduce greenhouse gas emissions. Healthy oceans depend on climate action, so all participants should mitigate their own climate footprints and lobby for policy solutions at all levels that reduce the threat of human-induced climate change.**

Upstream-stressor management

As coastal ecosystems, kelp forests are impacted by [land-based inputs](#), e.g., from rivers, streams, or outfalls, so, in impacted areas, these stressors need to be addressed at the source. If they are not permanently mitigated — ideally through broad coalitions or partnerships — there is a low probability that a kelp conservation project will be successful. Notably, these stressors can affect multiple aspects of coastal environments and are not specific to kelp forests.

Key recommendations:

- Researchers should identify where upstream stressors (sedimentation, urbanisation, nutrient pollution, toxic pollution) impede kelp conservation.
- [Working groups](#) should be created to bring together industry, resource managers, all levels of government, Indigenous communities, and marine scientists to develop management and abatement plans. Healthy kelp forests cannot exist without healthy oceans, and vice versa. Creating the necessary environmental conditions for healthy kelp forests and oceans requires policy plans informed by interdisciplinary teams.
- Government policies should be established to remedy stressors permanently and enable healthy marine ecosystems. Sustainable management of kelp forests requires implementing new policies to remediate and abate land-based stressors (nutrients, sedimentation, toxicity, etc.). These policies may involve stopping pollution at its source, improving water treatment, and enhancing land management to [reduce runoff](#). Complementary and comprehensive policy frameworks should be articulated at local, state, and federal levels.
- Ongoing polluters should be required to pay for their negative impacts on the marine environment, and these funds should be used to support conservation (e.g., [port charges](#), [plastic taxes](#), reparations (penalties) from [oil spills](#) ([Section 05](#)).
- Efforts to reduce stressors of kelp forests should tie-in with organisations and initiatives working with other ecosystems and environmental causes; as stressors affect multiple ecosystems, collaboration with organisations working in other ecosystems can amplify voices and reduce workloads.



Marine herbivore management

Overabundant populations of herbivores, particularly [sea urchins](#) but increasingly also [herbivorous fishes](#), are the most [common cause](#) of failed kelp recovery projects. The management of these populations through sea urchin removal, fisheries, culling, or by restoring balanced food webs and marine predator populations is a key element for the success of kelp conservation. If projects require herbivore management, fishers or community groups could be engaged to harvest or remove these targeted species.

Key recommendations:

- Robust food webs are integral for kelp conservation, and predator populations should be protected from depletion. The first priority should be to maintain predator populations so as to avoid the need for human intervention in managing herbivores such as sea urchins.
- From the outset of a project, it should be determined whether or not marine herbivores are overabundant and if managing them is necessary for kelp restoration success. If this is the case, projects should develop a sustainable management solution (e.g., fishery), restore the natural food web to control herbivores, or both.
- [Sea urchin fisheries](#), including [ranching](#) or removal programs, may be a useful tool for managing overabundant sea urchin populations.
 - ▶ Restoration projects should be co-developed with local Indigenous peoples, communities, and/or fishing organisations to develop sea urchin management plans.
 - ▶ Urchin fisheries should be considered as part of management plans to enable and benefit kelp conservation.
 - ▶ Governments can provide [subsidies](#) or incentives where necessary to grow sustainable urchin fisheries.
 - ▶ If and where fisheries are viable, the seafood industry should promote the concept of eating sustainably harvested or ranched sea urchins, and the available markets should be expanded.
 - Retail stores should promote [the sale of sea urchins](#).
 - The industry should communicate the benefits and sustainability of their product.
 - Chefs should be encouraged to create new [menus](#), cookbooks, [cooking shows](#), or other instructional documents for people to cook with sea urchins.
 - ▶ The same concepts could be applied for problematic herbivorous fishes.



SEEDING AND TRANSPLANTING FOR RESTORATION

04

If kelp populations do not naturally recover after the cause of the initial decline has been remediated or resolved, then seeding or transplanting will be required. Seeding is the introduction of the microscopic life stage of kelp into the seascape, while transplanting is the attaching of juvenile or adult kelp to the seafloor. By adding reproductive material back into the seascape, either of these approaches are key when kelp forests have been lost from large areas of coastline (10s-100s of kms). However, both seeding and transplanting are much more expensive and need more consideration than programmes that only involve removing herbivores.

Seeding approaches

While past projects have focused on transplanting, it is unlikely that this approach will be cost effective enough to restore ecologically meaningful areas of kelp forest. Seeding is currently an uncommon form of restoration, but it is potentially scalable, so there is a general need to move away from transplanting (with some exceptions) and think about investment in new seeding approaches. While work is emerging in this space — including through notable entities such as [Green Gravel](#) — further solutions are needed for a variety of environmental conditions, species, and sizes.

Key recommendations:

- **Prioritise research and development for new low-cost, non-destructive, scalable seeding methods. This work should involve aquaculturists, restorationists, engineers, biochemists, geneticists, microbiologists, and ecologists working together to create new solutions.**

Current approaches to developing new kelp restoration techniques are often restricted to ecologists or, in best-case scenarios, aquaculturists. However, there are multiple dimensions to this challenge, and the experts mentioned above should be integrated into the solution.
- **Direct seeding approaches consider the need to adapt current populations to future environmental conditions, i.e., [future proofing](#).**

Any successful seeding approach should seek to integrate the potential to select for stress- or thermally tolerant populations into its methodology.
- **If successful, the approach may be used by restoration practitioners but should not be monopolised.**

It is important that any technology developed is democratised for widespread use and application. This does not prevent its use in any for-profit industry, but it does ensure fair access for different groups around the world. Approaches which are developed with public funds should be available for use in public-good projects. Further, areas for restoration and protection should not be monopolised for private use.





Key recommendations:

Restoration projects and aquaculturists should collaborate to bring aquaculture methods to restoration.

- ▶ Working groups should be formed to facilitate collaboration.
- ▶ A knowledge document should be produced that instructs restoration projects on how to adopt the devised approaches.
- ▶ Local groups should consider how these approaches may be adopted for local species and environmental conditions.
- ▶ Efforts should prioritise the use of locally sourced kelp, ensure genetic diversity, and respect local [biosecurity](#) regulations.

Integration with kelp farming

Farming of kelp and seaweeds for food and materials is a well-developed industry in [Asia](#) and is emerging in [North America](#), [South America](#), [Australasia](#), and [Europe](#). And because, until the time of harvest, both kelp restoration and kelp/seaweed farming share the goal of growing kelp in the ocean at the desired size/area, there are likely learning opportunities and approaches that can be adopted from kelp farming and used in restoration. The Fisheries Resource Agency of Korea has already [integrated these approaches](#) (long lines, farmed kelp, genetic selection) into its restoration program; future projects around the world should consider how they can adopt and adapt farming techniques to enable restoration success.

At present, there are limited mechanisms for consistent communication and collaboration between kelp aquaculture industries and kelp forest conservation organisations: there is a gap between the knowledge of the people who cultivate kelp and the people who want to restore it. And, as many aquaculturists are interested in how their operations can support conservation efforts (“[restorative aquaculture](#)”) but are often unsure about how to support them, increased collaboration and communication between people working in marine conservation and kelp farming would benefit both parties. Moreover, in areas where seaweed species are being investigated for aquaculture production, there is often overlap in the species of interest and the research challenges (particularly in the nursery phase) in the realisation of both aquaculture production and kelp restoration goals.

One potential link between kelp farming and conservation is to use farming facilities to produce and safeguard reproductive material for conservation purposes.

Key recommendations:

Seed banks and culture facilities should be developed for species of conservation interest.

These stock centres should evaluate the genetic makeup of the kelp, aim to capture local genetic diversity, and be transparent about the origin of their stock.

Outside Asia, kelp used in restoration is usually sourced from wild populations, and gametophyte cultures are [created in-house](#) by restoration teams. This small-scale culturing is time intensive, can lack the quality controls found in professional culture facilities, is less cost effective, and is not as amenable to trait selection as dedicated culture facilities. Conversely, there are already kelp farming [groups](#) that provide seed stock for cultivated kelp species; these organisations could, therefore, create “seed stock” centres that are genetically diverse and underpinned by genomic knowledge. This could achieve two goals, the first of which would be to help restoration projects more easily source reproductive material for restoration. The second goal would be to create [genetically diverse biobanks](#) of kelp species. Depending on how they are funded, these centres and the cultivars they develop could operate either as for-profit or as not-for-profit entities.

Some projects, however, would prefer or are required to source their genetic stock from a local wild population. In those cases, it is likely that source stock centres and biobanks could support future kelp conservation efforts, particularly by allowing for the explicit consideration of kelp forest genetics in selecting populations for restoration, e.g., the identification of [thermally tolerant strains](#) of kelp for restoration in a warming ocean. As with [future-proofing](#) work, seed stockists need to consider the ethical, social, genetic, and ecological impacts of their work.



Integrate future-proofing techniques

The ocean has [warmed by ~1.3°C](#) over the last 100 years, and forecasts indicate that [further warming](#) will occur. Additionally, ocean currents have shifted, and the ocean layers have become increasingly stratified. Therefore, most ocean waters are warmer, and, in some areas, there are [fewer nutrients](#) available for kelp growth. In response to the combined effects of warming waters and reduced nutrients, some kelp populations have already disappeared, [contracted](#), or shifted, and these changes will continue. Kelp forest conservation must address these conditions and restore populations that are able to survive in the new and future environmental conditions. If there are no options to restore populations to a historic baseline, adaptation may consist of selective breeding of [warm-tolerant](#) populations, [genetically altering](#) populations to enhance tolerance, using [functionally similar](#) but non-native populations in restoration, or protecting new, non-native species in conservation. Each of these actions sits within a preference hierarchy from recover (more desirable) to revive, reinforce, and redefine (less desirable) and requires full consideration of the [ecological impacts, social licence, and technical feasibility](#).

Key recommendations:

● **Projects should evaluate the genetic diversity of their local populations, and this diversity should be promoted to enhance adaptive capacity and resilience in the face of known and unknown stressors.**

Greater genetic diversity has the potential to [increase the likelihood](#) that a kelp forest population will survive a stress event.

● **Research capacity should be enhanced to allow for greater understanding of the baseline genetic structure of wild populations as well as how to select and breed new strains of more tolerant kelp.**

Since the early 2000s, there have been at least [47 cultivars](#) of commercially harvested seaweed from five genera bred to enhance desired traits. These concepts may be applied to restoration, with specific consideration of how we can breed species of conservation interest to survive under changed abiotic (e.g., warmer temperatures) and biotic (e.g., greater herbivory) conditions.

● **Research is conducted in advance.**

As projects consider releasing these modified species into the natural environment, it is essential that advance research is conducted to determine the potential impact of these introductions. Before any large-scale introductions take place, projects will need to conduct strict pilot programs.

► If successful, these approaches should be integrated into the [cultivation centres](#).

Once the technology is developed, there will be a strategic opportunity to connect the future-proofing

techniques of kelp to cultivation centres; these centres may then be used to scale up production, which may then be used to scale up production of seed stock for restoration purposes.

► Working groups should be established to determine what policy regulations and community consultations will be required for these activities.

It is ultimately up to the local, regional, or national managers and their representative communities to determine which species to restore and where; any future-proofing techniques and their application in the ocean will require consultation with local communities. Similarly, there will be ethical considerations and specific requirements that need to be determined if permits are to be approved for these processes.

► A [decision tool](#) and [knowledge document](#) should be developed to determine when, if ever, a project should restore using a native, non-native, selected, modified, or natural source stock.

Because this is a relatively new field, any technical documents that help to guide future decisions about which species to restore and when will be extremely valuable for future restoration projects.

► These strains should not be proprietary. However, if they are, the cost barriers to using them for conservation purposes should be minimal.

Any new strains that are developed for conservation purposes, particularly those developed with public funding, should be readily available. They should not be monopolised, and costs for using them should be reasonable.



Achieve whole ecosystem restoration

Like other ecosystem restoration projects, kelp forest restoration should focus not only on restoring the foundation species, but on the [entire ecosystem](#) and its associated interrelated processes. However, most past restoration projects have focused only on [restoring the kelp](#) itself. Restoring the foundation kelp species may, in some instances, be [enough to allow](#) for an entire ecosystem to recover over time, as other marine algae and animals migrate into the kelp forest habitat, but this recovery is dependent on adequate source populations of those species being nearby and may not be possible if those species were lost with the kelp or have disappeared for other reasons (e.g., overharvesting of abalone or loss of sunflower sea stars due to disease). Therefore, future

projects should seek to obtain the highest possible restoration level ([Society of Ecological Restoration Principles 4 and 6](#)), and achieving this goal may require additional actions, such as stocking to restore kelp-associated species.

Key recommendations:

● **Projects should aim for full ecosystem restoration and should track overall biodiversity and ecosystem health alongside the health of the kelp itself.**

Restoration projects often fail to establish robust baselines or track associated biodiversity, ecosystem services, or other metrics of ecosystem health or societal benefit. In the future, projects should create clear baselines for these metrics and track them to help determine if kelp populations, other seaweed populations, associated biodiversity, and environmental quality are increasing. See the [Kelp Forest Alliance platform](#) for a global tracking site.

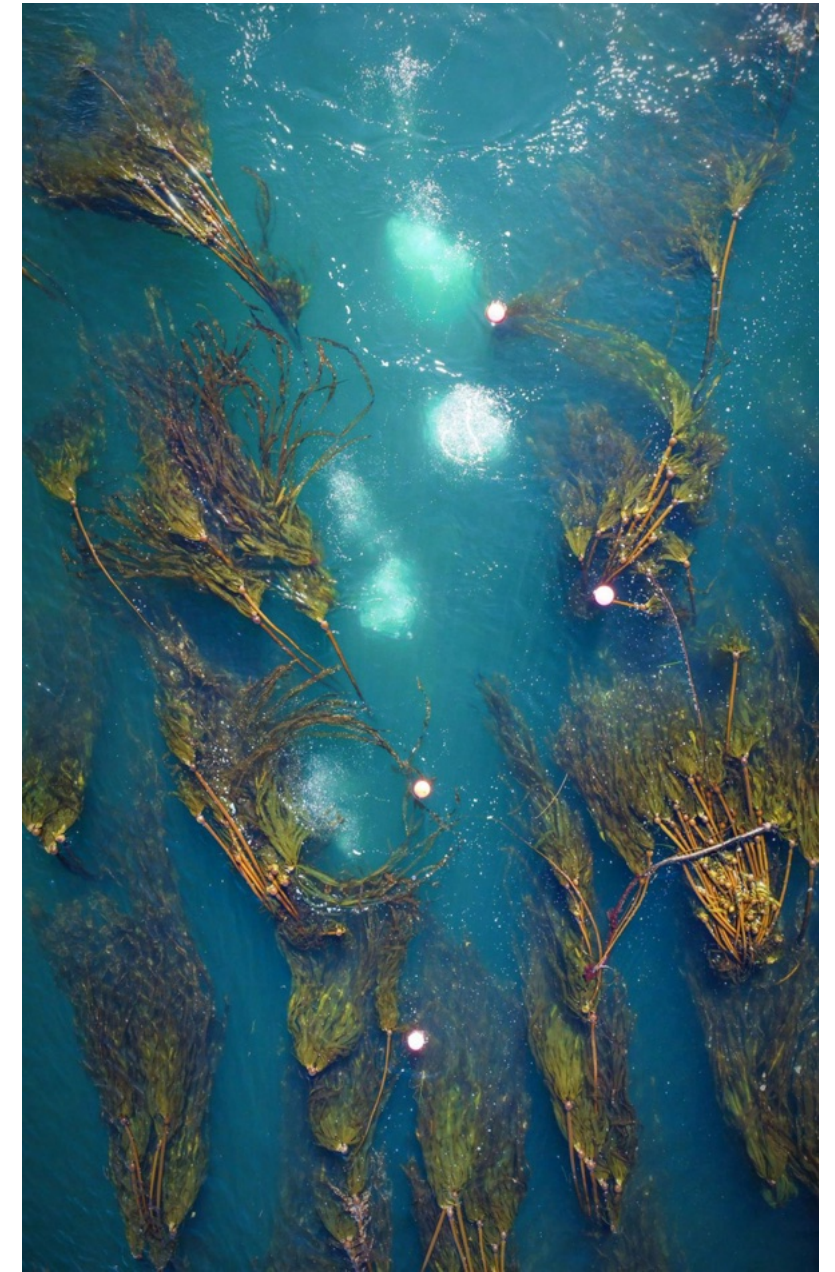
● **When unassisted ecosystem restoration is not possible, projects should determine how they can assist ecosystem recovery.**

● **If the biodiversity associated with kelp forests does not recover naturally, organisations should consider the technical requirements for breeding and stocking programs of desired species (e.g., fish, lobster, abalone, sea stars, other algal species).**



There are numerous examples of stocking programs for freshwater, terrestrial, and marine ecosystems around the world, including species such as salmon or [predator introductions](#). If predators can never re-establish, the site may be unsuitable for full ecosystem restoration.

Protection of existing species should be prioritised, but if re-stock is necessary, there are several requirements for these programs to expand. Namely, they need to develop the technical capacity to translocate or rear the animals in captivity, engage with the local community and obtain social licence to release these animals, conduct the necessary environmental impact assessments, and secure the necessary permits. When done without due care and consideration, re-introducing and restocking species can have detrimental impacts on ecosystem health. Therefore, developing the tools and resources to meet these requirements safely and ethically will require significant time and investment.





05 CONSERVATION FINANCE

Restoring one million hectares of kelp forests by 2040 (one of the goals of the Kelp Forest Challenge) will require significant financial input. Assuming a cost of USD \$40,000 per hectare for restoration, the restoration target of the Kelp Forest Challenge will cost approximately USD \$40 billion dollars over the next 17 years or USD \$2.4 billion per year. Conversely, the restoration of 1 million hectares could also create a [potential value](#) of USD \$111 billion per year.

Kelp forest research and conservation are heavily reliant on public funds from government agencies and private philanthropy and remain chronically [underfunded](#). While successfully achieving set goals will require significant public investment, there is an opportunity to lessen that burden with the use of private funds for conservation. While key concepts such as blue bonds, restoration or conservation credits, carbon credits, or payment for ecosystem services [are well known](#), there is still a lack of clarity about how they can be applied to kelp forest conservation. Increasing public awareness of kelp forests ([Section 06](#)) may significantly help to increase funding.

Key recommendations:

Governments should create funds for kelp restoration or protection projects. These funds could be a mix of public and private money.

Public funding will remain an important driver of kelp forest conservation, and governments should create funding pools to advance projects, e.g., \$10 million for restoration projects over 3 years. The funding burden may be distributed across levels of government as in Japan, where a fund is available with the condition that the regional government and a local management group provide contributions (typically, 50% and 25% respectively). Governments could also create programs where they match funds provided by entities such as NGOs, communities, or businesses.

Investment mechanisms for kelp conservation finance should be better investigated and better communicated to the research community and the general public.

There is significant interest in conservation finance to fund kelp protection and restoration projects. [These mechanisms](#) may take the form of restoration credits, kelp forest offsets, payment for ecosystem services, kelp carbon credits, blue bonds, or reduced rate loans. While these mechanisms exist for other ecosystems, the necessary steps required to create these finance mechanisms in kelp forests are poorly defined. Further work needs to be done to investigate how to apply finance mechanisms realistically to kelp forest conservation and then communicate the findings to those who are not experts in finance.

Researchers should continue to define and quantify the social and economic value of ecosystem services provided by kelp forests.

There are [emerging efforts](#) that put monetary value on the services provided by kelp forests, but they will require further refinement to be used in conservation-finance mechanisms. Specifically, the true economic activity that is locally generated by kelp forests each year should be determined.

Tools should be developed to help projects evaluate the ecosystem services and their economic value present in their kelp forest.

Putting an economic value on a kelp forest is a laborious process requiring high levels of expertise. For future projects that want to advertise the economic benefits of their own restoration efforts, it would be advantageous to have a tool or set of proxies to help groups make these approximations using locally relevant data.

Any investment mechanisms that are developed should directly benefit kelp forest conservation.

It is imperative that any conservation finance mechanism developed has material benefits for kelp forest conservation, and that its funding is not only directed to the financial institutions which manage the mechanism (e.g., brokers).

With any new development project, avoiding damage (i.e., conserving existing kelp forests) should be the first priority. However, if damage cannot be avoided, any organisation that damages the marine environment (see stressor management) should pay a penalty, which would then be used to finance kelp forest

conservation and/or restoration (among other marine conservation activities).

The [polluter pays model](#) should be linked to activities that adversely impact species (e.g., fisheries) or contribute to pollution or stressors entering coastal ecosystems (e.g., from illegal discharges, farms, or industrial practices). This system should not encourage these activities but rather, help to compensate for the damages incurred in public waters for private profits.

A marine conservation levy or tax (e.g., from boat trips, sales of marine equipment, or property tax) that supports marine conservation should be explored.

Similar to [the Pittman-Robertson Act](#) in the USA which funds land-based conservation by taxing outdoor and hunting equipment, countries can create marine conservation funds based on taxing a small percent of the sale of recreational marine equipment, from boats to fishing rods to SCUBA tanks. Additionally, governments could require tour operators to add a [levy or surcharge](#) to their excursions, and these funds could be invested in conservation, typically by marine management agencies.

Global funds for kelp forests should be created and should be easy for relevant organisations to access.

There is already a USD \$635 million global investment [fund for coral reef](#) restoration and conservation. A similar fund for kelp forests should be created by private and public organisations. Future projects should also lobby to access the generally available funds set aside in the Montreal Protocol to support conservation efforts.



Clear, supportive, and unambiguous government [policy](#) is required to guide, regulate, and enable kelp conservation. The level of government which is responsible for protecting or restoring kelp forests will vary by country and region, but different levels of government (local, regional, federal, [international](#)) should work together wherever possible. Setting policy that benefits kelp forests will also often benefit other terrestrial and marine ecosystems. Therefore, the below suggestions may include actors outside of the kelp forest conservation sector.

Local-regional policy

Locally, most permissions and regulations exist to limit harm to the marine environment. However, as kelp forests continue to decline, restorative actions are needed. There are currently few restoration-specific permits and regulation frameworks, which often means that the only available permitting pathways are not fit for purpose. In these instances, the permitting may be [uncoordinated](#), the regulatory barriers may be too large, and/or the process too [expensive](#) or time-consuming, thereby preventing and hindering effective kelp management (namely restoration). The emerging need for the active conservation approaches required to address rapidly emerging ecosystem disruptions will require more agile, responsive, and adaptive approaches to, and mechanics for, management and permitting.

Key recommendations:

The relevant regulatory body should create regional working groups to determine how the dual needs of protecting the ocean environment and restoration projects can be met.

Many existing policies and permitting strategies do not include kelp and are not designed to incorporate marine restoration. Policy solutions will likely vary by region, and one solution will not fit all. Therefore, regional groups with broad representation, including that from governments, should be created to design and inform new policies that protect the environment while enabling more responsive and adaptive restoration approaches.

After working groups are created, government agencies should redesign and streamline marine permitting and regulations to enable quicker reviews and decisions for restoration projects. This would allow conservation to be treated differently and more efficiently than industrial development / other activities that harm the marine environment.

In the future, there should be specific permitting processes for restoration. These processes should also allow for adaptive management and review if restoration activities need to be modified or enhanced to respond to restoration outcomes. These processes should be location specific, as rules and regulations vary by geography.

Case studies should be published that showcase restoration having been successfully integrated into regulatory frameworks to illustrate methodologies and highlight the potential for change. These lessons should be paired with attempts that have not worked but which still contain valuable information.

Different regions will create policy solutions with different methods, and each will work according to different timelines. As the first successful adjustments are made, detailed case studies can help to provide lessons for other regions and create a sense of possibility for these initiatives. Lessons learned from failed attempts are also valuable and can be paired with the successful case studies to help guide this process.



Regional-federal policy

[Regional or federal governments](#) are often responsible for protecting marine habitats, creating endangered species lists, and setting fisheries policies. Kelp forests are often overlooked in these policies and are thus under-protected, and/or the enabling conditions for their conservation are absent.

Key recommendations:

Governments should commit to protecting or sustainably managing 30% of kelp forest habitat in their jurisdiction by 2040 but ideally, by 2030 (in accordance with the Kunming-Montreal Framework).

Ideally, this 2030 goal should be met for kelp forests alongside those for other ecosystems. However, there may be a lag for kelp forests, because more information is needed about kelp forest distribution. This recommendation is contingent on accurate maps of kelp forest habitat ([Section 08](#)).

Kelp forests and their condition must be [explicitly considered](#) and included in national and regional marine management plans. These plans can direct actions to account for, manage, or protect kelp forests.

Governments should create [ecosystem recovery plans](#) for when kelp forests have declined.

Coordinated recovery plans can help accelerate activity and provide guidance for what needs to be done. These plans should be hosted by a relevant, high-level authority. The goals and actions contained within these plans should be informed by local and regional rights holders, stakeholders, and community. Progress should be tracked following the launch of the plan.

Kelp forests should be considered for regional or [federal conservation listings](#) if their populations have declined, and they meet the listing requirements.

Kelp forests have precipitously declined in some regions ([North Western Australia](#), [Northern California](#), [Tasmania](#)), yet they are rarely afforded status on endangered species lists. Including them on these lists can [mobilise action](#) and afford them funding for restoration. However, potential drawbacks to inclusion on such lists, such as limited community access and reduced ability to conduct scientific research, should also be considered.

Fisheries policies must be set sustainably to ensure healthy populations of top predators in kelp forest ecosystems.

The importance of healthy marine food webs for sustaining kelp forests cannot be overstated. Any active fishery of predators which facilitate healthy kelp forests should closely monitor its catch. Catch limits should not only consider what is sustainable or profitable; they should also consider how to ensure that the predator population is large enough to maintain balance in the ecosystem, i.e., ecosystem-based management.

International initiatives

Kelp forests are almost entirely absent from international agreements or initiatives. The Kelp Forest Challenge is a grassroots initiative and the first initiative aimed at global kelp forest conservation. For it to be successful, the Challenge requires international support. There is already substantial interest in marine restoration in the international community (see [UN Decade for Ecosystem Restoration](#) and [UN Decade of Ocean Science for Sustainable Development](#)), however that interest now needs to be expanded to include a focus on kelp forests.

Key recommendations:

International bodies should focus more of their resources on supporting kelp forest protection and restoration.

Research and support from international bodies have previously focused on tropical marine habitats such as coral reefs, mangroves, and seagrasses. There is now space for groups such as the International Union for the Conservation of Nature, United Nations Environment Programme, and Global Environment Facility to invest more resources into studying and protecting kelp forests.

Legislative bodies should incorporate kelp forests into existing treaties or create new treaties, laws, or agreements focused on restoring or protecting kelp forests.

The Kelp Forest Challenge presents the first global agenda for kelp conservation but is not a legally binding agreement. Legislative entities ([regional](#), national, international) should create legal agreements to protect and restore kelp ecosystems, in addition to other coastal ecosystems.

A Global Kelp Forest Day should be created to promote awareness of kelp forests and action to preserve them.

Official [days of recognition](#), passed by the United Nations General Assembly, are an effective tool to raise awareness for different causes. There are currently days of recognition for seagrass, coral reefs, and mangrove habitats, and there is an opportunity to provide the same recognition for kelp forests. The designation of this day should be done through a consultative process with the global kelp community to enable the selection of a meaningful date.





INDIGENOUS LAND AND SEA MANAGEMENT

Indigenous peoples (i.e., First Nations, Tribal, Aboriginal, Māori) around the world have inextricable ties to their [traditional lands and oceans](#), and many kelp conservation projects will occur on or in these lands and oceans. The treaty rights and custodianship of Indigenous peoples must be respected and followed. Furthermore, Indigenous peoples will hold unique [insights and perspectives](#) related to the management of the marine environment, and projects must incorporate their views and knowledge while acknowledging their [cultural intellectual property](#). Indigenous peoples are currently underrepresented in marine and kelp forest management initiatives, and this gap must be addressed; each of these actions is intended to increase the voice and influence of Indigenous peoples in the decision making of kelp conservation processes.

Key recommendations:

Projects should develop meaningful, long-term partnerships with Indigenous communities and co-develop conservation projects with those communities.

Conservation projects that occur on or in the traditional lands or seas of Indigenous Peoples should meaningfully engage with these communities, receive their approval, and integrate their views, values, and goals into the design of the conservation project. All co-development should be in line with the [CARE principles](#), including, but not limited to, free, prior, and informed consent.

A forum should be created and funded to allow Indigenous peoples to voice collectively their opinions, share traditional knowledge, and inform kelp conservation.

Indigenous voices are often the minority at scientific conferences or intergovernmental meetings. Creating a dedicated space for Indigenous peoples to share knowledge, lessons, and ideas can help spark new solutions and amplify shared views.

All partnerships, co-development, and activities should seek to engage an inclusive and representative group of people, including, but not limited to, women, youth, and elders.

Indigenous communities represent a variety of views, values, and interests. Projects working with these communities should seek to gain a representative understanding of those people and ensure the fair and balanced consideration of the views of Indigenous women, youth, and/or elders, all of whom are often underrepresented.

Projects should seek out and encourage the inclusion of relevant traditional knowledge that can be implemented during planning and preparations.

Projects should meaningfully collaborate with Indigenous peoples and incorporate their [views](#) from the outset. This collaboration may include topics such as the species being restored, other culturally important species connected to kelp forests, the individuals conducting the restoration, project outputs and goals, restoration location, and Indigenous uses for kelp including food and traditional weaving for housing and clothes.

Projects should take the time required to build trust and meaningful relationships with Indigenous communities before embarking on collaboration and/or knowledge-sharing opportunities.

Relationships are developed over time, and genuine trust requires dedicated input and meaningful engagement. Projects should establish connections with Indigenous communities well in advance of project deadlines to allow for the development of genuine relationships.

Project should remunerate their Indigenous partners.

Indigenous people's time is a valuable resource, and participants in conservation projects should be remunerated for their time and their costs covered for their attendance at meetings.

Promote and facilitate cultural awareness training and guidance for non-Indigenous stakeholders to lead to more productive and meaningful restoration collaborations with Indigenous peoples.

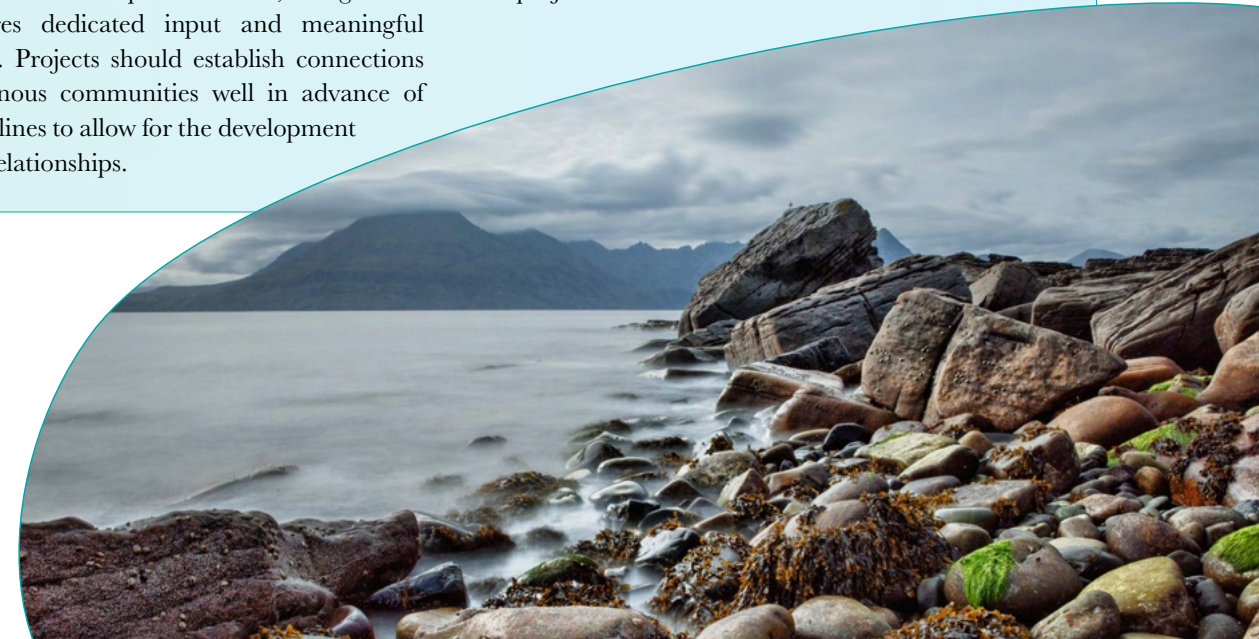
Help strengthen the capacity for Indigenous peoples to participate in, and directly manage and lead, projects. Marine restoration and conservation activities require new technical skills and capacity; projects should consider how to build these capacities in Indigenous communities so that they themselves may lead and direct projects, i.e., projects should [promote self-determination](#).

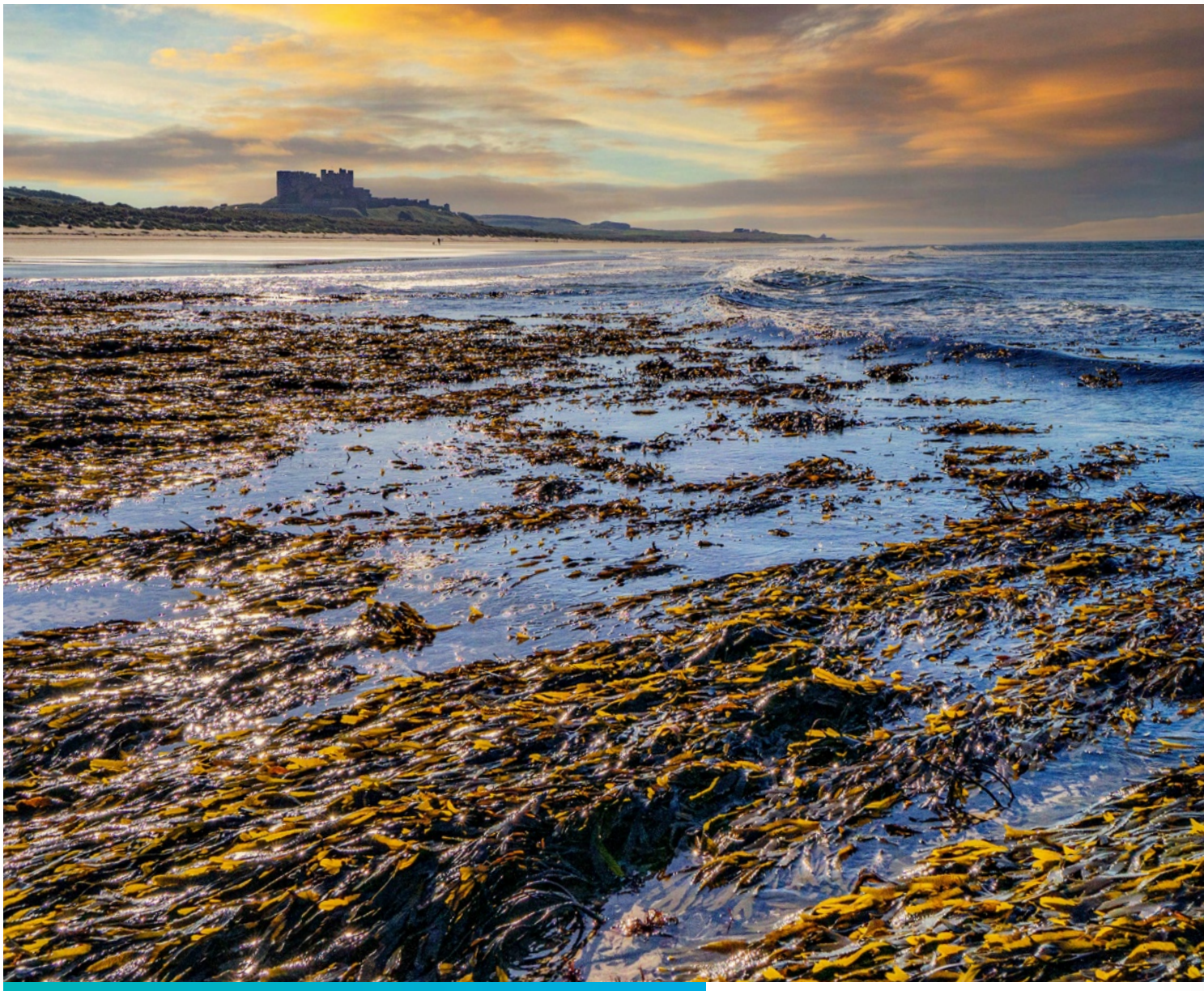
Projects and project partners should respect that views on what is desirable for marine management may differ between Indigenous peoples (noting point 3) and other parts of society.

There may be different value systems between Indigenous partners and other project partners, particularly if a traditional kelp species may be removed or replaced by a functionally similar but different kelp species. These differences need to be discussed and considered at the beginning of a project.

Scholarships and internships should be developed to grow the capacity for Indigenous young people to become more involved with conservation projects.

[Governments](#) and [universities](#) should continue to provide scholarships and opportunities to build capacity for Indigenous young people to gain new knowledge, build capacity, and lead conservation projects.





BUSINESS OPPORTUNITIES

To date, businesses have played a [limited role in kelp conservation efforts](#). This lack of engagement has existed despite many ocean businesses relying on healthy kelp forests and having a vested interest in protecting their marine environments. However, businesses often possess the skills or knowledge required for local conservation and are well placed to generate economically sustainable action plans. Bridging the gap between industry, science, and conservation can help inform and accelerate conservation projects, especially as failure to consider economic viability may prevent large-scale restoration from happening.

New opportunities

There are abundant opportunities to build [new industries](#) around kelp forest conservation and restoration; industries that could be tasked with doing the restoration work that is currently often done by NGOs, universities, or community groups. With restoration as their only or primary focus, any businesses that formed part of these industries could dedicate far more time and resources to restoration than the aforementioned groups normally can. However, these businesses will require support to get started.

Key recommendations:

Existing environmental businesses (e.g., consultants) should investigate how to expand their own businesses into marine restoration.

Many existing environmental consultant organisations already [perform terrestrial or intertidal](#) restoration. These groups could expand their scope to include subtidal restoration, such as kelp forests.

New businesses should be developed with a specific focus on marine restoration.

Given the specific nature of working underwater, there is also space to create dedicated marine restoration companies and consultancies specialising in these activities.

Provide subsidies and training for people and businesses in the industry.

Governments could provide subsidies and help [create training programs](#) to generate these shifts from existing business and/or help create entirely new businesses focused on restoring marine ecosystems. This help could include underwater training programs, such as a kelp forest or marine restoration diver certification, environmental monitoring courses, or fisheries management programs. Such programs should be developed with equity and representation.

New industries should be linked to a formal training process and to certification schemes such as tertiary courses on marine restoration or the Society for Ecological Restoration's [Certified Ecological Restoration Practitioner \(CERP\)](#) program.

It is important that these restoration industries follow emerging best practices in the field. The CERP program is the leading international program for providing practitioner certification and could be used to ensure quality across the new industry.

A funding stream should be identified, i.e., who is paying the business(es) to do the restoration.

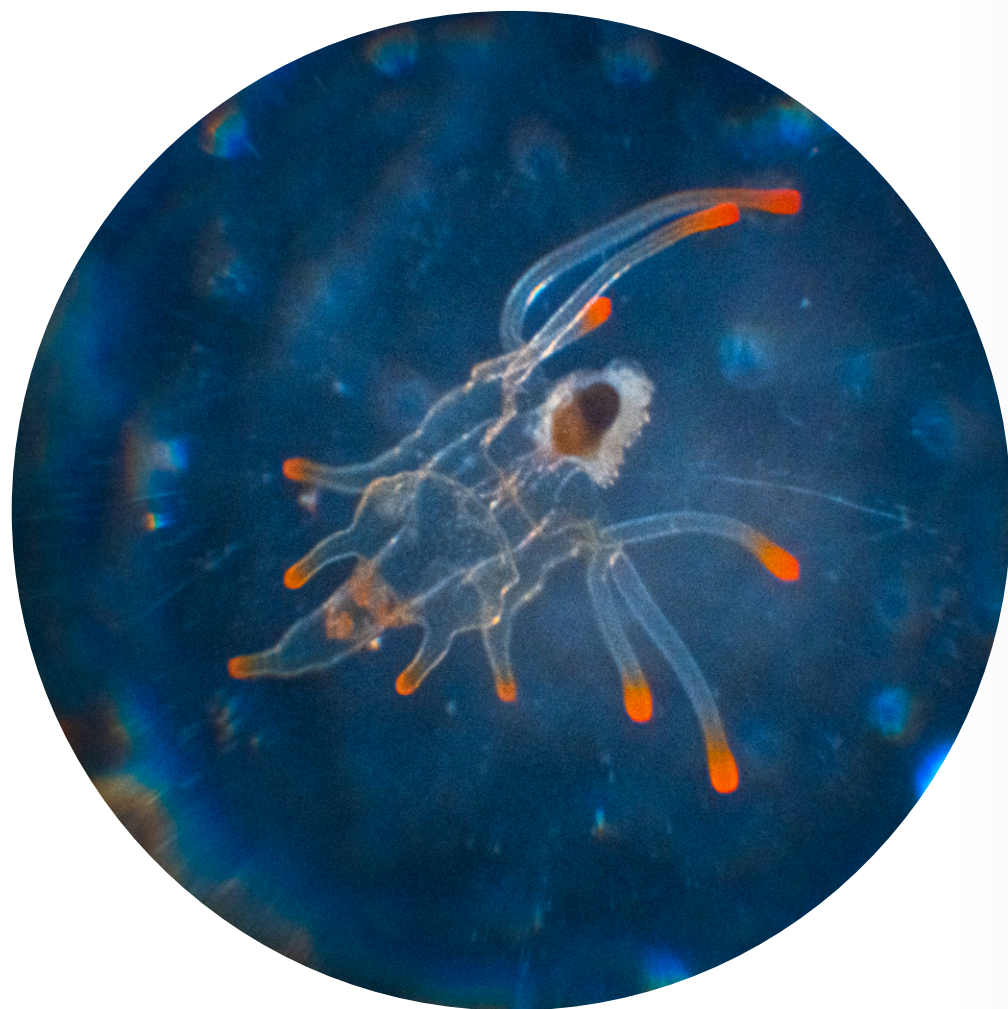
Funding is essential. If there is no organisation paying for restoration, the number of consulting companies in existence and with the required skills is irrelevant. Governments need to identify explicitly who is paying for these activities. Mandating that companies disclose their impact on nature (e.g., the [Taskforce on Nature-related Financial Disclosures](#)) will help determine who pays: if governments can assign responsibility for the impact, they can enforce compensation.





Existing opportunities

There are numerous businesses which rely on marine environments yet are not actively engaged in conservation, e.g., kelp aquaculture companies, kelp-based fisheries (abalone, sea urchins), dive companies, tour operators, seaweed harvesters, and seafood processors. These companies can be engaged to determine how they can benefit from, and assist in, kelp conservation.



Key recommendations:

- Aquaculture companies should be engaged to help provide seed stock for restoration ([Section 03](#)).
- Sea urchin fisheries should be engaged to help target urchin removals for maximum restoration benefits ([Section 02](#)).
- Other fisheries (e.g., abalone) which occur near kelp forests should also be engaged to help control sea urchin populations.
- Seafood processors and retailers must investigate their supply chains and ensure that they are not linked to habitat degradation, overexploitation, marine pollution, or other harmful practices.

Healthy kelp forests require healthy predator populations, and seafood operators must make sure that the seafood they are selling is kelp forest safe and isn't taken from a fishery that is overexploiting a keystone species in the kelp forest ecosystem.

Fisheries that depend on healthy kelp forests may be able and/or willing to invest in restoration efforts, as greater kelp forest coverage will equate to more sustainable fish stocks. Such groups could therefore fund or participate in restoration efforts with the expectation that they would benefit financially.

- Tour operators and dive shops should be engaged to increase tourism related to kelp forests and increase awareness about the link between healthy kelp and healthy oceans.

There is now a good opportunity for tourism companies to increase marketing and desirability for adventure or exploration packages in [kelp forests](#). While diving in kelp forests already exists, it is often afforded limited publicity. Expanding the marketing and promotion of kelp forest diving and the biodiversity associated with kelp forests can help increase appreciation for, and motivation to protect, these ecosystems.





INCREASING AWARENESS

Kelp forest ecosystems have a “public-relations problem”. They are not [well-known ecosystems](#), and even when they are known, they are often undervalued. Art, films, books, education, and other forms of communication could be used to increase awareness and understanding of kelp forest ecosystems and, over time, to nourish connection to them. As awareness increases, so too should support for greater protection and restoration, which should in turn result in increased funding and, ultimately, increased areas of protected and restored kelp forests.

Art

Art is a powerful communicator that helps people [connect to an ecosystem](#) at a more emotional level than can be achieved through text or data. An increasing number of artists are highlighting marine ecosystems and kelp forests in their work, however, society in general remains insufficiently aware of kelp forests, their needs, or the work being done to save them.

Key recommendations:

● **Artists should be integrated into kelp conservation projects to help them understand the science of kelp forests and communicate that knowledge to non-experts.**

New restoration and conservation projects can offer exciting opportunities for engagement and [collaboration with artists](#), not only to communicate the beauty of kelp forests and the experience of being in them but also to help people understand the projects themselves, their desired impacts, and the restoration and conservation work being carried out. Participating artists could be supported by additional grants or included in project funding budgets and applications.

● **Kelp experts should engage with filmmakers to tell the story of kelp forest restoration and conservation.**

[Short](#) or [feature-length](#) films may be especially helpful in emotionally connecting people to kelp forests; even films where kelp forests are just part of the scenery, rather than the key focus, e.g., [My Octopus Teacher](#) and Finding Nemo 2, can be useful. Scientists and the leaders of kelp projects should work with filmmakers to create films and ensure they are scientifically accurate.

Education

Education can teach people about the intricacies of kelp forests and help the public appreciate their significance, as well as the threats they face. Already successful in several countries, ocean-literacy campaigns can be expanded to focus on kelp forests, and educational modules could be developed for local regions based on the ecology of the area to help inform people about the marine environment.

Key recommendations:

● **Lessons about kelp forest ecology, conservation, and Traditional Ecological Knowledge should be integrated into school curricula.**

Existing ocean literacy campaigns could be expanded to teach children who live in regions with kelp forests about these ecosystems and their connections to society. These programs can be voluntary, or they can be incorporated into the official curriculum, but where appropriate, they should integrate Traditional and Indigenous knowledge.

● **Classroom kelp aquaculture modules where children grow kelp or other seaweeds should be created.**

Similar to having a classroom pet, classrooms could have shared aquaculture tanks where children grow [kelp forests in small aquariums](#) and watch them progress from the microscopic to the macroscopic stage. There is even an opportunity to have these school-grown kelps used in restoration efforts and [show schoolchildren](#) how their work is contributing to real-world conservation.

● **Create educational materials that may be easily shared.**

Adding to the [existing educational](#) content for kelp forest ecosystems would help people around the world learn about local and global kelp forests. Ideally, this content would be free and easy-to-access material that other educators could use to spread the reach of the work further.

● **Indigenous people, tourism companies, science centres, local councils, and/or other operators should create experiential programs for children and adults to learn more about kelp forests.**

In addition to formal education programs, informal programs can be created where adults and children are able to explore intertidal regions or go snorkelling, and then talk about kelp forests.





INCREASING AWARENESS

Kelp forests and the marine environment have a connection to many aspects of society; festivals which bring together art, science, food, music, and everyday people helps to highlight these connections. There have already been several successful [seaweed festivals](#) around the world, and there is considerable opportunity to expand the idea to new locations.





RESEARCH, MONITORING, AND TECHNOLOGICAL DEVELOPMENT

Research, development, and environmental monitoring will continue to be vital in the provision of important information to guide kelp forest conservation; researchers need to develop new tools, improve existing tools, and answer important scientific questions. It is important to continue to make academic research accessible to the public and decision-makers and also to expand opportunities for collaboration with Indigenous peoples to allow for more holistic perspectives and approaches.



Emerging technologies

New technologies which can assist in the restoration, management, and monitoring of kelp forests are becoming increasingly available. However, many require additional research and development to realise their potential.

Key recommendations:

Remote and autonomous technologies that expedite and lower the cost of monitoring, reporting, and managing problematic species should be created.

Mapping kelp forests, monitoring kelp forest ecosystems, seeding (see [Section 03](#)), and removing pest species from kelp forests are laborious activities which often require SCUBA divers, freedivers, or on-water personnel. As a result, [they are often high cost](#) and can only take place at smaller spatial scales. The development of autonomous or semi-autonomous approaches such as high-resolution [aerial mapping](#), [multibeam sonar](#), [automated underwater vehicles](#), [AI image and video](#) detection software (for quantifying biomass, biodiversity, and kelp cover), and efficient environmental monitoring can help scale up these activities and extend them beyond the depth limit of human divers.

Such autonomous technologies could also be developed to harvest or manage targeted species such as sea urchins or invasive seaweeds.

Environmental DNA (eDNA) sampling that could be used to measure biodiversity should be investigated.

Environmental DNA sampling protocols could be used to determine biodiversity information about [kelp forests](#) and [surrounding habitats](#). eDNA may provide a [scalable approach](#) for presence-absence biodiversity monitoring, particularly if it can assess relative abundance; further research is required to determine if it is a complement or substitute for traditional biodiversity monitoring.

Community or citizen science programs

Historically, scientists have conducted the majority of biodiversity surveys, but there are now many established volunteer-led programs which [enlist non-scientists](#) in ecological research. These projects often involve a level of scientific training and rigour and have been historically termed “citizen science”, although some projects now prefer “community science”, as it does not infer citizenship. Herein, we use both terms but recognise that definitions may vary.

Questions remain about data quality controls for the information that is collected and with regard to the scalability of volunteer-scientist programs but, [if used correctly](#), these programs can be a useful tool for [environmental monitoring](#) or, in regulated scenarios, [marine management](#). Additionally, involving community or citizen scientists builds [awareness of, and connection to](#), conservation work, and it could also help find evidence beyond the reach of the scientific community.



Key recommendations:

Training programs, technical guidance documents, and certification standards for community or citizen scientists should be developed to ensure consistent abilities across projects (see [Reef Life Survey](#), [Reef Check Foundation](#), [Hidden Deserts](#)).

Community and citizen scientists should be trained by instructional documents and in-water instruction. International certification specialties by dive trainers such as [PADI](#) and [NAUI](#) can ensure tuition and safety for research and restoration programs.

Well-trained community scientists should be engaged in the research and restoration of sites of interest.

Community and citizen scientists can be valuable contributors in the [monitoring](#) of kelp forest habitats and [restoration efforts](#), and community and citizen science programs could be integrated within larger collaborative efforts including those involving academia, government, and industry. [The Reef Life Survey](#) and the [Giant Giant Kelp Restoration Project](#) are two such examples of successful initiatives; success stories like these can be used as inspiration for replicating similar efforts across the globe or expanding the size of operations for comparable programmes.

It should be ensured that the data being collected via scientific surveys all adheres to the same standards and frameworks (see [data standards](#)).

Any community or citizen science programmes that are being conducted should adhere to the same standards and frameworks as other data collection protocols so as to be compatible with larger biodiversity and environmental monitoring programs.

Decision-making tools

Kelp forest conservation and restoration should strive to make the best decisions with the available information. There should also be a desire to get the highest conservation return for the lowest investment. Developing [decision-making tools](#) which can be used by multiple conservation projects can save considerable costs, both across the field and for individual projects.



Key recommendations:

Researchers should develop free tools to assist with site selection and prioritisation for kelp forest conservation and restoration projects.

Deciding when and where to carry out restoration is a considerable task that requires additional resources. Therefore, the creation of open access site-selection and prioritisation tools will help reduce the resource burden on individual organisations. These tools should consider the ecological, cultural, economic, and political restraints of selecting sites for kelp forest conservation.

Researchers should develop a standardised monitoring and reporting framework to unify data collection across the field.

Data collection is at the core of research and environmental management. Robust data collection practices can ensure that work is [FAIR](#), i.e., data which meets the principles of findability, accessibility, interoperability, and reusability. The creation of a standardised [kelp forest monitoring](#) and reporting framework will help increase data sharing, improve the quality of compiled databases, allow for large-scale synthesis, track the progress of the Kelp Forest Challenge and other conservation interventions, and ensure quality control in data collection. This process also incentivises groups to report on failures, which often contain valuable information. The [Kelp Forest Alliance](#) provides a global data platform, but regional data platforms may also be developed for specific needs.

Basic maps detailing the current and past extent of local and global kelp forests should be published.

There is still considerable uncertainty about the current and past extent, location, and condition of kelp forest habitats across the globe. These information gaps prevent researchers from accurately assessing progress towards targets, understanding baselines for conservation, and effectively managing these ecosystems, so filling them in should be a top priority.





PARTNERSHIPS AND THE KELP FOREST ALLIANCE HUB

The achievement and/or realisation of the suggestions outlined in this road map will require considerable resources, coordination, and intellectual contribution. No single group can achieve this work alone. It is therefore vital that the kelp forest community and relevant organisations work together to coordinate approaches and develop comprehensive packages to address these issues.

Many of these issues can be addressed by coordinated working groups. These working groups should be open to anyone, and their outputs should be freely available to the public. The Kelp Forest Alliance can help coordinate working groups, but other groups can also initiate similar efforts. It is important that working groups have strong leadership and participation by their members and that all participants retain ownership of their ideas and contributions.

The following working groups were identified during the initial February 2023 workshop, and we suggest that their development is prioritised.

- ▶ Practices for combining aquaculture and restoration
- ▶ Collaboration and co-development with Indigenous peoples
- ▶ Techniques and considerations for future-proofing kelp conservation
- ▶ Approaches and targets for furoid conservation
- ▶ A monitoring and reporting framework for ecosystem health and benefits
- ▶ Defining success in kelp restoration
- ▶ Sea urchin management
- ▶ Citizen scientists in kelp forest conservation

New ideas for working groups may be developed internally or circulated through the Kelp Forest Alliance network.

CONCLUSION

Kelp forests — one of the ocean’s most essential ecosystems — are at a tipping point. They face numerous threats, including climate change, overfishing, and pollution, and at the same time, they are under-appreciated and underfunded. This roadmap has outlined actions and strategies to increase awareness, funding, and capacity for kelp forest conservation with suggestions that range from traditional conservation approaches to innovative technologies and collaborations with businesses, artists, and citizen scientists. By implementing these strategies and prioritising research and development

of new technologies, we can increase awareness, understanding, and support for kelp forest conservation and restoration, ultimately leading to increased areas of protected and restored kelp forests. It will take a collective effort from individuals, organisations, and governments to meet the goals contained within the Kelp Forest Challenge and ensure the long-term health and survival of these crucial ecosystems, so connecting these efforts and spurring new actions and collaborations will remain key to protecting and restoring four million hectares of kelp forests by 2040.

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