RECOVERING JAPAN'S SEA FORESTS, *'MOBA'*

PATHWAY AND GUIDELINE TO ACCELERATE THE RESTORATION AND CONSERVATION EFFORTS

MOBILE SEA OTTERS 2022

photo credit: Yudai Tsubone

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Preface

From the 1950s, Japan experienced a period of high economic growth after World War II. This period was characterized by land reclamation for the construction of factories in the coastal area known as the Pacific Belt, which extends from Tokyo Bay, Ise Bay, Osaka Bay, the Seto Inland Sea, and Hakata Bay in Kyushu. This resulted in the destruction of *Moba* (seaweed and seagrass beds) in shallow waters (*1). Once the factories were in operation, factory effluent was discharged into the sea. Factory workers were concentrated in the Pacific Belt, the population increased, and sewage from the cities were also discharged into the sea. In the 1970s, the Fisheries Agency's Nansei Regional Fisheries Research Laboratory pointed out that the decline of seaweed beds led to a decline in fisheries resources (*2). Around the time of growing environmental issues, the Environment Agency was established and began to take measures to address the problem of eutrophication and control landfill through the regulation of factory effluent and the treatment of urban sewage, particularly in the Seto Inland Sea and landfill (*1). Efforts by fishers also cannot be overlooked although it was not until 1985 that fishers of the Hinase Fishery Cooperative in the Seto Inland Sea recognised that the decline in seagrass beds was leading to a decline in fish catches and began an initiative to sow eelgrass seeds (*3). Since then, such activities, mainly targeting eelgrass, have been carried out in many parts of Japan by fishers and citizens.

On the other hand, the disappearance of *Moba*, which used to be distributed in the past, and the continuation of poor growth conditions have been reported from various parts of Japan (*4).

The Fisheries Agency has also begun to work on the regeneration of seaweed beds as part of its "multifunctional fisheries and fishing village" project, with governmental grants which began in 2013 (*5). However, there are a variety of aspects to this project, including the creation of a rich natural environment that includes the regeneration of *Moba*, the provision of safety and security in the sea, and the provision of relaxing spaces (*6). These projects will be granted for a maximum of 3 years which is the duration of governmental aid. Therefore, it is difficult to carry out seaweed and seagrass bed restoration in all coasts. This is where the efforts of fishers and volunteers to restore seaweed seagrass beds become important. The strengths of this bottom-up approach are 1) continuity, 2) flexibility, 3) cross-sectionality and 4) solidarity. In other words, the horizontal linkage of information sharing and mutual exchange between local initiatives, the vertical linkage of continuity, and the ability to change the way we deal with situations.

Persistent poor *Moba* growth occurs not only in Japan, but all around the world. *Moba* fix carbon dioxide, turn it into organic matter and store it in the sea. Signs of global warming are appearing around the world in the form of extreme weather events. *Moba* also provide an essential base for biodiversity and fisheries organisms. We cannot succeed in building a sustainable society without the regeneration of seagrass and seaweed beds around the world.

To carry out such bottom-up efforts, it is important to have a comprehensive understanding of the status of rocky shore reefs, countermeasure methods, and activities being undertaken in bottom-up. This report focuses on seaweed beds degraded by overgrazing of sea urchins. In this sense, we believe that this Strategy Paper summarises Japan's experience and will provide important information for the activities of organisations working on seaweed bed restoration not only in Japan but also around the world.

Teruhisa Komatsu, Executive Director, Mobile Sea Otters

小松 輝久

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Executive Summary

Seaweed and seagrass beds called by the Japanese term "*Moba"* in this report are an invaluable component of the planet which have recently been highlighted for their importance in supporting marine biodiversity and potential in climate mitigation as blue carbon pointed out by UNEP in 2009 (UNEP, 2009). However, *Moba* are decreasing, just when we need it most to fight the climate crisis as well as preserve the ocean's biodiversity and support the livelihoods dependent on it (Chapter 1.1.1, 1.1.2).

Scientifically, *Moba* are beginning to be accepted as a valid source of carbon storage. The value they provide for society is immeasurable, however, ongoing efforts to quantify their value reveal that kelp forests generate an estimated €515 billion globally per year in economic benefits (*7). Within Japan, *Moba* have played a crucial role in supporting the diversity of food culture. From the perspective of *Moba* conservation, the tightknit fishing communities and Fisheries Act serve as both a promoter of restoration as well as barrier for non-fisheries-related individuals to join in on the conservation initiatives (Chapter 1.2.1).

An overview of several hundred current initiatives around the nation by the Fisheries Agency reveal that conservation efforts are frequent and numerous in Japan, although continuation and consistency remain a challenge (Chapter 2.1). Most efforts are led by fishers and fishery cooperatives and the involvement of other stakeholders such as diving shops, universities, NPOs etc., show that a diverse group of people are also joining *Moba* restoration. Presently, the literature surrounding these efforts have only been published in Japanese, making it hard for foreign actors to learn from shared experiences and methods.

The collection of experiences has laid out common methods of *Moba* restoration, identifying sea urchins and herbivorous fish as main culprits of its destruction. These initiatives point to measures such as sea urchin and herbivorous fish removal, creating barriers between seaweed and harmful organisms, supplying seaweed seeds etc. to restore these sea forests (Chapter 2.1). There are also new innovations such as the sea urchin vacuum, undergoing research and development to make this process more efficient (Chapter 2.4.1).

Finally, this report cumulates the above knowledge and experience to point to pathways to accelerate *Moba* restoration and conservation efforts. The key challenges (Chapter 3.1.1) are firstly, the importance of establishing collaborative relationships with stakeholders such as fishers, diving shops, volunteers, corporations to create initiatives appropriate with the local network. Secondly, securing sufficient, sustainable, and long-term funding is a key challenge in Japan that needs to be obtained for a successful project which in turn would sustain a robust organisation able to tackle long-term finance and legal matters. Lastly, increasing awareness on the importance of *Moba* is also necessary in pushing forward this effort with a diverse group of stakeholders. Opportunities in the *Moba* restoration projects in Japan (Chapter 3.1.2) point to a rise in interest in Blue Carbon, especially its offset credits, better utilisation of culled animals and acceleration of network and collaboration.

Introduction

"*Moba*" the Japanese term employed in in this report is used to describe marine plants that form sea forests under the sea. Hereafter, we will use *Moba* or sea forest to refer to submerged aquatic vegetation or macrophyte in the sea.

Recently *Moba* have been rapidly decreasing in many regions around the globe. The consequences are many and severe, with not only biodiversity of marine life becoming depleted and seriously damaging coastal fisheries but also releasing CO_2 accumulated in Moba to the atmosphere. When the ability of the Moba in sequestering carbon dioxide is lost, it accelerates the climate crisis whose impacts are already threatening safety and livelihoods of all of us today. There are many initiatives across Japan over decades that have worked to protect *Moba*. Yet, more immediate, powerful, and collective actions are required to tackle this problem. The general awareness of the importance of *Moba* remains low, and this must also be changed to engage diverse stakeholders into this movement.

Mobile Sea Otters (MSO), a non-profit organisation, was established in 2019 to tackle *Isoyake*, the decline of *Moba* in Japan. Through various activities across the nation, we have faced a lot of challenges, found solutions, and learnt many lessons and hints for further development for the future. MSO was commissioned to write this report to summarise and share the large accumulation of information publicly available in Japan as well as to make proposals to accelerate collective efforts to restore the invaluable *Moba* in our seas.

Goals and Objectives

This paper was written with the ambitious goal to propose new and effective directions and call for action to accelerate collaborative efforts to restore *Moba* in Japan.

The objectives are as follows:

- To serve as the one-stop summary of information around *Moba* from both scientific and social aspects, looking at existing initiatives and effective restoration methods.
- To introduce MSO's own activities and challenges faced to share insights.
- And based on the above, to identify key opportunities to develop efforts to restore and regenerate *Moba* in Japan.

Target audience

This paper is open to the public - mainly non-scientists, with the hope that it will help our fellow citizens and activists working to restore *Moba* in Japan and abroad. Particularly, the English version of is created in order to share the wealth of insights accumulated in Japan, most of which are only available in Japanese, with our readers overseas. We also hope to inform existing and potential partners and funders to join and support the work to restore and regenerate *Moba* in Japan - where collaboration is still limited, and funding is scarce for such important projects.

Report structure

This strategy paper consists of three main parts as follows

1. Context: the first chapter will address basic information and circumstances from scientific and social aspects in Japan.
2. Introduction of current initiatives and effective methods for Moba restoration and regeneration: the second chapter will summarise effective methods to restore seaweed beds, both already in place and innovations which are anticipated to support future efforts to restore and regenerate Moba.

We will also introduce some of the key initiatives which have been active across Japan, as well as the case study of MSO's own projects.

3. Proposals for the future: Finally, the third chapter will look at challenges as keys to success, and opportunities as proposals to accelerate collective efforts moving forward.

Terminology Table

Terms	Definition
藻場　'Moba'	Seaweed and seagrass bed in Japanese "Mo" and "ba" in Japanese mean "seaweed or seagrass" and "ground", respectively Submerged aquatic vegetation or macrophyte beds also colloquially described as "underwater forests/sea plant beds/sea forests" made up of seaweed and sea grasses.
磯焼け 'Isoyake'	Seaweed denudation or barren rocky shore in Japanese "Iso" and "yake" mean "nearshore rocky coast" and "burned", respectively A phenomenon in which seaweed beds significantly decline or disappear beyond the range of seasonal growth and slight changes over time, resulting in poor vegetation located in shallow water reefs and boulder areas over a period of more than several years. In cases of *Isoyake* where the cause is mainly by urchins, it is also referred to as an 'urchin barren'.
Common Fishery Right	The right of the fishers of a certain district to engage in fishing through the common use of a certain coastal fishery ground very near to the shore in front of the district. A licence for common fishery right is granted by the prefectural governor to the fishery co-operative in that area. The rule is derived from the traditional use of coastal fisheries resources by village people before the Edo period.

1.

CONTEXT

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1. Context

1.1 Scientific Aspect

1.1.1 What is *Moba*?

"Moba/ 藻場" in Japan is roughly classified into four types which form sea forests: *Sargassum* species called "garamo" in Japanese, *Eisenia bicyclis* and/or *Ecklonia* species called "arame" in Japanese, *Laminaria* species (*8) called "kombu" in Japanese and *Zostera* species called "amamo" in Japanese (*9).

According to Iizumi (*10), which calculated the total area of *Moba* (based on the results of the 4th Basic Survey on the Conservation of the Natural Environment - Survey on the Distribution of Tidal Flats, Moba and Coral Reefs by the Nature Conservation Bureau of the Environment Agency in 1992), there are 315,876 ha of seaweed beds along the coast of Japan. 27% of the total area consists of *Sargassum* sp. (Garamo) seaweed beds, 20% consisting of *Eisenia*/*Ecklonia* sp. (Arame) seaweed beds, 16% consist of *Zostera* sp. (Eelgrass) beds, 11% consist of *Saccharina* sp. (Kombu) seaweed beds, 10% consist of *Undaria pinnatifida* (Wakame) seaweed beds, 6% consist of Gelidacea (Tengusa) seaweed beds, 3% consist of Sea lettuce (Aosa) and green laver (Aonori) seaweed beds, and 7% consist of the others (Figure 1-1).

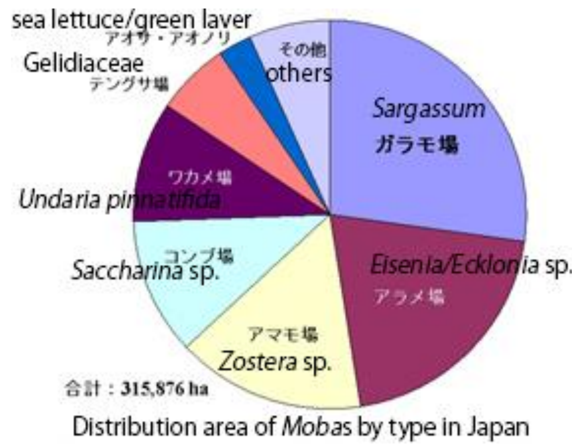

Figure 1-1. Percentages of distribution areas by *Moba* type in Japan with Sargassum, Eisenia/Ecklonia sp., and Zostera sp. as the top species. (Iizumi, 2003)

Seaweed and seagrass beds are distributed all around the world (image from *11) but due to their underwater nature, there are few opportunities for us to see them directly.

However, these underwater sea forests play a crucial role in the abundance of marine resources and have been quietly fighting against threats to the aquatic environment such as eutrophication and global warming through their life activities.

The most easily understood features of these seaweed and seagrass beds are their ability to absorb nutrients from seawater to harbour biodiversity and how they provide places for people to learn about the marine environment. However, we will soon see this is not all that the *Moba* provides for society and the planet.

In the following sections of this chapter, we will outline how these underwater forests support society and reveal a key role they play in the fight against climate crisis through the keywords of '**ecosystem services**' and '**blue carbon**'. The benefits of their existence will reveal the importance of protecting these seaweed and seagrass beds, especially now that they are facing unparalleled threats.

1.1.2 Ecosystem Services

The concept of "ecosystem Services" gained international spotlight in 2005 (*12), when the United Nations published the Millennium Ecosystem Assessment (*13) in which they introduced the term. In the assessment, ecosystem services are described as "the benefits people obtain from ecosystems". These benefits are categorized into provisioning, regulating, cultural, and supporting services. Provisioning services point to the ability of ecosystems to create food, water, timber, and fibre; regulating services outline their influence on climate, water flow and quality, disease, and waste; cultural services which provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling. For these benefits to be better protected in an economically driven society, there are ongoing efforts to quantify the economic value these services provide for society.

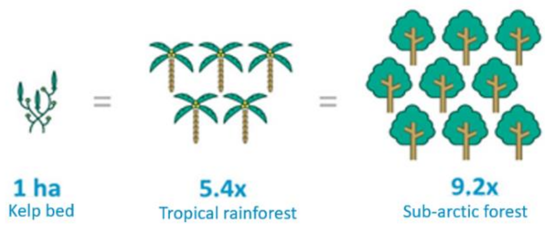

Figure 1-2. Schematic diagram to show 1 hectre of a kelp bed is equivalent to 5.4 times the area of a tropical rainforest and 9.2 times a sub-arctic forest in CO2 sequestration (Costanza, 2014)

Globally, kelp forests generate an estimated €515 billion annually in economic benefits (*7). Eger et al's (*14) ground-breaking report provides the first global economic estimation of the services of underwater sea kelp forests through its services supporting fisheries production, nutrient cycling, and carbon removal by the forests forming four major kelp genera of *Macrocystis*, *Nereocystis*, *Ecklonia*, and *Laminaria*. The report reveals that collectively, these kelp genera contribute $684 billion/year worldwide through their services - highlighting the importance of these kelp forests. However, this only reveals the underestimated value and the potential of these underwater forests which are gradually gaining credit as blue carbon, in other words for carbon sequestration which we will explore in the next section. Additionally, according to Costanza et al. (*12) one hectare of seaweed forest provides 5.4 times more ecosystem services than a tropical rainforest of the same area and 9.2 times more than a subarctic forest!

1.1.3 Blue carbon

Blue carbon is carbon stored in marine ecosystems and especially the vegetated coastal habitat which is heralded as one of the key elements necessary for mitigating climate crisis (*15). This term was coined by the United Nations Environmental Programme in 2009 to which they noted that "out of all the biological carbon (or green carbon) captured in the world, over half (55%) is captured by marine living organisms – not on land – hence it is called blue carbon" (*15). Coastal and marine ecosystems, primarily salt marshes, mangroves, and seagrasses have been the centre of attention due to their efficiency in storing and sequestering carbon. With the increasing threat of climate change, the importance of the restoration and protection of these "blue carbon ecosystems" are increasing. International organizations have even come as far as to list off the different ocean-based climate solutions that will be significant in the fight against climate change (*26).

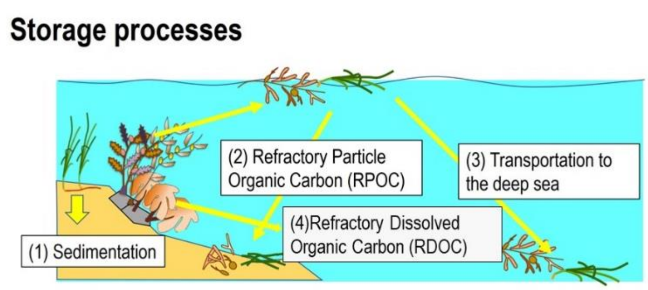

Figure 1-3. Storage processes of organic matter produced by seaweeds. (Modified from Hori, 2020)

Initially, the carbon dioxide (CO2) which is absorbed and released by seaweed were not included in the definition of blue carbon. This is because seaweed do not have root structures that store and trap carbon in the sediments like mangroves and salt marshes. However, recent scientific studies indicate that seaweed contribute to storage or sequestration of organic carbon through four main routes as shown on Figure 1-3. On an interesting note, the loss of seaweed habitats reduces carbon sequestration but does not result in emissions of CO2 to the atmosphere from sediments below the habitats, as occurs in mangroves, salt marshes, or seagrass beds.

With this difference in mind, seaweed have since become increasingly accepted as an essential factor in sequestering carbon. Researchers have been gradually filling the gap in the lack of knowledge around seaweed. A recent publication on Australian kelp forests reveals that "the omission of kelp forests from blue carbon assessments significantly underestimates the carbon storage and sequestration potential from vegetated coastal ecosystems globally"(*16).

Japan's National Institute for Environmental Studies has noted in 2020 that, the total amount of carbon dioxide sequestered from the surface layer of each seaweed bed in coastal Japan is estimated to be about 4.7 million t-CO2/year (*17). This value is considerably smaller than Japan's total greenhouse gas emissions of 1.24 billion tons (CO2 equivalent, fiscal year 2018). However, it is estimated that the amount of carbon dioxide emitted by the fisheries industry was 5.74 million tons in FY2008, which is almost equal to the amount sequestered by seaweed beds. (*4, Chapter 2). Even out of the varieties of blue carbon, we can see that seaweed have great potential in storing and sequestering carbon dioxide.

1.1.4 What is *Isoyake*, decline of seaweed beds?

Isoyake in Japanese, also known as seaweed denudation, is used to describe a phenomenon in which seaweed beds significantly decline or disappear beyond the range of seasonal growth and slight changes over time, resulting in *poor Moba* growth located in shallow water reefs and boulder areas as mentioned above. The term is said to have originated from fishers in Izu, Shizuoka prefecture, which has since spread throughout Japan to recognize the same phenomena. Academically, the concept of *Isoyake* was introduced by Shinnosuke Matsubara (1853~1916) and the usage of the term was introduced by Kamakichi Kishinouye in 1986 (*45). Throughout its history, Japan has actively used seaweed for food, fertilizer, as thickening agent, and other purposes, and there has been interest in the changes in the growth of seaweed. The recognition of *'Isoyake'* rose in the mid-Meiji period (Japan Fisheries Agency, 2021).

Figure 1-4. Landscape of *Isoyake* area caused by sea urchins called as sea urchin barren. Photo by Yuiko Mitani.

Japan was one of the first countries in the world to notice this phenomenon more than 100 years ago, and efforts have been made to decrease the speed of seaweed decline through placing stones, beach cleaning, and fertilization of the seaweed beds (*4).

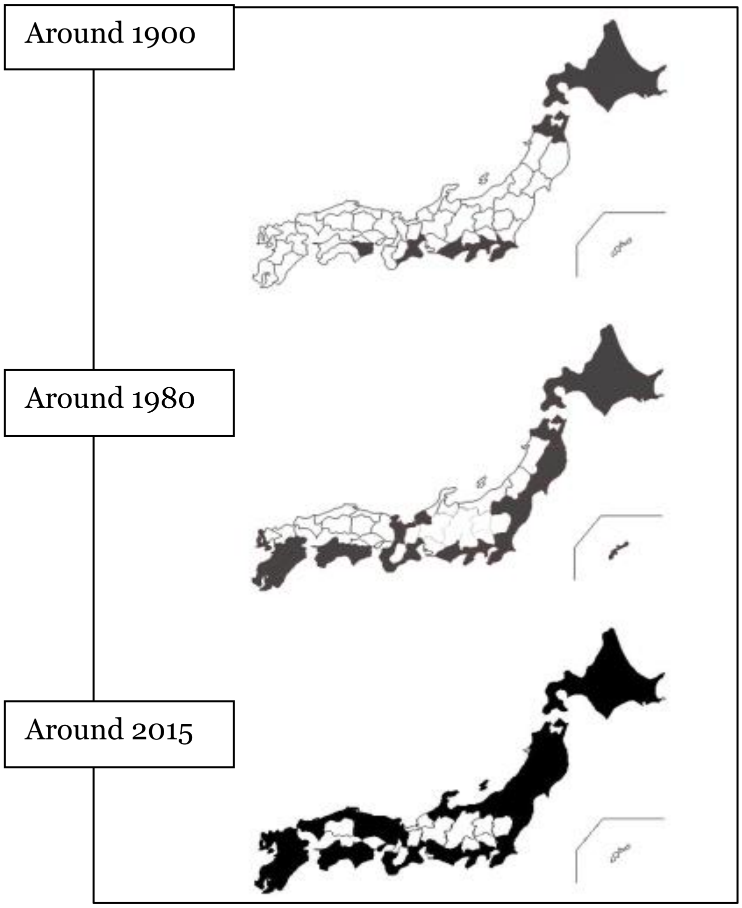

Figure 1-5. Comparison of prefectures with confirmed isoyake coloured in black from 1900, 1980, to 2015 （EMECS 2021）

As can be observed, Moba have played a large role in Japanese society and its decline is an issue of social and environmental importance. Over the past 4 decades, transformations from seaweeds beds to sea urchin barrens have been widely reported around the world especially along temperate coastlines. These coastlines have visibly changed from densely vegetated areas to barren seascapes now replaced by sea urchin, bare seafloors, or rocky surfaces. The direct and main cause of Isoyake has been assigned to damage caused by organisms that eat seaweed and seagrass. These feeding organisms are sea urchins and herbivorous fish such as lionfish and snapper. This is an issue of whether there is an equilibrium between supply of biomass growth quantity of seaweeds and demand of feed quantity for consumers. However, when the numbers of these organisms increase too much, the rate of their feeding exceeds the rate of the growth of the seaweed and seagrass. This feeding damage can become serious, resulting in a scorched and barren rocky shore.

According to a recent report (*18), the decline of seaweed beds extends almost to the entire coast of Japan. This report was based off surveys conducted by the Fisheries Agency to coastal prefectural officers, asking “whether the seaweed beds have declined or not”. A 2016 survey revealed that around 35.9% prefectures reported no or unknown *Moba* decline. In the prefectures that reported the decline of seaweed beds, sea urchins were noted as the sole cause of decline for 30.8% of these prefectures, 17.9% for herbivorous fish and 15.4% noted a decline due to a combination of both sea urchins and herbivorous fish.

Across the world, seaweed forests are in sharp decline and 40 to 60% have already been lost (*19), destroyed by pollution, overgrazing, overfishing, coastal developments, and ocean heatwaves increasing due to climate change are all increasing concern about the ecological and socioeconomic consequences of their disappearance (*7).

In the Japanese Fisheries Agency’s most recent Guidelines for Countermeasures against Isoyake (*4, Chapter 1 and 3) revised and published March 2021, the report states that around the 1990s Japan’s coastal *Moba* surface area was around 200,000 ha which had dropped by around 6400 ha in the previous 13 years. The breakdown of the causes of decline is as follows: direct changes such as reclamation (1,942 hectares, 30 prefectures), *Isoyake* (1,016 hectares, 9 prefectures), overfishing (31 hectares, 1 prefecture), changes in sea conditions, etc. (1,117 hectares, 16 prefectures), unknown (2,801 hectares, 17 prefectures). Although most of the loss of seaweed beds due to direct alteration is not due to seaweed denudation, the classification of the four items after rock scorch is extremely vague. In this survey, seaweed beds deeper than 20 m, on some islands, and under one hectare were not included.

As we will explore in the next chapter, the social aspect of fishers such as declining population, aging, and becoming more dual income are factors to consider in addition to scientific aspects to manage and restore seaweed beds.

1.2 Social Aspect

1.2.1 Social structures of Japanese fisheries

Home to some of the best fishing grounds, Japan has profited from a diverse group of seasonal fish and shellfish since ancient times. It is no surprise that Japan's per capita consumption of marine products is one of the highest in the world. As a result, the seafood market has become an important market for domestic fisheries and aquaculture (*20).

According to the OECD Review of Fisheries note on Japan (*21), in 2018, Japan **produced 4.2 million tons of fish** (including molluscs and crustaceans), with a **value of USD 13775.7 million**. 38% of this value came from aquaculture and 62% from fisheries, that is, the capture of wild resources. Between 2008 and 2018, the quantity produced decreased by 25%, while its value decreased by 10%. In 2018, Japan accounted for 9.857% volume share of global fisheries and aquaculture imports (*21). Japan's per capita consumption of edible fish and shellfish per year is at 23.8kg, declining from its peak in 2011 at 40.2kg but is more than twice the global average.

These numbers demonstrate how close Japanese society is with its fisheries and inherently the support the seaweed and seagrass beds provide for fisheries resources.

Fisheries products are essential to the Japanese lifestyle although there has been recent loss of demand in fish due to changing diet and demographic compression. However, Japanese culinary and agricultural ways of life have been intertwined with the sea. Seaweed has been utilized for food, fertilizer, and thickening agent traditionally and therefore people have been sensitive to changes of seaweed harvest. For example, fertilizer data from Tsushima, Nagasaki Prefecture in the latter half of the 18th century mentions a series of years when no seaweed fertilizer could be harvested (*4, Chapter 3.7). Not only fish and seaweed but sea urchins are regarded as high-value food product often consumed as sushi. This signifies how seaweed and seagrass bed conservation influences a part of the Japanese diet.

1.2.1.1 Fisheries Act, fishing rights, and fishery cooperatives

The Fisheries Act was first created in the Meiji period. It was a codification of customary practices by fishing communities dating back to the period before the Edo period. Hence, the present Act which aims to develop fisheries through the comprehensive use of fishing grounds, carries the tradition of fishing communities. It prescribes fishing rights, fishery permits, and fishery adjustment committees. **The right to fish** is the exclusive right to engage in a specific type of fishing in a certain water surface, especially waters very near to the coast, which is categorized into three rights. The rights are firstly, the "fixed gear fishery right" which refers to the right of operating a fixed gear fishery; the "demarcated fishery right," which is the right of operating a demarcated fishery such as set net and aquaculture; and the "common fishery right," which is the right of operating a common fishery (*22). They are categorized in this manner because traditional use of coastal waters has been managed by villages in front of the coast and these people have had the equal right to exploit fishery resources.

Under this legal structure, the prefectural governor licenses fishing rights to **fishery cooperatives** or their associations (hereinafter referred to as "fishery cooperatives") and other legal entities for fisheries (*20). To understand the fishery cooperatives, one must first understand the JF Zengyoren (National Federation of Japan Fisheries Cooperative Associations), which consists mainly of prefectural JF federations of fishery cooperatives, which amount to about 940 fishery cooperatives engaged in coastal fishing activities throughout the nation. JF Zengyoren exist to protect the fisheries management and lives of JF members, foster rich marine resources, contribute to the creation of enriched communities, and improve the social and economic status of cooperative members. Each cooperative has an average of around 300 members. According to the 2019 governor-approved simultaneous survey on employees of fishery cooperatives the total number of associate members and regular members is 277,124. To become a member, one must make a capital contribution, be living at an applicable region, and have fished at least 90-120 days per year (depending on the cooperative). This is why one must work as an employee of a fisherman or fisheries company of set net belonging to a fisheries cooperative to become its member (*23). Like many sectors in Japan, members of fishery cooperatives have been decreasing as the number of fishers has been decreasing, and there are many small-scale cooperatives. In addition, the transaction volume of the sales business, which is the core business of fishery cooperatives, has been on a flat trend in recent years.

The current **Fisheries Act** was revised recently in 2018 in which it lays out the ways in which marine resources should be managed such as limits on the number and size of fishing vessels, the size of the fish, the fishing season, etc. Under the new Fisheries Act, the national and prefectural governments are responsible for the proper conservation and management of fisheries resources, and the resources are to be managed with the goal of achieving maximum sustainable yield (MSY) in catches, with total allowable catch (TAC) as the basic management method. By 2030, the Fisheries Agency's goal is to restore fisheries production (excluding aquaculture and algae production) to 4.44 million tons (*24).

Matsuda (*25) claims laws and systems that support the conservation and restoration of *Moba* and tidal flats are now in place. As one of the examples of this support, he mentions how the Fisheries Agency announced the " **Moba/Higata (Seaweed and seagrass bed/Tidal flat Vision**" (hereinafter **'the Vision'**) in January 2016(explored in Chapter 2.1.1 of this report). Additionally, prior to this, the conservation and restoration of *Moba* and tidal flats had been an important theme in the National Biodiversity Strategy based on the Basic Act on Biodiversity, the Basic Plan for Ocean Policy based on the Basic Act on Ocean Policy, as well as the National Sea Restoration Project.

As outlined above, fishing rights are strictly defined by the Fisheries Act, and this makes any form of *Moba* conservation initiatives in which unrelated persons crush and harvest sea creatures, including sea urchins and seaweed, without permission illegal. The no-fishing period, the lower limit on the size of organisms that can be fished, and the protected waters defined by each prefecture under Act on the Protection of Fishery Resources also express the uniqueness of each prefecture and or fisheries cooperative branch and are particularly relevant to seaweed bed conservation activities. Any activities in the sea, even with environmental conservation or scientific research purposes, require a complicated process such as obtaining consent of the local fisheries cooperative branch and its fishers, as well as official permit from the prefectural fisheries offices and sometimes Japan Coast Guard, which can often be a barrier for non-fisher groups wishing to conduct restoration projects. However, this process is essential especially since it is crucial for fishers who make a living from natural resources in these areas.

1.2.1.2 Fishers and fishing communities

As of 2018, there were 151,701 people working in fisheries, with the largest number of people over the age of 65. The number of people working in fisheries have been on a downward trend, decreasing by 61% over the past 30 years. In terms of age, the percentage of people aged 65 and above has been consistently increasing (*28). In recent years, there has been an increase in the number of people who have changed their jobs to fisheries because of different values of work and lifestyle, and this is the reason why a variety of people are interested in fisheries as a place to work. The Japanese Government, local authorities and some fisheries co-operatives are promoting the growth of new individual entrants to coastal fisheries. For example, a monthly stipend is offered to individual new entrants for two years, and skilled fishers are assigned to mentor individual new entrants so that they can fully learn fishing techniques. As a result, young, non-native fishers are gradually coming to live in the fishing villages and taking up coastal fishing. However, this trend is not strong enough to reverse the downward trend of the overall fishing population.

In the 2020 report by the Fisheries Agency, they note the aging and growing shortage of maritime technicians (*28). The overall population of youth working in the primary industry has decreased which can also be observed in the fisheries sector. Overall rates of youth choosing to continue higher education has increased and the phenomenon of depopulation in rural areas with an influx of urban migration influences the fisheries sector. It is clear, fisheries have not been able to escape the national trend of aging and decreasing population in their sector. As we will observe in the next chapter, *Moba* conservation also struggles with these demographic changes. Therefore initiatives should also delve into how other stakeholders can cooperate to restore and protect the *Moba* with fishing communities.

Regional fishing communities are not always easily accessible by outsiders, due to multiple reasons like strict regulations depending on a community and history in which fishing rights are passed down through family and as a result, tight knit communities of generations of fishers are created over decades, sometimes centuries. On the other hand, decrease in fishers in such villages is changing to make them open to new entrants outside the villages as fishers by the policy mentioned above. However, social aspect can be a high hurdle for non-fisher groups to enter to push forward and participate in *Moba* restoration.

1.2.2 Context on Japanese marine conservation

In a nationwide survey of Japanese people's awareness of the sea in July 2017 by the Nippon Foundation aimed to clarify the actual state of Japanese people's awareness of and actions toward the sea, to define the content and goals that should be addressed in order to pass the healthy sea on to future generations. The survey, conducted among 11,600 people in their teens to 60s, revealed the following: "40% of youth in their teens and 20s do not feel much affinity for the sea" and "44.2% of people who did not go to the ocean during the 6 years of elementary school did not know that the fish we eat now will not be able to be eaten in the future" (*28). Therefore, in Japan, people's awareness of the need to conserve the marine environment is limited. Based on MSO's observations, among marine environmental issues, plastic waste in the sea has been the focus issue in recent years, and awareness of the threat and necessity for seaweed and seagrass bed conservation is relatively low.

As we have addressed in this chapter , there is a harder element of the legal and policy framework as well as the softer elements of tradition and cultural aspects of common fishery right that needs to be understood for a successful *Moba* conservation initiative. The complexity of these approaches poses a challenge for newly-joining actors such as non-profit organisations and volunteers to engage in marine environmental conservation in Japan. Most of the existing groups working on restorative efforts consist of local people, often involving fishers and professional divers.

With the understanding of the scientific and social aspects surrounding the seaweed and seagrass bed conservation topic, we will now delve into the actual initiatives ongoing on the ground in the next chapter.

2.

CURRENT INITIATIVES

MOBILE SEA OTTERS

2. Current Initiatives

This chapter will investigate the established, innovative, and ongoing methods of *Moba* restorations in Japan. The contents will outline initiatives that have been ongoing and the partially established or innovative methods that have emerged from these practices. MSO's own projects will also be introduced as a detailed case study at the end of this chapter.

2.1 Effective methods to combat Isoyake: Summary of 'Guidelines for Countermeasures against Isoyake'

The third edition of the 'Guidelines for Countermeasures against Isoyake' (hereinafter 'the Guideline') was recently published in March 2021 from which this report benefits greatly from. The Guideline is a hefty 200-page report (only published in Japanese) in which the Fisheries Agency has compiled learnings from Isoyake measures from around the country. Below, we aim to translate and introduce many of the effective methods and existing initiatives that have been reported in Japan. For further understanding, referring to the original Guideline is recommended.

Out of the many elements of *Moba* restorations, the defined steps of the operation usually begin with understanding the situation of the studied region, specifying harmful factors to *Moba* in an area, enforcing measures fit to combat the identified harmful factors, monitoring, and evaluating the measures and improving and/or continuing this cycle.

To understand the current situation, many operations have utilised the internet, conducted field work, went diving and used unmanned flying objects like drones to survey the area. In order to specify harmful factors towards the seagrass and seaweed beds, the Guideline recommends simple field experiments (seen in image below -p97, Chapter 7), experiments to evaluate feeding damage by fish, and acquiring environmental data.

After the harmful factors or threats to the area have been identified, the Guideline has summarized the possible measures depending on the identified threats (Figure 2-2).

In the following paragraphs, the 8 measures to combat Isoyake will be laid out. For further reading on other parts of the restoration process such as monitoring and evaluating the measures, further reading of Chapter 7 of the Guideline (*4) is advised. The measures are a) urchin removal, b) fish removal, c) deploying a fence, d) supplying seaweed seeds, e) providing substrates for attachment of seaweed, f) creating surfaces conducive to seaweed growth, g) supplying nutrients for seaweed and h) accelerating water flow against predation of sea urchins on seaweeds by shallowing the depth of the seabed surface by adding substrate to the seabed.

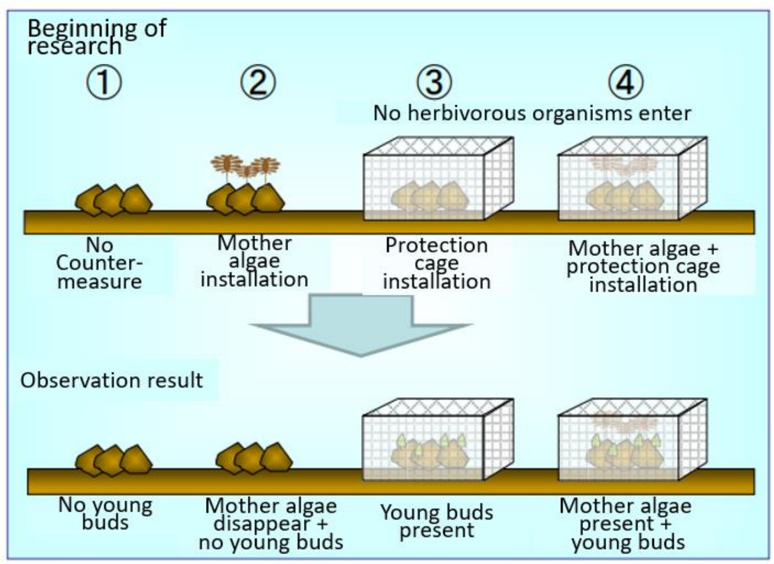

Figure 2-1. Confirming factors that inhibit formation of seaweed beds. The experiment lays out 4 variations to compare between no countermeasures, planting the mother algae, installing a cage, installing a cage and planting the mother algae on seaweed growth. (the Guideline, 2021)

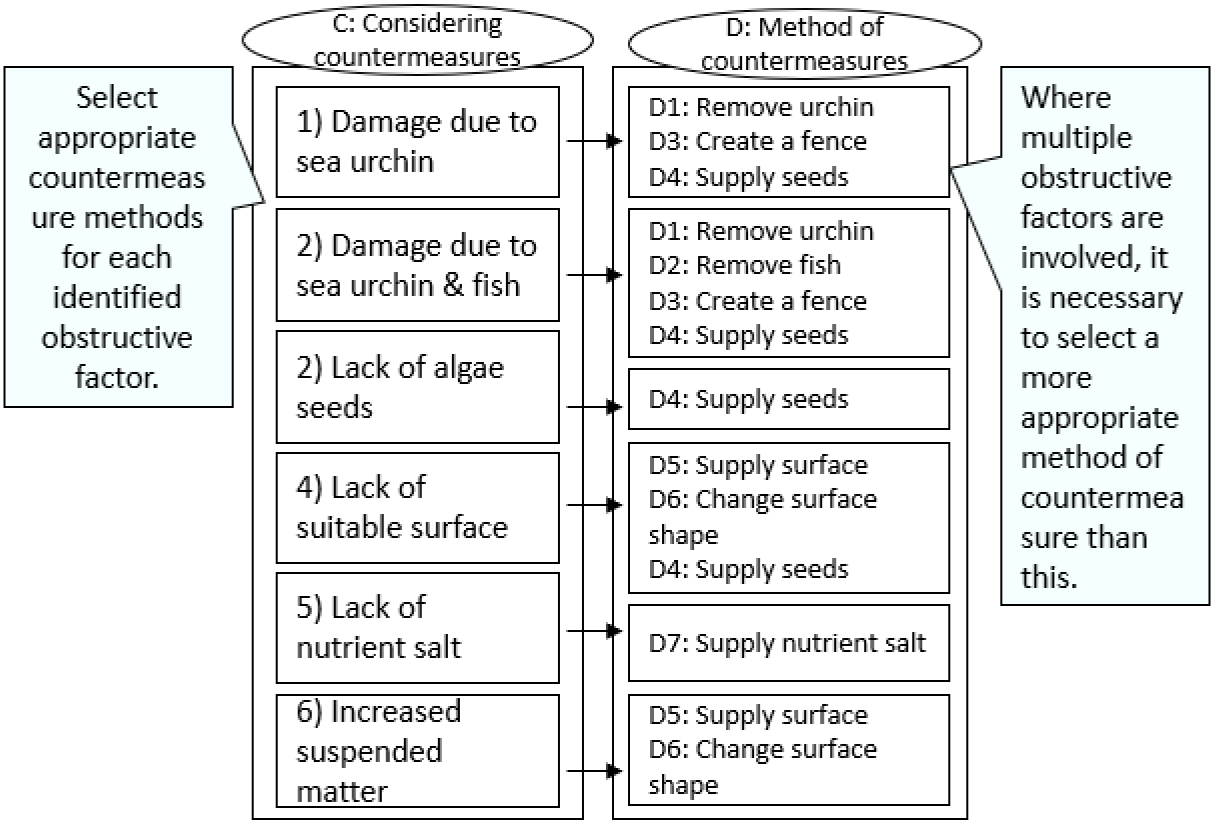

Figure 2-2. Workflow of determining *Isoyake* countermeasures. Outlining considerations such as of urchin's eating seaweed to nutritious salt deficiency (left) in relation to countermeasures written in detail (right) (the Guideline, 2021)

a. Urchin removal

In the case of urchin removal, diving with appropriate scuba diving gear is the most efficient. Other options also include skin-diving and poking at urchins from a boat to either crush urchins on the seafloor or to collect them. However, skin-diving and operations from a boat limit removal area and are less efficient. In addition, other considerations during this measure need to be made, such as which type of urchins to target, where, during which season and timing, how many people are available for diving removal measures, how long the effect of removal will last etc.

b. Fish removal

By reducing the number of herbivorous fish populations from the target area, feeding pressure on the *Moba* will be reduced, aiding restoration. Removal methods vary from "gill nets," "longlines," "fixed nets," and "traps". The most appropriate method should be selected according to the ecological characteristics of the fish species and physical environment of a location. When these fish are caught by fisheries as bycatch during a usual fishing operation, they should not be released back into the sea, but should be brought on land and utilized. In Japan, these approaches differ depending on species of herbivorous fish such as Mottled spinefoot ('Aigo'アイゴ *Siganus fuscescens*), Southern drummer ('Noto-isuzumi'ノトイスズミ *Kyphosus bigibbus*) and Japanese parrotfish ('Budai' ブダイ *Calotomus japonicus*) and the location, season need to be considered to weigh the pros and cons of the most effective fish removal method. From the ongoing initiatives, issues of by-catch where the fish removal nets have caught other marine species have been identified.

c. Creating a fence

Fencing can be divided into two types between whether the fences are against sea urchins or herbivorous fish. An urchin fence physically creates a barrier that surrounds a certain area where seaweed beds are restored in a circular, square or u-shape. Depending on the location, the requirement for materials and coverage can be determined. These urchin fences can be made (image p132) from 5 materials: floating material rope, polyethylene rope, netted material, chain, and cable ties.

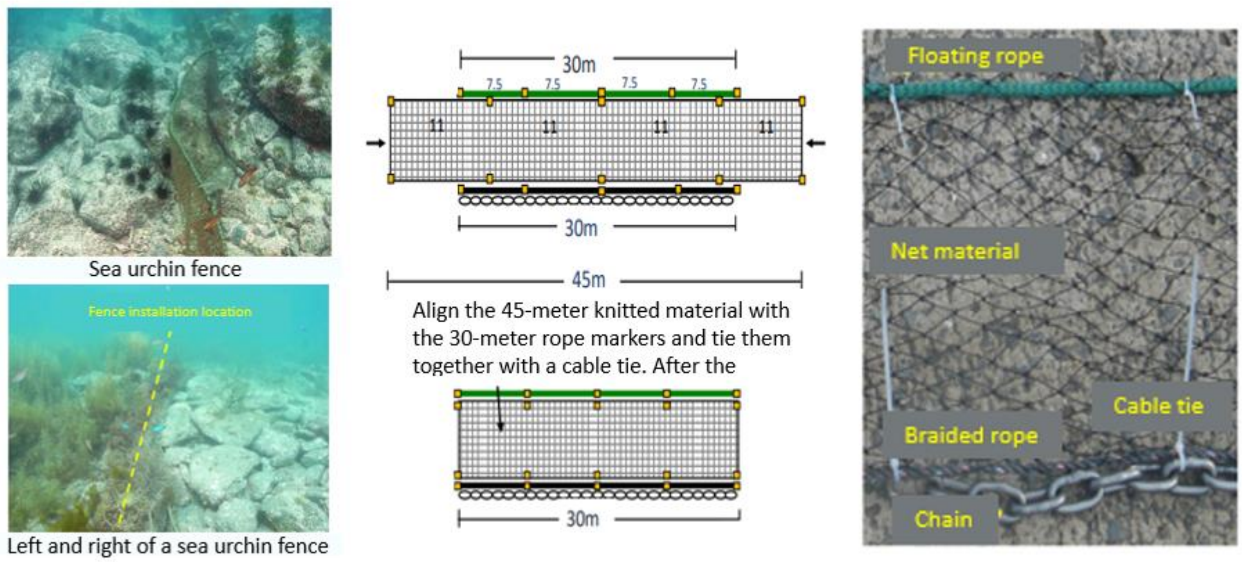

Figure 2-3. Urchin fence pictured on the left and designed on the right (the Guideline, 2021)

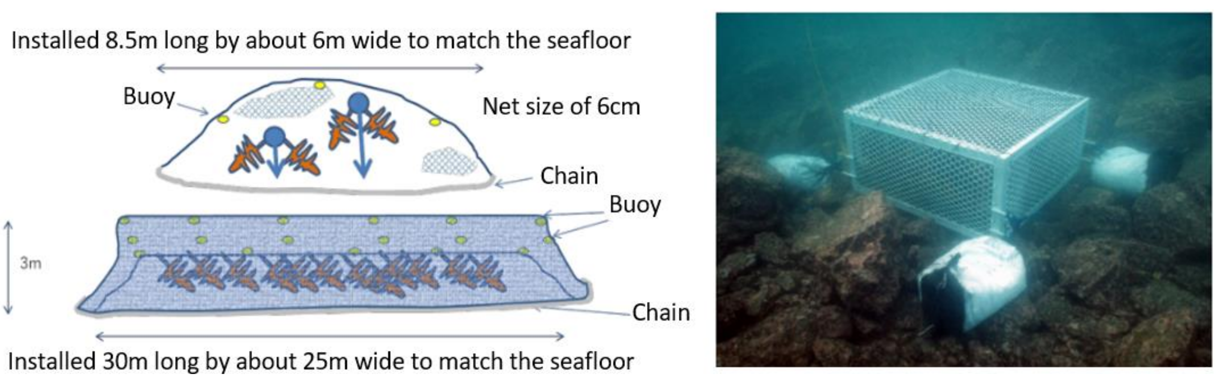

Figure 2-4. Protective net surrounding mother algae (the Guideline, 2021)

Fences made to keep herbivorous fish out can be broadly divided into several variations such as those that protect the mother algae or are caged around *Moba*. Unlike urchin fences, these fences need to cover the seabed to the water surface and are therefore more expensive. Additionally, to maintain the function of the fence after installation, maintenance such as removal of attached organisms and repair of damage is required periodically.

d. Supplying seaweed seeds

In the case of lack of seaweed matured mother thallus, spores and/or propagules can be supplied by transplanting mother algae, deploying spore bags which mother thalli are put into, or by transplantation of cultured individuals. Depending on the type of seaweed, the cost, and difficulty of the use of the mother algae, the method of transplanting artificially cultured seedlings can be used. Seeds and seedlings are collected from the wild, obtained from research institutes, or purchased from seed and seedling production companies. Then they can be used through the wrapping, fixing, or inserting method. They are simply put, either seedlings wrapped around a string or net, seedlings fixed onto concrete, mortar or slate plates or seedlings directly inserted onto blocks or natural rocks.

e. Providing substrates for seaweeds

In areas where reefs are buried in sand or are worn away by floating sand, providing substrates that serve as an attachment surface for seaweed to grow at a height that is not affected by sand. In other situations, it may be necessary to detach and remove organisms that are competing for a substrate surface which seaweeds grow and germinate on. This can be done on a small-scale by individuals with hammers, scrapers, or high-pressure cleaners or on a larger scale by heavier machines. During these operations, caution is advised for what type of species should be removed and what can be left untouched.

f. Composing surface shapes for seaweeds

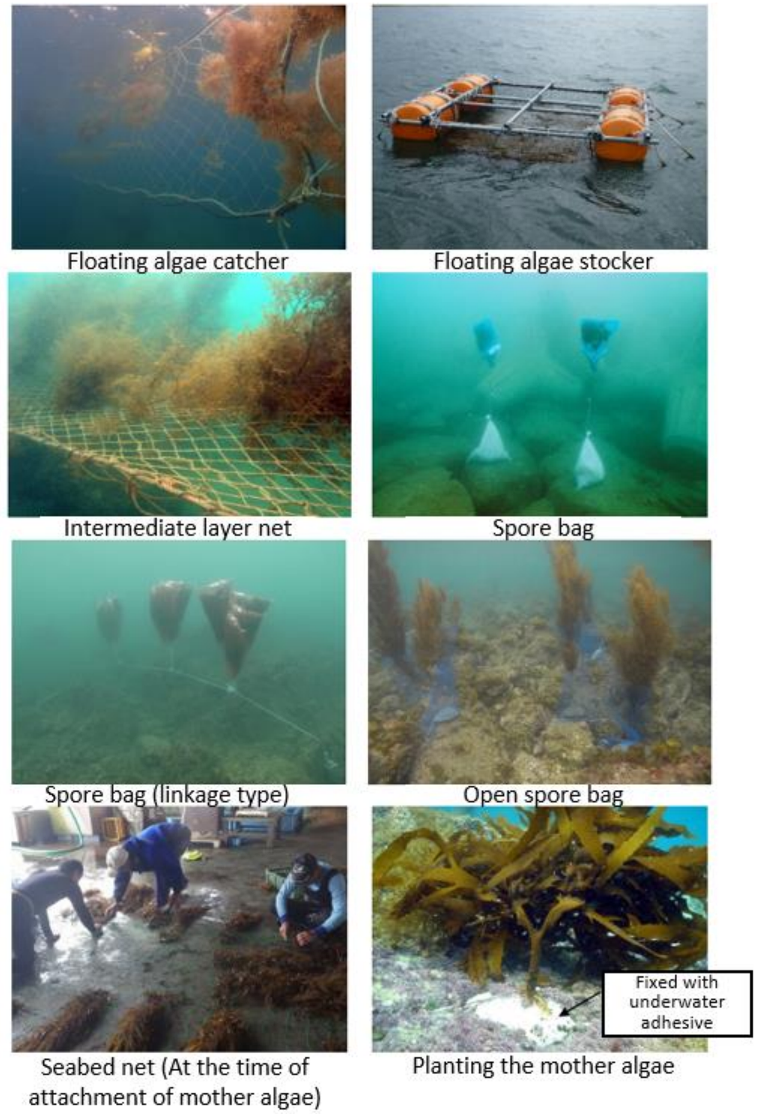

Figure 2-5. Main methods of mother algae usage (the Guideline, 2021)

Example of a groove in block   Kajime growing on the groove

Grooves in the block and Kajime growth

Figure 2-6. Examples of surface shapes (the Guideline, 2021, page 162)

Base materials installed on the seabed can be configured into different shapes to reduce the effects of sedimentation of floating mud, to promote the growth of seaweed, and to reduce the feeding pressure of herbivorous fish. On rocky reefs facing the open sea and subject to strong waves, it is difficult for floating mud to accumulate, so there is nothing inhibiting seaweed growth. These practices change the surface areas where the seaweed grow from. An example is how fissures can be created on the surface they are growing from. Ropes can be also used to keep seaweed from accumulation of mud or from predating sea urchin.

Mobile Sea Otters
モバイルラッコ隊

g. Supplying nutrients

Promoting growth of seaweeds by supplying nutrients can aid their growth. In recent years, the purification of seawater has been progressing due to wastewater regulations, and due to the decrease in dissolved nitrogen in coastal areas, colour fading has become a problem in seaweed cultivation (*4, p165). Recently, attempts to artificially control nutrient concentrations have been introduced in Seto Inland Sea to foster *Undaria pinnatifida* aquaculture in winter. It is necessary to investigate their impacts on coastal ecosystems.

h. Accelerating water flow

Sea urchins cannot graze seaweeds in strong water flow. Thus, accelerating water flow to *Moba* by shallowing bottom depths by throwing stones, placing blocks or raising the seabed (Figure 2-7) prevents sea urchins from approaching. The main problem with this structural transformation is the high cost.

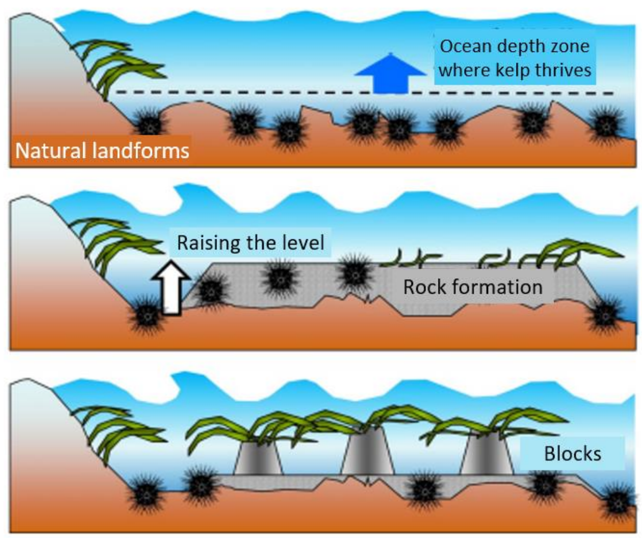

Figure 2-7. Proposal for utilizing blocks to change growth depth (the Guideline, 2021)

2.2 Utilizing the PDCA Cycle

Isoyake are caused by a complex combination of factors, and it is important to keep measures resilient and flexible to unexpected results. Therefore, the PDCA (Plan-Do-Check-Act) approach is recommended, which is based on recurring improvement (*4, Chapter 6). The PDCA cycle consists of the following steps: (1) identifying the current status of *Isoyake* and preparing a concrete plan according to the set goals, (2) implementing measures to prevent *Isoyake* based on the plan, (3) monitoring and evaluating the results of the activities, (4) reviewing the plan and making the next plan according to the evaluation, and (5) repeating this cycle.

In planning a project, detailed consideration should be given to goal setting, division of roles, safety of work, activity schedule, necessary expenses, coordination with stakeholders, etc. In the following, main considerations to make during the PDCA cycle will be outlined.

A. Planning the project

- During the process of planning a project, first clarify the goals of the project. This means outlining short, medium to long-term goals in order to set a time of achievement. The short-term goals should be specific and include achievable figures such as a specific measurement of increased area coverage of *Moba*.

- Targeted areas should be those where *Moba* once existed in or are currently in the vicinity of an area beginning to experience *Isoyake*. In addition, select a site that can be implemented safely and without undue effort.

B. Annual flow of a project:

- Detecting rocky shoreline erosion, assessing the current situation, studying, and planning countermeasures, implementing countermeasures, monitoring, evaluating, and studying the next countermeasures – and then the cycle is repeated.

C. Establishing a system

- **Establishment of an implementation structure**
  To effectively implement measures against *Isoyake*, it is necessary to hold a council meeting to reach a consensus with various stakeholders and to continue the activities. It is necessary to recognize the residents' interest in environmental issues and the aging population problems that the area is facing. In the future, it is also important to consider the creation of a system that enables community-wide efforts among fishery officials, residents, NPOs, etc., experts/researchers, and government officials.

- **Information sharing**
  Sharing information and techniques on best practices and initiatives is key in strengthening the organization. Not only communication among members, but also active collection of new information through exchanges with organizations such as fisheries agencies and research institutes. The information site Hitoumi.jp provides information on the efforts in various parts of the country (*46).

- **Coordination of hard and soft measures**
  Factors that inhibit the formation of *Moba* need to be counter measured by soft and hard measures. The coordination of hard and soft measures means, for example, installing seaweed bed reefs where seaweed seedlings released from natural seaweed beds are transported by tidal currents over a wide area to create seaweed beds, and implementing soft measures such as removing sea urchins to maintain the seaweed beds. In order to achieve this kind of coordination, it is important to establish the system and share information as described above, and it is necessary to skillfully combine both types of planning.

D. Maintenance

- It is important to manage the seaweed beds so that they continue to function. In addition, once restored, the goal should be to maintain and increase the *Moba* coverage. Measures to prevent a return to *Isoyake* should be implemented as appropriate, and the status of resources in the agreed area as well as the active area should be monitored annually.

E. Evaluation and consideration of the next measures

- This stage is necessary to evaluate the process and results of the activities through recording and monitoring. The following points should be considered during the evaluation:
  - Verify the achievement of numerical targets and share the results with participants.
  - The results of the evaluation should be summarized in a report for long-term analysis.
  - Plan the next measures based on the results and continue these activities.
  - The plan should be made mainly by fishermen and municipalities, with advice from supporters if necessary.

2.3 Overview of ongoing initiatives

With the support of the Guideline, many restorative efforts have been in place in Japan, both officially organised and more casual ad-hoc projects. This section will introduce ongoing initiatives related to seaweed restoration that has been reported to the multifunctional fisheries grant scheme, which amounts to around 300 in Japan (*46). (However, since these numbers only reveal projects supported by the government, other projects could be excluded.)

Examples of restoration initiatives can be categorized into large-scale projects such as the installation of seaweed reef blocks and smaller-scale projects which are more numerous and diverse. Usually smaller-scale projects require continuous monitoring and operation management such as the removal of harmful organisms like urchins and herbivorous fish or installing seaweed mother algae and "spore bags".

For the success and continuation of these restoration initiatives, wide stakeholder involvement is necessary. As we will list down below, there are currently ongoing initiatives in most prefectures suffering from *Isoyake*. However, many of these activities are government grant-funded and require improved scientific input, further funding, and human resources.

2.3.1Government-led

The Fisheries Agency has pushed forward the Vision in which they lay out basic policy to achieve 1. accurate understanding of the causes of decline, 2. implementation of wide-area measures that integrate hardware and software, 3. proactive introduction of new knowledge concerning seaweed and seagrass beds and tidal flats. This was due to past experiences of lack of long-term monitoring and maintenance 'soft' measures following 'hard' measures of constructing artificial reefs for seaweed beds. With continuous and successful efforts of local groups in soft measures like environmental monitoring and environmental education, this Vision sought to link hard and soft measures in a complementary manner (*25).

The Fisheries Agency has been providing grants for **"Measures to demonstrate the multifunctional role of fisheries"** (*29) (hereinafter 'multifunctional fisheries grants') since 2009.

The applicable activities are largely categorized between environmental and ecosystem conservation and ensuring marine safety. Within the former category, the restoration and conservation of *Moba* are included. For *Moba* restoration, the government accepts the proposals after examination of plans from local groups consisting of fisheries cooperative, local community government and prefectural government. The main activities of many of plans are as follows (*30):

a. Installation of mother algae
b. Seaweed seedling production
c. Introduction of seaweed seeds and seedlings
d. Transplantation and seeding of eelgrass
e. Removal of harmful organisms (sea urchins)
f. Removal of harmful organisms (fish)
g. Establishment of protected area
h. Sea urchin density control
i. Nutrient salts supply
j. Bedrock cleaning
k. Afforestation in the watershed
l. Removal of floating and sediment
m. Other specially approved activities
n. Monitoring

Activities outlined are conducted by fishery cooperatives, with other stakeholders like scientists and local government participation which will be outlined in the following section. It is important to note that the above measures have been recognized and can be applicable for grants by the government. It is announced the government will grant half of the cost of implementing the plan (*5). Many fishers take advantage of these measures and the list of initiatives listed are led by fishers. Since the government's policy aims to increase the effectiveness of fisheries and fishing communities in their role of protecting the marine environment, the restoration of *Moba* is a good fit.
Other larger initiatives related to *Moba* creation/restoration in close relation with the government are listed below:

The **Kansai International Airport's** *Moba* is an example of a method of artificial creation of seaweed beds as environmental mitigation to damage of reclamation for the airport (*47). This artificial island was created to locate the primary international airport closest to the cities of Osaka, Kyoto, and Kobe in 1994. The creation of this airport was a controversial and environmental issue. To mitigate environmental damages, the sea wall around the artificial island was built with a gentle slope to allow seaweeds to grow although land area created by reclamation is usually surrounded with vertical wall with no places where seaweeds attach. The airport continues to push forward initiatives to further seaweed creation by installing reef blocks and net bags (or spore bags) containing mature fronds of seaweeds.

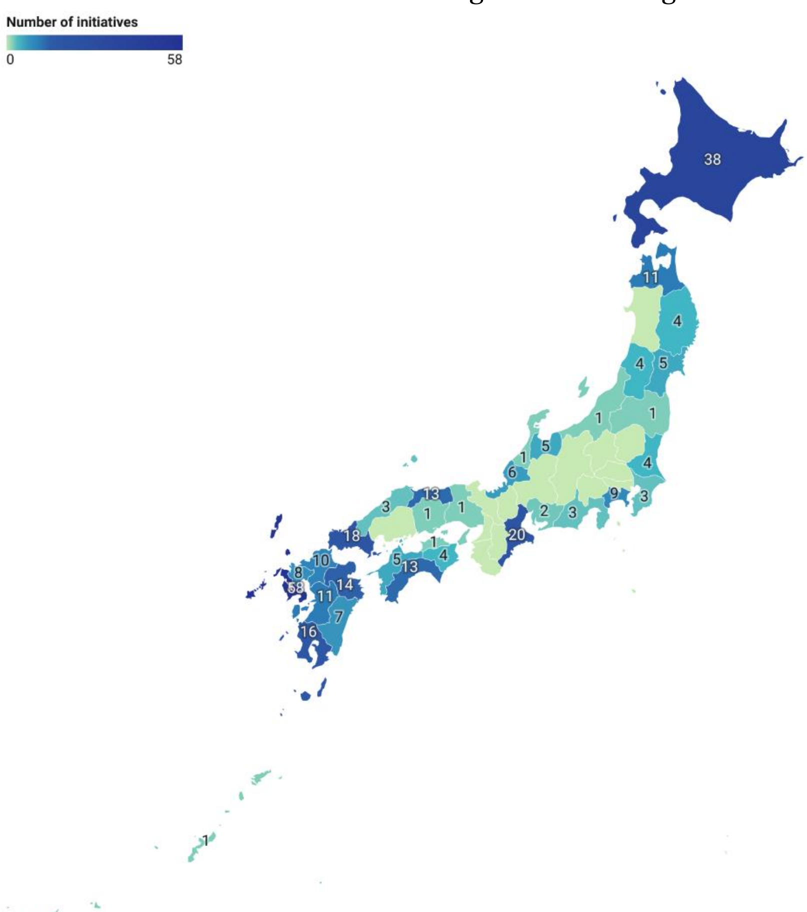

Figure 2-8. Japan's Moba conservation initiatives recognized by the government and its distribution by prefecture (Okuyama 2021, data from the Measures to demonstrate the multifunctional role of fisheries Information Website)

The 'Satoumi' 里海 Initiative mainly conducts their activities around the Kanazawa port in Yokohama (*48). Although they are a general incorporated association created in 2016, they are closely linked to the local city government because they take part in the **"Yokohama Blue Carbon Project"** which promotes carbon offsetting and supporting the utilization of marine resources to mitigate climate change. The project led by the city of Yokohama started in waters where fisheries cooperative abandoned common fishery right and that belong to a port area in 2014 and aims to simultaneously promote measures against global warming and the creation of a sea that is friendly to citizens by adding environmental conservation and environmental awareness. The Satoumi Initiative has been farming kombu seaweed with the help of fishers and have been able to provide opportunities for citizens to experience the process.

The relation between the local government and local citizen needs a balance between top-down and bottom-up approaches. In the past, the typical combination was a top-down type of hard project and a bottom-up type of soft project. However, it is becoming clear that top-down budgetary measures are necessary for monitoring of seaweed beds and tidal flats (soft projects), and top-down institutional support is desired for grass-roots bottom-up soft projects (*25).

Furthermore, the Guideline by the Fisheries Agency still points to room for improvement because there are many cases where the recovery of seaweed beds is on a small scale, or after a temporary recovery, the seaweed beds return to the state of *Isoyake* (*4, Preface). It can be said that maintaining and expanding the seaweed beds that have once recovered is an issue for the future. These issues can only be solved if a sustained effort for *Moba* restoration is achieved (*4, Introduction).

2.3.2 Fishers and Fishery cooperatives-led

Even before the 'multifunctional fisheries grants', the work of fishers in promoting seaweed and seagrass bed restoration was being noted by the Fisheries Agency. In 2006, it was reported that 290 of fishery cooperatives had conducted restoration or conservation projects to strengthen *Moba* productivity, decrease feeding pressure etc (*31).

Below are 6 examples of initiatives led by fishers or fishery cooperatives that have been approved under the multifunctional fisheries grants (*4). Examples of efforts are introduced as follows.

Oshimacho, Saikai City, Nagasaki Prefecture c. 1995 (*4, Chapter 8)

Led by diving fishers, they started off by removing sea urchin and small herbivorous gastropods. After learning from other method to protect seaweeds from predation of sea urchins in Hokkaido, they installed sea urchin fences in 1995. In 2002, to decrease loss of seaweeds by feeding fish, they partnered up with an artificial fish reef production company to develop a caged seaweed reef. Even though methods to protect seaweeds from predations had not yet been established during that time, their initiative was able to try out different methods and succeed through continuous efforts. Even with the success of preventing predation of seaweeds, it has not led to the complete recovery of the *Moba* in the area. Presently, they are utilizing movable rocks or plates around the caged seaweed reef and moving and protecting these plates with to other areas once young seaweeds have attached onto the surface.

Nagoya, Saiki City, Oita Prefecture c.2007

This initiative is led by 7 diving fishers, with the help from various experts, researchers of National Institute of Fisheries Technology, employees of the city and prefecture governments as well as the Oita Fisheries Cooperative Nagoya branch. Their initiative is multiple and include installing sea urchin fences, removal of sea urchin, planting and introducing mother algae with spore bags, removal of herbivorous fish feeding on seaweeds like the Japanese parrotfish *Calotomus japonicus* (with gill nets, longlines), monitoring of seaweed beds (*32). In the future, they aim to improve the efficiency of catching threatening species, increase the seaweed and further utilize Japanese parrotfish. An issue they face is to bring back "a profitable seaweed beds" by removing the Japanese parrotfish and restoring abalone in the region.

Haidaura, Owase and Kihoku, Mie Prefecture c.2010 (*4, Chapter 8)

Starting in 2010, fishers and divers have been removing sea urchin in these areas. The local diving shop, volunteer divers and students at Mie University have been crucial in continuing these efforts. In the 5 years between 2015 to 2019, they were conducting activities in 92,768 ㎡ and have recorded the restoration of 52,961 ㎡ in the total area of their activities. In the beginning, activities in Haidaura, amounted to the removal of 10,000 sea urchins annually. Presently, the removal of only 1,000 sea urchins is necessary to maintain the seaweeds bed there. Not limiting their activities to sea urchin removal, they report and collect data as well as use drones to take aerial pictures of an area to monitor *Moba* distribution.

Figure 2-9. Diver crushing sea urchin (The Guideline, 2021)

Hiraiwa, Hyuga, Miyazaki Prefecture c. 2010

The Hiraiwa-Saikaimo Group started their initiative in partnership with the Miyazaki Prefecture Fisheries Cooperative Hiraiwa branch (*32). Members consist of fishers and employees of the cooperative and an officer of Hyuga City. Their efforts are mainly in sea urchin removal, removal of floating and debris on the bottom such as driftwood and removal of herbivorous fishes. They have listed aging and lack of younger members as concerns for the future in continuing their initiative.

Shakotan, Hokkaido Prefecture c.2011

The Shakotan initiative is particularly characterized by the strong linkages between the local fisheries cooperative, local government of Shakotan Town and technological companies (*32). The efforts for restoration are done by two groups mainly formed by the East Shakotan Fisheries Cooperative. Their initiative includes density control of sea urchins by transporting sea urchins from high density areas to low areas, supply of nutrients to the area through introducing fertilizer (nutrient salts) to promote the growth of kombu seaweeds, afforestation in areas upriver to intend to restore *Moba* and releasing juveniles of Masu salmon (*Onchochyncus masou masou*) and chum salmon (*Oncorhynchus keta*) from a hatchery upriver for not only increase in these fish resources but also nutrients brought by those returning from the sea. Notably, they have also experimented with the reuse of sea urchin shells as coating material for fertilizer ropes to use in cultivating seaweed (technological advancements further explored in the next chapter of this report). This initiative aims to have the double benefit of utilizing the sea urchin shells that would otherwise be thrown away and at the same time, promote the growth of seaweed once these ropes are put into the sea.

Wajima, Ishikawa Prefecture c. 2013

Wajima City is very famous of ‘Ama 海女’, female divers, who can be literally translated to “sea women in Japanese who take abalone, turban shells, sea urchins and seaweeds in seaweed forests by skin diving more than 400 years ago (http://noto-satoyamasatoumi.jp/detail.php?tp_no=90). A group of female divers of Wajima have led “Protect the Satoumi” project Notably, Ama are known for wearing only a wet suit and goggles to dive more than ten meters deep into the sea to collect abalone, turban shells and seaweed. Their traditional methods have continued since the last half of the 7th century, which are noted in Japan’s oldest existing poetry collection called “Manyoshu” and they have been listed as Japan’s ‘Important Intangible Folk Cultural Property’ since 2018 (*33). This acknowledges their unique catching skill and methods, their deep understanding of the natural environment and how they have passed down this culture collectively over multiple generations (*34). Wajima Ama are presently around 200 women with the oldest members in their 70s, coming second in size to the Ama group in Mie Prefecture.

With their close relation to marine fauna and flora, they have been the predominant voice speaking up about the changing seas in the area. They have so far observed and relayed information to other fishers on how the seaweed they have traditionally gathered has been declining and that they have felt water temperatures of fishery grounds rising from the 2000s. The Group has so far mainly planted mother algae, removed sea urchin, and have gotten rid of floating and sedimentary litters from the sea and stranded ones from the beach.

Overall, we can see from these initiatives that fishers and fishery cooperatives undoubtedly have a deep understanding of their fishing grounds and the means to upstart movements for restoring *Moba*. There are still concerns surrounding the declining and aging population of fishers and perhaps a benefit in incorporating other actors we will outline in the following to support the longevity and continuation of restoration and conservation efforts.

2.3.3 Diving Community-led

Scuba diving is a crucial part of *Moba* restoration and conservation. To maintain a consistent restoration and conservation operation, it is very important for diving shops in each area. In a common fishery right area, it is legally necessary for any scuba divers to obtain a consent of a local fisheries cooperative which manages the area without exception. A diving shop using a common fishery right area as a training diving site, or a pleasure diving site has already had such a consent of local fisheries cooperative and a good relationship with the cooperative. Most of customers of diving shops are interested in coastal habitats and understand how important they are. They are potential volunteer divers. Therefore, local diving shops have opportunities to restore seaweed beds with fishers, scientists, and the public through diving as one of the main elements of activities to restore seaweed beds with a fisheries cooperative and local communities. Below are a few initiatives that demonstrate such successful collaborative efforts, led by the diving community.

Diving Shop NANA

It is located in Hayama; Kanagawa prefecture has been working to restore *Moba* in the area. As of November 2020, they have not only involved scuba divers and fishers but also skin divers and scientists to push forward their project. Their activities usually centre around sea urchin removal, installing spore bags of mother algae with following activities like sea urchin tasting sessions, barbeque, or a study session to better engage volunteer divers (*35).

Figure 2-10. Participants with spore bags, (Diving Shop NANA)

The Non-profit Organization 'Sanriku (三陸)' Volunteer Divers

It is led by Mr. Hiroshi Sato, a diving instructor and owner of the diving shop "Michinoku Diving RIAS". Although he has been in Thailand as a diving instructor, he returned to Ofunato and opened his shop for supporting fishers to recover coastal fisheries on the Sanriku Coast after the huge tsunami on 11 March 2011. Beginning their activities in response to the Great East Japan Earthquake in 2011, the NPO of a volunteer divers' network began their works in seafloor clean ups, debris survey, survey on water quality and drift objects in Okirai Bay of Ofunato City. With 1000 dives taking place annually under the NPO, they have accumulated experiences and knowledges of the Sanriku coastal environment. Through these activities, they have discovered the issue of seaweed denudation, namely sea urchin barrens, due to the sea urchins' predation and started their activities to recover seaweed beds by removing sea urchins from the sea urchin barrens.

Figure 2-11. Divers collecting debris off the seafloor (Sanriku Volunteer Divers)

As a result of these activities, they have amassed regeneration methods and data with which they conduct projects commissioned by the government and fishery cooperatives. They are also able to collaborate with communities outside of Sanriku that are looking for know-how, such as the Enoshima area in Kanagawa Prefecture (*36).

The Role of Volunteer Divers

On another note, the role of volunteer divers for the continuation of restoration/conservation efforts cannot be undermined.

In Japan, fishers who take sea urchins and also measures against *Isoyake* and preserve seaweed beds are aging year by year similar to farmers in rural areas and people in cities. Traditionally, most of fishers take sea urchins from the boat with hook attached to long pole or bamboo and hydroscope eventually to limit overfishing of sea urchin resources. Since they are not divers, sea urchin removal is not efficient. Some fishery cooperative hire professional divers to take sea urchins to sell them. However, sea urchins that devastated seaweed beds have no commercial value due to lack of ovary. Therefore, it is not economically acceptable for fishry cooperative to hire professional divers to remove such sea urchins. On the other hand, the number of ordinary citizens who are familiar with the sea and wish to use the clean and abundant sea for a long time is increasing, and the number of people who enjoy scuba diving as a leisure activity is increasing. For these reasons, one way to sustainably implement measures against *Isoyake* is to have sensible and motivated volunteer divers participate. In fact, there are areas where volunteer divers are participating in the measures against *Isoyake* in the project for demonstrating the multifunctionality of fisheries. In this section, we will introduce some of these citizen-participating measures against *Isoyake* with fishery cooperatives. However, in some areas, the participation of volunteer divers has not proceeded smoothly due to lack of intermediary between a local fisheries cooperative and volunteer divers and divers' lack of knowledge on rules in a common fishery right area. For example, volunteer divers do not need to obtain permission from a prefectural government to break sea urchins' shells in the water if they have a consent of a local fisheries cooperative to the removal of sea urchins in the sea by scuba diving in its common fishery right area. However, a fisheries cooperative depending on fisheries of abalone and turban shells don't want to consent to scuba diving because it concerns about an increase in poaching. In some cases, volunteer divers have no connection to contact a local fishery cooperative. Thus, there is an important role for Mobile Sea Otter to connect such divers to a local fisheries cooperative instead of them.

2.3.4 Civil organizations and student-led

Other than actors in the public, fisheries, and diving sector, we will now look at initiatives pushed forward by civil organizations and student communities like diving clubs in universities and students from local high schools.

Sotome, Nagasaki Prefecture

Fishers started a seaweed bed restoration organization in 2013. They have been removing sea urchins and herbivorous fish and deploying spore bags in which matured fronds of mother algae were put. However, due to the small number of members and the elderly age of the fishers, the removal of sea urchins from the boat using a hydroscope and a filet was not effective even after multiple attempts. Therefore, after consulting with experts, they decided to recruit the **diving club of Nagasaki University**, which is very mobile, and asked them to participate as volunteer divers.

The students of the diving club were all unfamiliar with *Isoyake* (barren rocky shore), but they learned about the current state of the marine environment. Activities are held twice a year, once in June before spawning season of the sea urchins dominant in this area and once in November after the spawning season, with five to six people participating each time. Although students change members as the year goes by, each time they devise a way to have the next student among the participants to connect with the activity. The club also uses SNS to communicate its activities (*37). Although the students begin their activities unfamiliar with tools such as the hook and hammer to remove sea urchins in the water, they gradually learn the tricks and are able to remove sea urchins efficiently (*4, Chapter 8).

Kimotsuki Town, Kagoshima Prefecture

At the seaweed bed restoration efforts in Kimotsuki Town, Kagoshima Prefecture, sea urchin removal had been done by skin divers from 2006. However, there was a limit to how many sea urchins could be removed with skin diving and therefore from 2008, the students at **Kagoshima Fisheries High School** have been helping with removals by scuba diving. Similar cooperative relations have begun at the **Kyoto Marine High School**. Interaction with students is expected to lead to the development of their successors. In Shakotan Town, Hokkaido, the town and fishers consulted with the professor teaching marine environment at **Otaru University of Commerce** and worked together on the development of technology which utilized the nitrogen, phosphorus, and other components contained in sea urchin shells that aid the growth of seaweed, and developed a fertilizer made sea urchin shells that promotes the growth of seaweed.

These are some of the many other examples of students contributing to initiatives even if they are not the main actors through removal of animals causing *Isoyake*, research, awareness-building etc (*4, p221). In most cases, these activities are possible because of the contacts between fishery cooperatives and teachers of fisheries high schools or a professor of a university introduced by researchers of prefectural fisheries research stations or prefectural fisheries extension office etc.

2.3.5 Others

Moba conservation initiatives can take many other forms with diverse stakeholders. Below we will pick up unique examples of actors joining the effort.

Urchinomics ('Uninomics' in Japan)

It is a company that works to meet increasingly larger global demand in uni (sea urchin roe) with ecologically restorative urchins cultured on land. The company gathers overgrazing sea urchins from barrens, feeds them in shallow rectangular aquaculture tanks on land, then sells the fattened-up results to distributors and restaurants. By 2020, Urchinomics has secured permits and property to operate in Japan, Norway, Canada and the United States (*38). In April 2021, Urchinomics' local subsidiary, Oita Uni Farm, has officially started its operation in Oita Prefecture. Similar to how Urchinomics works to promote seaweed forest restoration/conservation through commercial utilisation of sea urchins, there are plenty of initiatives that also work to find ways to better utilise urchins and other seaweed predators (herbivorous fish etc.) as food or fertilizer (further reading about utilization for feed and fertilizer in the Guideline).

Youtuber: Suichannel

It is of an anonymous person (possibly closely linked with the fishing or diving industry) who has 224,000 subscribers at the time this report was written. His most watched video has had 2.5 million views and he often post videos of sea urchin removal, planting seaweed seedlings, seafloor, and coral clean ups, observing marine organisms and frequently talks of environmental issues which are added into the otherwise light commentary on his hobby and frequent diving experiences (*39).

Hainan, Shizuoka Prefecture c.1997

The Minami-Surugawan Fisheries cooperative in partnership with Chubu Electric Power which has their **Hamaoka nuclear power plant**. This initiative is special in that a large power generating company is involved and that there are at least a dozen large companies cooperating with their efforts. Their projects centre around regeneration of 'Kajime' (*Ecklonia cava*, an edible marine brown alga) installation and management of algae reefs, release of abalone and survey and extermination of herbivorous fish. This initiative is meant to mitigate reduction of seaweed beds for local ing communities suffering the reduction around the nuclear power plant because the cooling water discharged from a nuclear power plant is higher than the surrounding seawater, causing reduction of seaweed beds around the plant.

In Chapter 2.3, we will also go into more detail concerning innovative technologies that are being developed in relation to these measures.

2.4 New technologies and innovative methods

In this section, we will shed light on the current and undergoing developments of new technologies utilized in *Moba* restoration initiatives. As we can see from ongoing initiatives, the *Moba* restoration/conservation efforts have been fragmented and individually trying to figure out what methods and know-how is effective. These experiences and knowledge are sometimes particular to each area, therefore making it difficult for one technology to be proposed as the one-size-fits-all tool. However, with the accumulation of data, methods, and experience – there are emerging methods and technologies that may prove helpful for effective restoration/conservation operations.

2.4.1 Urchin-related innovations

Sea urchin vacuum

The sea urchin suction system is currently being developed by Prof. Yuji Tanaka of Tokyo University of Marine Science and Technology. This system would allow for the efficient and quick removal of sea urchins from the seafloor to above the sea surface onto a boat. The system would use an electric pump to suck the seawater along with the sea urchin which would be sieved through a net and collect the sea urchins. This suction system was experimentally completed. It is needed to conduct the final experiment in situ, which has been postponed due to coronavirus pandemic before the practical use and is scheduled to completed by 2022 (*41).

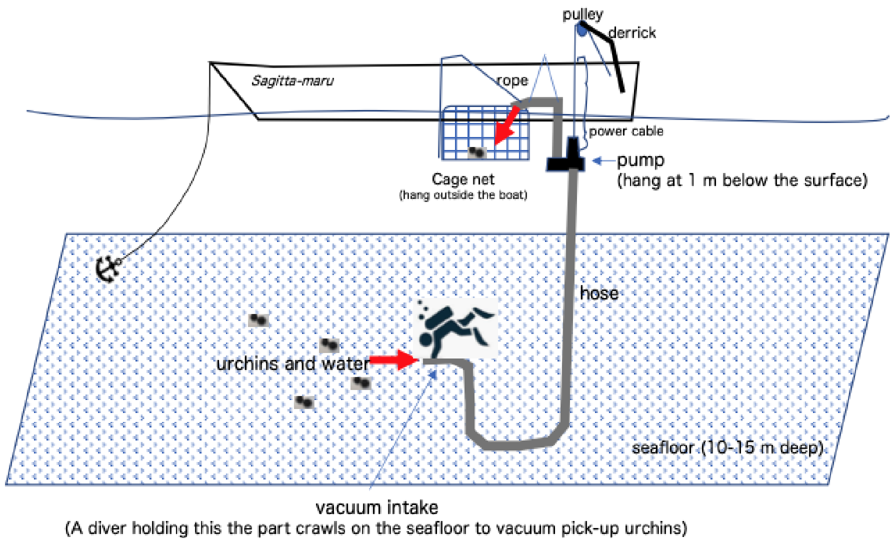

Figure 2-12. Schematic view of sea urchin vacuum system (Tanaka, 2021)

Urchin buster

This is an air compressing machine which shoots air out from a nozzle to destroy sea urchin underwater with one push of a button. It was developed as part of the Fisheries Agency's multifunctional fisheries grant programme by the Sumi Reef Corporation. Currently, they are allowing free rentals of the device to other active groups within the grant programme (*42).

Figure 2-13. Urchin buster used to destroy sea urchins (Sumi Reef Co., Ltd)

Sea urchin identification and removal robot / Sea urchin processing robot

Tokyo University of Marine Science and Technology and NEC Solution Innovator, Inc. have collaborated to efficiently eradicate sea urchins in the rocky shore areas of Miyagi Prefecture under the national project “the development of advanced technologies for the revitalization of food-producing regions” of the Ministry of Agriculture, Forestry and Fisheries of Japan (*4, Chapter 7 and 8). They have collaborated to develop the world's first remote-controlled unmanned underwater vehicle (hereinafter referred to as "robot") that uses AI technology to identify sea urchins and efficiently exterminate them. The robot can identify sea urchins at depths of 10 m or more in the sea.

The maximum suction speed is 1 individual/2 seconds (1,800 individuals/hour), reducing the work efficiency by more than 30% compared to human labour. The robot is equipped with a sea urchin basket that holds 300 individuals at a time.

In addition to this robot, Miyagi University has also developed a robot with an image sensing sensor that remove the sea urchin shell on land under the project. The Miyagi University robot can split the sea urchin shell into 3:2 parts within 42 seconds without damaging the flesh to remove sea urchin shell.

Figure 2-14. Picture showing urchin suction robot bottom (the Guideline, 2021)

Figure 2-15. Pictures showing sea urchin-infused fertilizing rope (the Guideline, 2021)

Sea Urchin-infused fertilizing rope

The town of Shakotan, Hokkaido dispose of about 100 tons of sea urchin shells every year. In order to utilize this resource, the fishers of Shakotan working on seaweed restoration chose to utilize

Figure 2-16. Process of creating and testing fertilizer ropes (Shakotan document from the National Council for the Prevention of Isoyake, 2020)

the fertilizing abilities of sea urchin shells (*4, pp.221-222). This is since sea urchin shells contain high levels of nitrogen, phosphorous, magnesium and other nutrients that are beneficial for seaweed growth. To begin with, they verified the effect of the fertilizer by wrapping seed threads around ropes with ground sea urchin shell powder (fertilizer) and comparing the growth with a rope with no fertilizer. They left the ropes with seaweed seedlings germinated from seeds from November 2018 to April 2019 and found that the ropes with sea urchin shell fertilizer grew maximum 3.8 times heavier than the control rope.

2.5 Case study: Mobile Sea Otters (MSO)'s pilot project

Mobile Sea Otters (MSO), a non-profit organisation was established in 2019 to explore ecologically and economically sustainable ways to restore and conserve the Japanese *Moba*. This section will provide a summary of activities conducted by MSO to share the lessons learnt through them which can be useful for similar projects.

The activities conducted by MSO between 2019 and 2022 can be classified into two main categories: direct restorative activities (culling overgrazing urchins and deploying spore bags) and monitoring research (research on seaweed, urchins, comparison of different predators – urchins vs herbivorous fish, and attempts to quantify CO_2 sequestered by seaweed beds). MSO also engaged in other related activities such as educational workshops and promotional activities to support the main activities.

Direct restorative activities: MSO has worked with various stakeholders, often with professional and volunteer divers, to conduct scuba-diving activities – culling overgrazing urchins and installing spore bags to restore seaweed beds in different locations. While specific methodologies and tools used vary in different projects, the basic approaches were based on the Guideline published by the Fisheries Agency (please refer to Chapter 2.1 for details).

Monitoring research: MSO is focused on deploying effective approaches based on science, thus monitoring research has been a crucial part of the projects to understand the situation of *Isoyake*, identify its main cause and select appropriate countermeasures for each location. As Dr. Teruhisa Komatsu, the representative director of MSO can conduct such monitoring research with his academic expertise in remote sensing, MSO has also worked with external partners, sometimes upon request to conduct research. Methodologies deployed include the following: 1. Scuba diving (photographing, counting numbers and unit sampling of urchins and seaweed), 2. Drop-camera (hanging a camera from a boat, which can take photos and video footage of wider areas), 3. Sonar (similar to Drop-camera, able to capture volume/biomass or horizontal distributions of seaweed beds along a transect across wider areas with echosounder mounted on a boat or sides, can sonar to obtain an image of acoustic bottom hardness with wider range along a transect similar to aerial photography or movie by a drone), 4. Drone (flying a drone to capture the approximate size of seaweed beds), and 5. Satellite image analysis (able to capture much wider areas, also able to obtain historical data from archived satellite imageries and compare chronologically). One or multiple of the above methodologies have been utilised according to the purpose of the study, location characteristics and project budget. Any research project starts with desk research and interviews with local fishers and divers to narrow down the specific research location, scope and make a hypothesis.

In addition, other activities such as educational workshops and promotional activities also played an important role in engaging stakeholders to enable the above activities. Workshops and meetings with direct stakeholders like fishers and divers to explain the situation, project objectives and instructions were necessary at the beginning of each project, while MSO has also engaged in activities for wider audience including leisure divers, youth environmental groups and potential funders, to increase awareness of the importance of *Moba* and the current problem of *Isoyake*.

All of the above activities are related to each other and using a mixture of multiple activity types has become a norm for different projects across Japan. With various projects in different regions over the past two years, the below will introduce three key projects as case studies: Project1: Chronological study - monitoring seaweed regrowth, Project2: Comparison of the influence of urchins and herbivorous fish on seaweed through engagement of volunteer divers and Project3: Large-scale scientific research on seaweed beds and urchins for blue carbon, with key information like activity types, stakeholders, project objectives and results.

Figure 2-17. All locations where MSO conducted activities. Dots represent the regions of Japan in colour.The number in a circle responds to the project described in this section (MSO, xxxx)

<u>Project1: Chronological study - monitoring seaweed regrowth</u>

- Location: Rikuzen-takata, Iwate prefecture
- Stakeholders: Yonesaki Otomo branch of the Hirota Bay Fisheries Cooperative and its fishers, NPO Sanriku Volunteer Divers, local volunteer divers
- Project objectives: To study and document the restoration of kelp forests by regular removal of urchins and instalment of spore bags. The project also aims to collect chronological records including photography, videos and datasets which other groups can also use freely to garner support for future restoration effort.
- Project overview: In March 2020, two squares were set up on the seabed as the study areas, as well as one empty square as comparison. The population density of sea urchins in the square frame areas was recorded, then all sea urchins inside the squares were removed, at intervals of once to twice per month immediately after the installation of the squares and at irregular intervals thereafter. Spore bags containing mature fronds of Kajime (*Eisenia bicyclis*) were installed in October and November 2020 to encourage regrowth of the seaweed.
- Project results: At the beginning of the research, seaweed was not distributed, and sea urchins were dominant in the research area (The population density of sea urchins was 19.3 individuals/m^{2}). After the first few dives, the density of sea urchins in the quadrats was kept less than 5 individuals/m^2 and seaweeds were consistently distributed. We confirmed that if the density of sea urchins is kept below the population of less than 5 individuals/m^2 for northern sea urchins, seaweed will grow, as suggested by the Guideline. In the post-project observation in June 2021, the difference was visible among the quadrats – two squares from which urchins

were removed saw various kinds of seaweed back in flourish, as well as large abalones and some shells. On the other hand, one control quadrat still had high density of urchins and little seaweed.

(image: 8. 広田湾モニタリング位置)

Project2: Comparison of the influence of urchins and herbivorous fish on seaweed through engagement of volunteer divers

- Location: Tateyama, Chiba prefecture
- Stakeholders: Tateyama Fishery Cooperative branch, local diving shop Marine Snow, volunteer divers
- Project objectives: The main objective of this project was to conduct a small study to find out how much overgrazing urchins and herbivorous fish influenced the *Isoyake* situation in the area. With the location easily accessible from Tokyo, increasing engagement and education of new volunteer divers was also an important part of this project.
- Project overview: In October 2020, 9 underwater research areas, sized 4 m^2 each were installed: 3 with nets to avoid both urchins and herbivorous fish, 3 to avoid only urchins and 3 control areas as comparison. The project consisted of a pre-project educational workshop, 5 days of urchin removal and 2 days of instalment of spore bags, with regular monitoring and additional check-up dives, all supported by a group of volunteer divers.
- Project results: Due to some strong waves during winter 2020-2021, the research nets were severely damaged, with some holes where animals could enter the monitoring areas – thus, the result of the monitoring research was not successful. This lesson is invaluable in making improvements for future projects: building stronger nets and securing them to seabeds to endure strong waves. Also, growth of seaweed including young Kajime (*Ecklonia cava*) were witnessed around the study areas, following removal of urchins and deployment of spore bags in the previous autumn. The project was also highly successful in recruiting new volunteer divers, who were both passionate about the cause and skilled enough to participate in diving activities.

(image: 3. Tateyama spore bags 4. Tateyama spore bags 2)
(image 9. Tateyama monitoring 10. Tateyama monitoring results)

Project3: Large-scale scientific research on seaweed beds and urchins for blue carbon

- Location: Kunisaki, Oita prefecture
- Stakeholders: Kunisaki, Kunimi and Nagoya Fishery Cooperative branches, Oita Uni Farm, Urchinomics, ENEOS, Kitazato university and professional divers
- Project objectives: Oita Uni Farm, the subsidiary of Urchinomics (introduced in chapter 2.2.5), began its operations in the area in April 2021: removing sea urchins from the sea urchin barrens and restoring the seaweed forests in an ecologically restorative way by controlling the population density of sea urchins, while at the same time farming the removed sea urchins in onshore facilities. This research project has been conducted to understand the current situation of the seaweed beds and urchin density in the area, and to regularly monitor the restoration progress anticipated as overgrazing urchins are caught through Oita Uni Farm's business over the years. The project, funded by the Japanese leading energy company ENEOS, will also aim to quantify the amount of CO_2 sequestered in this region and utilise this dataset for calculation of blue carbon credit, which makes this research project the first of its kind in Japan.

- Project overview: MSO, with scientific expertise of the representative director Dr. Teruhisa Komatsu, planned and supervised this research. The research is conducted in different seasons throughout the year – Late spring when seaweeds flourish, and summer/autumn when annual seaweeds decrease or disappear because dominant seaweeds are *Sargassum* species of which luxuriant seasons are spring. A mixture of research methodologies has been employed – scuba diving, drop-camera, sonar, drone, and satellite image analysis. The sonar study was supported by Prof. Ken-ichi Hayashizaki of Kitasato University. This comprehensive approach enables collection of various datasets such as seaweed bed area, type s and biomass of *Moba*, population density of sea urchins and estimated the total number of urchins.
- Project results: This project is a good example of how a non-profit organisation can engage various stakeholders through a blue carbon project, through which MSO was able to garner financial support as well. The project is still ongoing at the time this report was written, with the results of this research to be published on MSO's website (*4) [1] upon completion. The abstract of this study using sonar analysis will be published on the proceedings of Autumn Conference of the Japanese Society of Fisheries Science by Hayashizaki's team[2] in September 2021.

(image: 5. Kunimi-tsubogari 6. Kunisaki monitoring 7. Kunisaki sonar-research)

As shown by the selection of initiatives and MSO's project case studies introduced in Chapter 2, the projects to restore *Moba* can take many different forms. The question that remains is: how can we together connect and scale up these existing efforts and create a momentum into the future?

As the writer of this paper, our lessons are mostly learnt through MSO's project activities, some specific to the project but most are relevant for other groups working on restoration of *Moba* as well. We have taken from these lessons the keys to success and opportunities, which will be discussed in detail in chapter 3.

[1] Mobile Sea Otters website (https://rakkotai.org/en/)
[2] The Japanese Society of Fisheries Science (https://jsfs.jp/en/)

photo credit: Yudai Tsubone

3.

PROPOSALS
TO ACCELERATE COLLECTIVE EFFOTS IN JAPAN

MOBILE SEA OTTERS

3. Proposals to accelerate collective efforts in Japan

3.1 Overview

We would like to conclude by summarising challenges/keys to success and highlighting emerging opportunities that we have identified in this section as recommendations for further development of *Moba* restoration efforts.

In Japan, due to its ecological characteristics, *Moba* restoration is a long-term project, typically said to require at least three years of regular activities before results can be anticipated. In many cases, even after certain success is achieved, it is not the end of the restoration, and *Moba* conservation needs to be continued, otherwise the restored *Moba* can go back to the *Isoyake* state unless causes of *Isoyake* are removed. It is crucial that any project starts with a clear goal and objectives, flexible planning and equip with sufficient resources, especially funding. And even with that, results are not guaranteed, for example, due to typhoon that destroys fences – thus improving awareness of the importance of *Moba* as part of the wider marine environment, which is not controllable by human, as well as securing flexibility within each project is important.

3.1.1 Challenges / keys to success

This section will summarise challenges and keys to success, identified through lessons from MSO's previous activities (Chapter2.3). This list is by no means exhaustive, but they are the significant factors to take into consideration when planning and executing restoration projects. Although these lessons were learnt through MSO's individual activities, we strongly believe there are common factors also applicable thus insightful to other non-fisher groups, particularly non-profit organisations, and citizen-led groups, to engage in *Moba* restoration in Japan.

To establish collaborative relationships with various stakeholders

This is certainly the most important factor when working on restoration efforts in Japan. There is no one-fits-all solution or collaboration model that can be applied to different projects – it is crucial to understand the regional diversity and characteristics and respect the "local rules".

- Fishery cooperatives/fishers: Any activity in the coastal waters very near to the shore in Japan requires some form of consent of a local fisheries cooperative /permission of prefectural government or cooperation -official or unofficial- from fishery cooperatives and fishers. However, they are often difficult to approach for non-profit environmental organisations. This is also the stakeholder group with potentially the largest regional differences, in both their 'hard' characteristics (such as fishing regulations including fishing methods, tools, seasons, sizes of resources and areas allowed, managed by each prefecture and/or each fisheries cooperative branch) and 'soft' characteristics (such as their cultural traits, personalities and who has the decision authority within the organisation, etc.). One useful approach may be to work with locally trusted diving shops and local conservation activists as residents of an area of interest with a strong connection with a fisheries cooperative that can serve as 'mediators'.
- Diving shops/diving instructors: Recently, an increasing number of diving shops and instructors are already engaged or interested in conservation of marine environment and seagrass and seaweed forests – this makes them strong allies for restorative projects. In Japan, even for leisure-purpose scuba diving, consent of the local fisheries cooperative branch to scuba diving is necessary, thus most diving shops are likely to have already-established relationships with them. Restoration groups can also coordinate safety management and insurance with diving shops.
- Volunteers: There is a high level of interest in the marine environment amongst divers, and recently, there are a small number of divers, especially among the younger generation, who started

scuba diving because of their desire to participate in environmental restoration activities. The cooperation of such passionate volunteers is both necessary and encouraging for *Moba* restoration projects. However, there are limitations related to scuba-diving activities: high expenses, safety management and skills required due to the high risk involved, and their commitment (availability and locations). These are challenges the organisation receiving volunteer divers needs to overcome, which otherwise prevents welcoming a wider group of volunteers into the projects.

- Corporations: In recent years, with the increase in interest in blue carbon, companies in the energy and other industries which are traditionally not related to the sea, have also become increasingly interested in *Moba* conservation (Chapter 3.1.2).

To secure sufficient, sustainable, and long-term funding

In Japan, there are only a limited number of grants and donations available for non-fisher groups to engage in marine environmental conservation including restoration of *Moba*. Available local grants are often smaller amount (less than 1 million yen per year), for a short period (typically one to two years) or restricted in their use (e.g. they cannot be used for staff wages or general overhead costs to maintain the organisation), which makes it difficult for non-fisher groups to plan and execute meaningful projects over a long period of time. *Moba* restoration requires a large sum of direct and indirect costs in order to deploy scientifically valid restoration methods and ensure safe activity, particularly involving scuba-diving. Length and flexibility of use should also be considered, as restorative efforts are typically multiple-year projects and there are often unexpected changes. Therefore, it is essential to secure sufficient, long-term, and flexible funding sources, and activity groups need to seek alternative sources of funding including corporate sponsorship, income through profitable projects, or grants from outside Japan to name but a few.

To sustain robust organisation

As discussed above, restoration of *Moba* requires long-term approaches, and robust organisational structure is necessary to take care of back-office aspects including finance and legal matters. Each prefecture has its own special requirements for the Special Catch Permit, which is legally required for field studies and restoration/conservation activities involving the collection or culling of marine organisms including urchins and seaweeds. Therefore, the organisation engaged in such activities needs to prepare the application form to a prefectural government contacting a prefectural officer in charge of permission and fisheries cooperative. For the safety of the volunteers, it is important to fully prepare insurance and materials including consent forms and indemnity documents etc., and the pro bono support from legal professionals was extremely useful. Mobile Sea Otters has received legal support from the pro-bono team at Nishimura&Asahi, through TrustLaw, global matching platform for non-profits and legal professionals, provided by Thomson Reuters Foundation. This collaborative project won TrustLaw Innovation Award 2020 (*40).

To increase awareness on the importance of *Moba*

The low awareness of the importance of *Moba* for ordinary people, especially in cities, in Japan is one of the major barriers faced by groups working on restoration. One of the main reasons for this is that the younger generation is becoming less and less interested in the sea. Wider and correct understanding of *Moba* ecosystems that are invaluable to our livelihoods will lead to smoother settlement of other factors mentioned above as well, especially engagement of diverse stakeholders and securing funding. Therefore, it has become even more important to educate the public about the importance of *Moba*.

3.1.2 Opportunities / proposal

This section will highlight three key opportunities we have identified that restoration projects in Japan can leverage to maximise the collective impact moving forward.

Rise in interest in Blue Carbon, especially its offset credits

In October 2020, the Japanese government announced its target to make Japan Carbon Neutral by 2050 (*43). There are also closer goals that Japan is committed to, including the reduction of greenhouse gas emissions by 26% from 2013 levels by 2030. Although many companies had engaged in carbon reduction efforts before these targets, the ambitious 2050 Carbon Neutral target puts a lot more pressure on corporations, that are now seeking new technologies to lower and means to offset their carbon emissions. As a result, there is a rise in interest in potentials of blue carbon among corporations, especially its offset credits and economic benefits, which are not yet widely in place in Japan but anticipated to be introduced soon. This rapidly increasing trend makes it easier for *Moba* restoration projects to engage corporations, which may signify increasing potential for restoration projects to secure funding and engaging other stakeholders as a result. Within the framework of blue carbon, with its tangible economic incentives, it may be easier to involve a variety of stakeholders such as fishery cooperatives and fishers, and clear up rights issues, which are often problematic in conservation activities, including obtaining permission to start such efforts.

Better utilisation of culled animals

As introduced in chapter 2, there is an increasing number of initiatives by start-up companies and prefectural fisheries experiment stations to utilise too many of animals that make *Moba* barren like overgrazing urchins and herbivorous fish that eat up seaweed. Particularly, urchins are premium delicacy widely enjoyed in Japan and overseas, and there are technologies already in place that can better utilise urchins which are otherwise culled and discarded in the *Moba* restorative activities. If these initiatives can process overgrazing urchins at a larger scale, there is a large potential for restoration projects to obtain sustainable sources of income through them. On the other hand, utilisation of herbivorous fish causing *Isoyake* currently has lower potential mostly due to the fish species not widely consumed by Japanese and low profitability as a result. As well as informing consumers that these fish are delicious and increasing consumption, there are other uses such as animal feed and fertiliser. For example, Kanagawa Prefectural Maritime High School has developed Isoyake burger made from herbivorous fish, Mottled spinefoot (*Siganus fuscescens*) and sold it at Yokosuka Fish Festival since 2017 (anon., 2020). However, other ways of utilisation like animal feed and fertiliser can be more encouraged.

Acceleration of network and collaboration

There are already many active groups in Japan working to restore/conserve *Moba* as introduced in this paper, but network and collaboration among different groups are still limited. As the different sets of the same restoration methods are often employed, existing and new groups will greatly benefit from sharing accumulated know-hows on methods and operations suitable for their target locations and advice amongst each other. Moreover, working within the nature of the sea, it is difficult to carry out activities according to the pre-made plans: there are many unforeseen changes in sea conditions and unexpected discoveries in the environment. The best way to overcome this is to build a flexible team consisted of local members who know the sea in the area well and located close by to be able to respond to sudden changes. Thus, it can be argued that the most ideal model of *Moba* restoration in Japan may be many small groups to take care of their local sea areas as they already are, while maintaining a collaborative network.

Wider application of scientific approaches may be one additional factor to accelerate such collaboration: although this paper has argued that scientifically effective approaches are crucial to make restoration efforts successful, it is not always accessible for all groups. Organisations like MSO that has received the scientists' help can share the expertise with other groups. We hope publishing this paper and sharing our lessons will be a step in the right direction.

One strong outlook to encourage collaboration among different stakeholders is to create a nationwide open consortium that welcome a variety of stakeholders, where both tangible resources like funding, innovative tools and experienced divers and intangible ones including knowledge and advice are actively shared. The stakeholders can include restoration groups, fishers and fishery cooperatives, divers and diving shops, corporations, scientists, universities, other educational institutions, and students, as well as any other groups and individuals interested in the cause. In the future when fishing communities shrink in numbers, it is of utmost urgency to create a structure where participation from non-fishing communities like non-profit organisations and passionate volunteers is encouraged. Finally, the ambitious proposal may be for seabed where *Isoyake* problem is recognised and not utilised for fisheries, to be registered as "*Isoyake* seabed areas" where *Moba* restoration activities are allowed and treated of the highest priority.

Final Remarks

The causes of *Isoyake* are many and varied, including feeding damage by various organisms such as sea urchins and herbivorous fish as well as many other complex factors including rising sea temperatures, etc. Restoration efforts, despite a lot of effort and resources required, do not always come with guaranteed results. However, the greater benefits and importance of *Moba* outweigh the difficulty of these challenges, which leaves many of us motivated to tackle these challenges.

Isoyake, the decline of seaweed beds, is such a severe problem impacting Japan and its wider ecosystems, fishing communities and all of us citizens. Despite the many challenges, immediate and persistent actions are required. To enable this, collaboration among existing activity groups and various stakeholders is necessary, as this paper has repeatedly argued.

The IPCC's Sixth Report, just released in August 2021, reaffirmed the seriousness of the climate crisis and was the first to report on the certainty of its impact on humanity. As the SDGs gain momentum, the attention and commitment of the general public and businesses is also increasing, along with the seriousness of the climate crisis and environmental destruction. However, despite the fact that the conservation of the "sea forest" seaweed beds, which are closely linked to the marine ecosystem, the fishing industry and the climate crisis, is an issue that cannot wait, there is currently a huge gap between the general public and those in the fisheries sector in terms of the urgency of the matter and the level of progress and awareness of the issue.

In a country like Japan, with its unique culture and long history of close contact with the sea, the preservation of the sea and its natural environment has been carried on by the local community without the need to speak loudly about "environmental preservation". This can be seen in the various documents, the culture of women divers, and the current system. This report also points out that there are some aspects of Japan's environmental restoration/conservation efforts that have not caught up with international standards, but there are many efforts that Japan has made on its own that should not be underestimated and should continue to be explored. However, in the midst of environmental changes such as the decline in the population of fishers, there are many systems that are no longer functioning properly, and it is a fact that the cooperative systems and paths for the restoration/conservation of *Moba* need major changes. From now on, we would like to create a form in which fishers, officers of local and central governments, the general public, volunteer divers, researchers, non-profit environmental organisations such as ourselves, and companies can work together to restore/conserve *Moba*. Only in this way will we be able to sustain the long-term, time-consuming, labour-intensive, but meaningful activities to protect the *Moba*.

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Figure 1-3 Modified from Hori 2020
Figure 1-4 Image taken by Yuiko Mitani
Figure 1-5 International EMECS Centre. (August, 2021). Progress Report on "Document survey and field inquiry on barren rocky coasts caused by sea urchin predation in Japan, and exploration of potential solutions"
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Figure 2-10 Image taken by Diving Shop NANA
Figure 2-11 Image taken by Sanriku Volunteer Divers
Figure 2-12 Yuji, Tanaka. (2021). "Development of vacuum cleaning system with an underwater large volume pump to remove sea urchins" Tokyo University of Marine Science and Technology.
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Figure 2-17 MSO locations
Figure 2-18 MSO activities tables

Appendix

Translation list

Japanese Terms	English Terms
藻場　Moba	Submerged aquatic vegetation Seaweed and seagrass beds Sea forest
磯焼け Isoyake	Sea forest denudation Barren rocky shore
水産多面的機能発揮対策事業	Measures to demonstrate the multifunctional role of fisheries 'Multifunctional fisheries grants'
漁業組合	Fishery cooperative associations 'Fishery cooperatives'
全国漁業協同組合連合会 全漁連	National Federation of Fisheries Cooperative Associations 'JF Zengyoren'
水産庁	Fisheries Agency
漁師	Fishers
漁業権	Fishing rights
共同漁業権	Common fishery right
磯根漁業	Rocky shore fisheries
ガラモ	*Sargassum* beds/forests
アラメ	Eisenia bicyclis
昆布　コンブ	Kelp Kelp genera laminaria

アマモ	Eelgrass *Zostera* species. In Japan *Zostera marina* is the dominat species among eelgrasses. Sea grass
ウニ	Sea urchin, [Echinoidea]
アイゴ	Mottled spinefoot Siganus fuscescens
ノトイスズミ	Southern drummer Kyphosus bigibbus Lacepède
ブダイ	Japanese parrotfish Calotomus japonicus
素潜り	Skin diving
海女	'Ama' Female divers

General Incorporated Non-profit Association

Mobile Sea Otters

https://rakkotai.org/