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Satoumi Science

Co-creating Social-Ecological Harmony Between Human and the Sea

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Cover illustration: The classic fishing gear: stone tidal weir in Shiraho, Okinawa, Japan.

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Preface

"Satoumi" is rather recent term in Japan, first formally appearing in the documents in 1998. "Sato" means the area where people live and "umi" means the sea in Japanese. The Ministry of the Environment, Japan, once described Satoumi as "coastal sea areas in which there is a harmonious coexistence of Nature and human-being." In many parts of Japan, people put effort to create Satoumi. This movement is spreading not only in Japan but also throughout the world. These Satoumi are extremely diverse, and it is difficult to capture them with a single definition or perspective. The primary aim of this book is to analyze the various types of Satoumi in Japan and around the world from multiple perspectives, including technology, institutions, and culture, and to clarify what Satoumi is and how it can be created.

The most commonly used definition of Satoumi in Japan is "high productivity and biodiversity in the coastal sea with human interaction (intervention)" by Tetsuo Yanagi, an editor of this book. When he proposed this definition, he was criticized by some ecologists who said, "in Satoyama (yama means the mountain in Japanese), biodiversity increases with human intervention, but in coastal areas, biodiversity decreases with human intervention." In response to this criticism, Yanagi conducted case studies across Japan and experiments in coastal waters. As a result, he found that it is possible to increase the biodiversity and productivity of coastal waters with human intervention in an adaptive manner. I also conducted research in Okinawa and found many cases where human intervention increased the biodiversity and productivity of coastal waters.

However, can we not call coastal areas Satoumi unless biodiversity and productivity increase with direct human intervention? I believe that the most important aspect (essence) of Satoumi, rather than a definition, is that the ecosystem functions of coastal waters are enhanced through environmental conservation and resource management in which local people are closely involved. This aspect is in contrast to the historical Western concept of environmental conservation and resource management that eliminates human influence as much as possible.

Taking the coral reef conservation as an example, activities such as coral restoration and crown-of-thorns starfish extermination that require direct human

intervention are called active measures, while activities such as measures against red soil pollution and excess nutrients are sometimes called passive measures. The passive measures are not inactive activities, and such activities are often more important for environmental conservation. For the active measures, it is easy to understand the relationship between humans and the sea. Alternatively, for the passive measures, including measures against pollution from land, fisheries resource management, improvement of fish distribution, and institutional systems, it is not easy to understand the relationship between humans and the sea. However, I believe those passive measures are deeply related to the essence of Satoumi. A feature of this book is to focus on both the active and passive measures of Satoumi creation.

This book is a fruit of a five-year project conducted by the Research Institute for Humanity and Nature from 2012, entitled "Creation and Sustainable Governance of New Commons through Formation of Integrated Local Environmental Knowledge." This project elucidated the mechanisms for managing the various benefits (ecosystem services) that ecosystems provide to us, such as biological resources, based on the knowledge bases of the various people involved in their use. Satoumi is one of the important themes of the project, and some of the authors of this book were members of the "Satoumi and Fisheries Resource Management Task Force," of which I was the leader.

This book analyzes Satoumi in five regions in Japan and four countries overseas and is not just a collection of case studies, but also analyzes and clarifies diverse Satoumi from various perspectives. I hope that it will help readers understand the concept of Satoumi, which is an environmental conservation and resource management concept originated in Japan.

Saga, Japan — Shinichiro Kakuma
Fukuoka, Japan — Tetsuo Yanagi
Matsuyama, Japan — Tetsu Sato

Contents

Chapter 1
Prologue: What Is Satoumi?

Shinichiro Kakuma and Tetsu Sato

Abstract Satoumi contributes to achieve various Sustainable Development Goals (SDGs) and is relevant to the Convention on Biological Diversity (CBD) mandate. The definitions of Satoumi are highly variable, but "activities and processes of environmental conservation and resource management in coastal areas with involvement of diverse people inside and outside coastal communities" would be the most overarching definition of Satoumi creation. Satoumi creation requires Satoumi science as a transdisciplinary science in extremely complicated and highly uncertain social-ecological systems. This book focuses on the process in which residential researchers and bilateral knowledge translators use integrated local environmental knowledge (ILEK) to support Satoumi creation. This book comprises four parts. Part I summarizes history and the global impact of Satoumi and roles of women in Satoumi in three chapters. In Part II, cases in Shiraho and Hinase (Japan) and Indonesia are introduced. Part III introduces cases in Okinawa City (Japan), Malawi, and Fiji. Part IV introduces cases in Onna Village and Kashiwajima (Japan) and Florida (USA).

Keywords Satoumi definition · Active measures · Passive measures · Transdisciplinary science · Residential researcher · Knowledge translator

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1.1 Significance of Satoumi in the World

Coastal areas, ecosystems, biodiversity, and fishery resources have been devastating worldwide because of diverse reasons. To solve this problem, not only top-down efforts by governments and organizations at various spatial scales and governance levels but also bottom-up activities that local people take initiative are required. The Sustainable Development Goals (SDGs) proposed by the United Nations in 2015 and the Convention on Biological Diversity (CBD), to which 196 countries are currently signatories, suggest the need to protect the world's coastal ecosystems, biodiversity, and fisheries resources. We believe Satoumi contribute to achieve various SDG targets including SDG 14 "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" and there is obvious relevance of Satoumi to the CBD mandate (see Chap. 3).

Of the 120 million people in the world whose livelihoods depend on fisheries sector, including fish distribution, 90% are involved in small-scale fisheries. Ninety percent of these people live in developing countries, and 95% of their landings are consumed locally. Fifty percent of these people are women, and about six million live in poverty, earning less than US$1 a day (FAO 2015).

Indigenous peoples in coastal areas depend on the landing of these small-scale fisheries for their lives, and a study of 1900 coastal communities (27 million people) in 87 countries (Cisneros-Montemayor et al. 2016) found that indigenous peoples consume about two million tons of seafood annually (2% of the global total). The per capita consumption was 15 times higher than that of non-indigenous people.

These small-scale fishers and indigenous peoples are vulnerable to environmental and socioeconomic changes and can easily lose their livelihoods if coastal ecosystems, biodiversity, and fisheries resources are not properly managed. They can, under certain conditions, be effectively managed as common pool resources (commons) of the communities (Ostrom 1990). One of the objectives of this book is to analyze the process of effective management of the commons using Satoumi concepts and approaches developed in Japan and around the world.

1.2 Definition of Satoumi

Satoumi processes are embedded in social-ecological systems composed of multidirectional interactions between diverse people in coastal communities and ecosystems, with huge complexities and uncertainties (Berkes et al. 2003; Folke 2007; Ostrom 2009). Diverse actors/stakeholders are involved in these complex systems to interact from different contexts, history, and worldviews. Satoumi bears different meanings and values among relevant actors, resulting in a wide variety of perceptions about coastal social-ecological systems. Therefore, the definitions of Satoumi would also be highly variable reflecting complexities of the Satoumi.

In 2009, a joint research meeting on Satoumi which one of the authors (Kakuma) represented was held at Kyushu University. During this research meeting, 13 people who are involved in Satoumi creation in various parts of Japan announced their own definitions of Satoumi, which were diverse enough reflecting complexities of social-ecological systems. Among them, Osamu Matsuda who has been deeply involved with Satoumi in the Seto Inland Sea suggested that we should respect various ideal ways of involvement between people and the sea, rather than establishing exclusive definitions (Kakuma 2011). Subsequently, Matsuda explained that the term Satoumi is a comprehensive concept prescription, which is widely recognized but cannot be easily defined in specific terms, just like the term "wise use" (Matsuda 2013). Whereas the most typical aspect of Satoumi consists of activities intended to enhance biodiversity and productivity by direct human intervention in coastal areas, these activities are not all of Satoumi creation. It is important that people are closely involved and implementing environmental conservation and resource management in coastal areas. "Activities and processes of environmental conservation and resource management in coastal areas with involvement of diverse people inside and outside coastal communities" would be the most overarching definition of Satoumi creation.

Let us go over the active measures and passive measures (Berque and Matsuda 2011) for Satoumi creation appeared in Foreword once more. Active measures are literally the activities in which direct human intervention is implemented. On the other hand, passive measures are less clear the relationship between people and the sea. In many cases, government organizations also support active measures when it comes to projects related to Satoumi. The fisheries multi-functionality program in Japan started by the Fisheries Agency in 2013 supported activities that fishers led to protect seagrass and algal beds, tidal flats, coral reefs, and inland waters. Almost all activities in the list were active measures except for monitoring. For example, activities to protect coral reefs included coral planting, crown-of-thorns starfish extermination, and seaweed removal, while activities to protect seagrass and algal beds included the removal of predators such as sea urchins and rabbit fish, cleaning of bedrock, and providing matured algae and seagrass planting. However, the "Satoumi Creation Manual" published by the Ministry of the Environment of Japan (Ministry of the Environment, Japan 2011a) defined that reducing the volume of land-based contaminants flowing into the sea and establishing no-take zones (passive measures) were also human interventions. In other words, human interventions include direct interventions (active measures) and indirect interventions (passive measures). It is important to properly combine these active and passive measures for the Satoumi creation. Most of the nine regions of Satoumi creation introduced in this book are successful cases of such combinations.

1.3 Satoumi Science as Transdisciplinary Knowledge Co-production

Satoumi creation requires not only interdisciplinary sciences that integrate natural sciences, social sciences, and humanities but also transdisciplinary sciences incorporating co-design of research agenda, co-production of integrated knowledge, and co-delivery of research outcomes in collaboration with diverse actors/stakeholders outside academia (Mauser et al. 2013; Sato 2020). In the dynamic and adaptive processes of transdisciplinary science, scientists, experts, and local stakeholders closely collaborate with each other in all stages of research with the aim of solving complicated challenges that are difficult to deal with. As opposed to conventional discipline-based sciences which are driven by the curiosity of scientists subdivided into fields of expertise aiming at the development of science itself, transdisciplinary science can be characterized as issue-driven and solution-oriented sciences driven by real-world problems, with the aim of integrating diverse knowledge sets emerging among stakeholders including academia (Sato et al. 2018b). The transdisciplinary co-design, co-production, and co-delivery processes are also capable of mobilizing both scientific and societal processes in parallel, simultaneously producing academic and societal impacts through adaptive processes and mutual learning (Lang et al. 2012).

Social-ecological systems are extremely complicated and highly uncertain, and challenges that the social-ecological systems in Satoumi areas face are also extremely complicated, ill-defined, and extremely difficult to solve with diverse trade-offs and synergies ("wicked problems"). This is why solving problems in Satoumi areas is not easy when scientists and experts from outside the community define the problems and implement research without the involvement of the local people. It is the local people who understand the real nature of the complicated local problems the best. With the premise that the local people act as the main entity in devising the solutions, making decisions, and putting them into actions, science should provide support for them (Sato 2020). Accordingly, scientists, experts, and other actors from outside the community should collaboratively think about the problems in Satoumi with local stakeholders and learn from each other to define the problems, produce knowledge, and put the research results into action together. We propose that we call the transdisciplinary science to promote knowledge co-productions to provide solutions in Satoumi through adaptive processes as "Satoumi science."

1.4 Books and Articles on Satoumi Thus Far

The results of the pioneer research on Satoumi by Tetsuo Yanagi are summarized in *Satoumi Theory* (Yanagi 2006) and *Satoumi Creation Theory* (Yanagi 2010). Eight authors including Tamiji Yamamoto compiled a comprehensive guide titled "Satoumi—New Concept for the use of Coastal Seas," under the supervision of

the Japanese Society of Fisheries Science (Yamamoto 2010). Also, the Japanese Society of Fisheries Science put together a special issue titled "My idea, sense, and approach to Satoumi Part I/Part II" in their journal and introduced a collection of opinions from 12 experts (Japanese Society of Fisheries Science 2013, 2014). Concerning the cultural aspect of Satoumi, Fukashi Setoyama wrote "Living in Satoumi" (Setoyama 2003), while Toshihide Innami and others compiled "Nature and Life of Satoumi—Past, Present, and Future of Ocean and Lake Resources" (Inami 2011). In addition, concerning the institutional aspect, Mitsuru Nakajima wrote "What Is Satoumi: Coastal Fisheries Use and the Uses of Local Rules," while Takashi Hidaka compiled "Satoumi and Coastal Area Management—Managing Satoumi" (Hidaka 2016).

Similarly, outside Japan, many articles were published at the International Satoumi Workshops, which have been held every year somewhere in the world since 2008 (the workshop reports can be obtained from the International EMECS Center website n.d.), and the Secretariat of the Convention on Biological Diversity published their 61st technical report that introduced Satoumi in ten coastal regions in Japan (SCBD 2011).

The primary difference between these books/articles and this book is that this book deeply analyzes the diverse problems and challenges of Satoumi areas within and outside Japan by looking Satoumi with different angles through the lenses of diverse stakeholders including scientists. Many of the authors of the chapters are not university researchers but those who are involved in the creation of Satoumi in local communities in various positions, from NPO workers to a fisher, a fisheries cooperative worker, an employee of food processing company, researchers at private research institutes, and researchers working for the central or local municipalities.

1.5 Integrated Local Environmental Knowledge Project

This book is based on the outcomes of an international transdisciplinary research project titled "Creation and Sustainable Governance of New Commons through Formation of Integrated Local Environmental Knowledge" (ILEK project), funded by the Research Institute for Humanity and Nature, Kyoto, Japan, and conducted from 2012 for 5 years (Sato et al. 2018a). The concept of the integrated local environmental knowledge (ILEK) developed in this project has its roots in accumulation of analyses of knowledge systems in local communities including traditional ecological knowledge (TEK Berkes 2008, Berkes et al. 2000) and local ecological knowledge (LEK, Olsson and Folke 2001). These analyses have mainly focused on typologies of the knowledge systems to indicate the importance of alternative knowledge systems to supplement the limitations of scientific knowledge productions. In contrast, ILEK strongly focuses on dynamism of knowledge co-production in the transdisciplinary processes, with clear perspectives to develop solutions in the complex social-ecological systems by integrating heterogeneous knowledge systems from academia and other diverse sources including traditional, culturally specific,

experience-based knowledge systems (Sato et al. 2018b). Dynamic and adaptive transformation of ILEK through collaborations among diverse knowledge producers provides bases for collaborative decision-makings and collective actions to tackle with "wicked problems" associated with Satoumi creation processes.

In the research in ILEK project, we identified and analyzed the roles of important actors in the transdisciplinary processes: residential researchers and bilateral knowledge translators. The term residential researchers refers to the researchers who reside and base themselves in a certain local community and become a member of the local community simultaneously as being an expert to produce scientific knowledge (Sato et al. 2018b). Bilateral knowledge translators are defined as the persons, organizations, or groups that play the role of bridging the gap between heterogeneous knowledge systems and technologies (including social technologies) emerging from diverse framing by creating their new meanings (Sato 2016; Sato et al. 2018b). Driven to solve local issues, they reorganize and compile diverse scientific knowledge and assist the process of using the knowledge for mobilizing collective actions among diverse actors/stakeholders. Simultaneously, they play the role of widely communicating the wisdom and ingenuity that various local stakeholders have gained through their actions aimed at solving the issues. This book also focuses on the process in which residential researchers and bilateral knowledge translators use ILEK to support Satoumi creation. The roles of residential researchers are discussed in detail in Chap. 12, while the roles of bilateral knowledge translators are examined in Chap. 9.

1.6 Structure of This Book and Outline of Each Chapter

This book comprises four parts. Part I titled "Significance of Satoumi Concept and Growing Satoumi Actions" summarizes history of the global spread of activities for Satoumi creation, the global impact of the Satoumi concept, and roles of women in Satoumi in three chapters. In Part II titled "Enhancing Ecosystem Function by Direct Human Intervention," cases in Shiraho in Okinawa Prefecture, Hinase in Okayama Prefecture, and Indonesia where active measures are being implemented for Satoumi creation are introduced. Part III titled "Managing and Enriching Coastal Resources" introduces cases in Okinawa City in Okinawa Prefecture, Malawi in Africa, and Fiji in the Pacific where fishery resource management is implemented as passive measures. Part IV titled "Building Broader Connections Between People and the Sea" introduces cases in Onna Village in Okinawa Prefecture, Kashiwajima Island in Kochi Prefecture, and Florida in the United States where promotion of interactions between local and urban areas and cooperation between divers and fishers and between professional scientists and citizen scientists are being implemented.

1.6.1 Part I: Significance of Satoumi Concept and Growing Satoumi Actions

Chapter 2, "The History and Future of Satoumi Concept," summarizes the history of the emergence and spread of the Satoumi concept in Japan as well as outside Japan with its future perspectives. Although activities for Satoumi creation had already been conducted in various regions in Japan, the first time the term "Satoumi" appeared in journal articles and books was in 1998 when Tetsuo Yanagi, the author of Chap. 2, described it. Many marine policies in Japan started to take up the concept of Satoumi following these publications. In particular, the Ministry of the Environment established projects titled Satoumi creation and compiled a manual for creating Satoumi. Satoumi is also spreading to outside Japan.

Although the Satoumi concept initially received criticism due to differences in the ways of thinking between Western countries and Japan/Asia on environmental conservation and resource management, the concept was gradually accepted afterward. Since 2008, the International Satoumi Workshop has been held annually somewhere in the world. Chapter 2 also provides a theoretical analysis of similarities and differences among Satoumi, EBM (Ecosystem-Based Management), CBM (Community-Based Management), MSP (Marine Spatial Planning), and ICM (Integrated Coastal Management). Furthermore, the chapter logically and empirically discusses the process of improving the material circulation in coastal areas through Satoumi creation in the future.

In Chap. 3, "Global Effect of the Satoumi Concept: Harmony of Human Society with the Ocean Biome," the global impact of the Satoumi concept is analyzed from the viewpoint of Westerners. Western and Asian philosophies for the interactions of humans and nature have, at least in the past, exhibited differential approaches. A major theme of historic Western environmental philosophy is human separation from nature, with humans and nature comprising two separate and often opposing elements. Asian environmental philosophy has generally had a theme that humans and the environment must harmonize, with humans as an integral part of the environment. It is from this environmental philosophy that the concept of Satoumi had been born.

In this chapter, the integration of Satoumi and MPA (Marine Protected Area) is analyzed in detail. Environmental conservation and resource management in coastal areas in the United States focus on MPAs. Along with the international frameworks such as UNESCO MAB: Man and the Biosphere Programme, the development of the MPA system began as a national project in the United States under the presidential decree in 2000. Although biodiversity conservation used to be the most serious issue in the US MPAs, major issues have changed to ecosystem conservation, balanced resource use, participation of local residents, and consideration of traditional cultures. Therefore, it concludes that the introduction of the Satoumi concept would also be effective for environmental conservation and resource management in coastal areas in Western societies.

Chapter 4 deals with "Roles of Women in Satoumi" as titled. The column chapter examines the diverse roles of women in the process of Satoumi co-creation in Japan, by exploring women-led examples of creating linkages between the community and the coastal environment. This chapter also describes "Ama" (women divers) as direct actors in fishing activities and as sustainability and TEK (traditional ecological knowledge) stewards in Satoumi.

1.6.2 Part II: Enhancing Ecosystem Function by Direct Human Intervention

In Chap. 5, "Enlivening Ecosystems with Human Hands: Building Satoumi Through Coral Reef Culture," the focus is Shiraho village on Ishigaki Island in Okinawa Prefecture. The characteristics of Satoumi creation in Shiraho are that the restoration and use of a stone tidal weir, which is an active measure, not only enhanced biodiversity and productivity but also fostered the sense of ownership for the Satoumi. This process brought about the passive measures including the greenbelt planting activities for preventing red soil runoff and the Sunday Market of the local products. The cultural aspect of Satoumi, literally the coral reef culture, connected the local people who had been torn by issues arising from the airport construction and integrated the conservation activities of environmental organizations and local communities with varying purposes. Also, the essential stakeholders of the Shiraho region, the farmers, joined the Satoumi creation activities. A residential researcher played a major role in conducting the partnership-type project in which people with varying values and positions cooperated with each other.

Chapter 6 titled "Restoring Eelgrass Beds and Culturing Oysters" introduces the Satoumi of seagrass and oysters in Hinase, which is in the southeastern part of Okayama Prefecture. In this area, conservation activities including seeding of eelgrass (seagrass) and sediment improvement by scattering oyster shell are causing rapid recovery of seagrass beds, which were once lost. This is a region where active measures for Satoumi creation are working most effectively. The area of seagrass beds decreased from 590 ha in the 1950s to 12 ha in 1985, yet the area recovered up to 250 ha in 2015. Restoration activities of seagrass beds were initially conducted for recovering resources for small set net. However, the current main purpose is stabilizing production of oyster aquaculture through the effects of seagrass beds to stabilize the water temperature and dissolved oxygen concentration. The activities initiated by the leadership of a single fisher have been carried out continuously for more than 30 years. The chapter also discusses the technical issues for the restoration of seagrass beds, carrying back activities of seabed debris, direct selling of fishery products at a market, and adoption of blue carbon.

Satoumi is also spreading to countries in Southeast Asia, such as the Philippines and Thailand. Chapter 7 titled "Reviving Abandoned Aquaculture Ponds and Coastal Areas by Integrated Multi-trophic Aquaculture" discusses the Satoumi

areas in Indonesia, focusing on those in the West Java region in particular. Unlike other chapters, this chapter focuses on the technical aspect of the active measures that are referred to as integrated multi-trophic aquaculture (IMTA). While shrimp aquaculture is widely practiced in this region, abandoned fishponds due to prevailing diseases have been causing severe environmental problems. When a researcher who learned the concept of Satoumi in Japan returned to Indonesia and was assigned to be in charge of the revitalization project for abandoned fishpond areas by the government, he established a revitalization plan using the Satoumi concept that involves participation of local residents. As a result, they achieved to improve the water quality and productivity of closed water systems through IMTA of shrimps, fish, seaweed, and bivalves. The local fishers also have continued to plant mangroves around their culture ponds for protecting them from the wave erosion and maintaining their water quality. Indonesia is promoting the Satoumi creation as a national policy, and the Satoumi concept is believed to be the most widely known in the country after Japan.

1.6.3 Part III: Managing and Enriching Coastal Resources

Chapter 8 titled "Conserving Multiple Coral Reef Resources" discusses Okinawa City located on the eastern coast of central Okinawa Island. In this area, a leader of fishers and a prefectural fisheries extension officer have functioned as bilateral knowledge translators. The leader established an NPO and implemented a wide variety of activities, from passing down marine culture, environmental education, research, and conservation activities, together with coral aquaculture and planting for Satoumi creation. These activities were taken over by the Satoumi Fisheries Council established afterward, and the council has been implementing various passive measures including length limits for the most important fish species, the establishment of an MPA, and resource and environmental monitoring by fishers.

Chapter 8 also analyzes the institutional issues of Satoumi in detail. It summarizes the complex relationship between common fishery rights and customs in Okinawa, involvement of non-fishers in Satoumi creation, and response to increasing marine recreational use.

Chapter 9 titled "Villagers Managing Lake Fisheries Resources by Themselves: Mbenji Islands in lake Malawi" introduces the Satoumi (Sato-lake, to be exact) in Lake Malawi in East Africa. Although most cases of the Satoumi creation process documented so far took place in Japan, which is a developed country, there are Satoumi areas functioning in various parts of the world, and no least developed country in Africa is an exception. Moreover, in the same way as Satoumi creation in marine areas, Sato-lake and Sato-river creation activities are also carried out in the shore of lakes and rivers with close human interactions.

Chapter 9 analyzes the activities for aquatic resource management, which have been conducted by the residents of riparian communities in Lake Malawi since the 1950s. In this region, the village's traditional authorities and fishers over three

generations have effectively managed the seasonal closure of fisheries during spawning periods while being rooted in the local culture. The villagers themselves, such as chiefs and elders, took the role of bilateral knowledge translators and translated governmental regulations to fit to local framing and used them spontaneously. It is also interesting that seasonal closure, which started as an arrangement to ensure the safety of fishers from dangerous thunderstorms, led to Satoumi processes of resource management as a by-product. The chapter also provides a detailed analysis of conditions and actors required for people in poverty in a least developed country to promote the Satoumi process despite various restrictions and difficulties.

Chapter 10 titled "Protecting Fisheries Resources Through Marine Protected Area Networks: Fiji" analyzes the rapid advancement of a network-based management project for fishery resources and ecosystems in Fiji, which is referred to as the Fiji Locally Managed Marine Area (FLMMA). The central activities of the FLMMA project are the establishment and management of MPAs in marine areas referred to as "*qoliqoli*," which is similar to areas of common fishery rights in Japan. Many institutions, including the University of the South Pacific, the Fisheries Department of the Government, and environmental NGOs, are supporting the activities of the communities. In one village, integrated local environmental knowledge and their perceptions dynamically transformed through the mediation of a bilateral knowledge translator and led to various collective actions for Satoumi creation.

This chapter summarizes how three types of MPAs are selected and run depending on the target resources, the size of fishing grounds, and other factors, in addition to how MPAs are being used for tourism in four regions, resource management of sea cucumbers, and release of giant clams. The chapter also discusses the balance between ecosystem conservation and resource use, which is an important issue in Satoumi creation.

1.6.4 Part IV: Building Broader Connections Between People and the Sea

Chapter 11 titled "Connecting Local Regions and Cities Through Mozuku Seaweed Farming and Coral Reef Restoration: Onna Village, Okinawa" introduces Onna Village, which is a representative Satoumi of Okinawa. In this area, a worker of fisheries cooperative functions as a residential researcher and a bilateral knowledge translator. The Onna Village Fisheries Cooperative was the first to develop the aquaculture techniques for all of three major seaweeds in Okinawa: Mozuku, Hitoegusa, and Umibudo. These techniques were applied to the aquaculture and outplanting techniques for corals, and today, they have become the most effective coral reef restoration techniques in Japan (Okinawa Prefecture Environment Department Nature Conservation Division 2017). Production of seedlings and aquaculture of Mozuku, aquaculture and outplanting of corals, and crown-of-thorns starfish extermination are active measures for Satoumi creation conducted to enhance

biodiversity through human interventions. Additionally, the Onna Village Fisheries Cooperative is most advanced in Okinawa in terms of measures for red soil pollution, which are passive measures. These activities have been carried out in an adaptive manner according to multiple plans including the Churaumi (beautiful sea) Plan.

In Onna, other passive measures such as promotion of fish distribution and interactions among people are also actively conducted. In particular, new values of Satoumi are being created by the Mozuku Foundation established through the collaboration of a fisheries cooperative, a food processing company, and consumers' cooperatives. The funds supplied through the foundation are spent on the conservation activities for coral reefs, which include aquaculture and outplanting of corals.

Chapter 12 titled "Divers and Fishermen Working Together to Create Satoumi" introduces Kashiwajima Island in the southwestern part of Kochi Prefecture. The sea of Kashiwajima is a Satoumi area where over 1000 fish species gather and provide humans with rich blessings. The main characteristic of the Satoumi creation in this area is that a worker of the NPO Kuroshio Zikkan (feeling) Center effectively functions as a residential researcher. This chapter analyzes the characteristics, roles, and issues of residential researchers compared to visiting researchers in detail.

Since Kashiwajima is one of the most popular diving spots in Japan, the Satoumi creation in this area is characterized by the cooperation between fishers and divers. The installation of artificial spawning beds for bigfin reef squid *Sepioteuthis lessoniana* implemented as active measures was especially effective for Satoumi creation. Great achievements for spawning of bigfin reef squid were made through the application of "Shibazuke" or a traditional artificial spawning bed used by fishers based on indigenous knowledge. The divers who had been in conflict with fishers applied the technique, in combination with scientific knowledge of the residential researcher. The researcher has also carried out various passive measures with the key phrases of "protecting the nature and culture" and "re-connecting people to people and people to nature" by "regarding the whole island as a museum."

Chapter 13 titled "Models for Implementing the Satoumi Concept via Residential Research Institute Collaborations with Citizen Scientists in the United States" introduces activities implemented in Florida, USA. A private research institute Mote Marine Laboratory and the volunteer citizen scientists function as residential research institutes/researchers and bilateral knowledge translators.

Their active measures include releasing scallop seedlings for restoring resources, planting of corals by using innovative technologies, and releasing and monitoring snook (*Centropomus undecimalis*), which is an important local fish resource. Concerning passive measures, the large number of volunteer researchers are performing environmental monitoring and educational activities.

1.7 Functions and Issues of Satoumi

1.7.1 Functions of Satoumi

The important purposes of Satoumi creation are environmental conservation that aims for clean seas and resource management that aims for rich seas. In terms of functions, the purposes can be divided into (1) enhancement of biological productivity (including management of fishery resources), (2) environmental conservation (including biodiversity enhancement and improving material circulation), (3) promotion of interactions (including environmental education and improving fish distribution), and (4) passing down the culture. The nine areas introduced as case studies in this book have various activities with diverse functions. We organized the nine Satoumi areas documented in this book by focusing on their functions as shown in Table 1.1. This categorization reflects our judgment on reading each chapter, not the authors of the chapters. We hope the readers would read all the chapters without preconceived images.

1.7.2 MPA (Marine Protected Area)

In this book, MPAs are discussed in many chapters. In Chap. 3, "Effect of Satoumi Concept to the World," and Chap. 10 on Fiji, the main theme is MPAs. Similarly, Chap. 8 on Okinawa City, Chap. 9 on Malawi, and Chap. 13 on Florida also have MPAs. MPAs themselves are not Satoumi, but rather they are the tools for Satoumi creation.

In Japan, MPAs include marine parks, protected waters, and various types of no-take zones. The Ministry of the Environment defines the MPAs in Japan as "Marine areas designated and managed by laws or other effective measures for purposes of conservation of biodiversity supporting sound structures and functions of marine ecosystem and sustainable use of ecosystem services in consideration of the utilized form" (Ministry of the Environment, Japan 2011b). Similarly, MPAs is the collective term for marine parks, reserves, marine sanctuaries, no-take zones, and tabu areas outside Japan.

As shown in Chap. 10, the types of MPAs vary widely, including complete no-take zones throughout the year, areas where certain fishing methods or certain species are forbidden, and areas where a certain period of each year is set as a no-take period. MPAs also vary in size, from a few hectares to a few tens of millions of hectares. Some MPAs are legally established as seen in the United States, while others are autonomously established by local people, as seen in Fiji, Malawi, and Okinawa City. The main purposes of their establishment also differ, from the conservation of biodiversity to management of fishery resources to promotion of the tourism.

Table 1.1 Functions of Satoumi

Function of Satoumi	Shiraho	Hinase	Indonesia	Okinawa City	Malawi	Fiji	Onna Village	Kashiwajima	Florida
1. Enhancement of biological productivity (fishery resource management)	△	○	◎	◎	◎	◎	○	○	○
2. Environmental protection (biodiversity enhancement) (improving material circulation)	○	◎	○	○	△	△	○	△	○
3. Promotion of interaction (environmental education) (fish distribution)	○	○	○	○	○	○	◎	◎	◎
4. Passing down the culture	◎	△	△	△	○	○	△	○	△

○ signifies a function that is present, ◎ signifies the major function, and △ signifies the minor function

However, MPAs are not panaceas and cannot solve everything, and establishing MPAs does not transform the coastal area into Satoumi right away. MPAs are no more than just a tool in creating Satoumi. Some MPAs are in fact contradictory to Satoumi. They are the type of MPAs that removes people from the area. For example, although the MPA area is inhabited by people today, Sabah State in Malaysia once established an MPA by removing the marine tribe Sama (Bajau) who had illegally inhabited the area. There have also been conflicts in West Africa due to the establishment of MPAs by removing people (Sekino 2014). To discuss Satoumi-type MPAs that can balance between ecosystem conservation and sustainable resource use is also a theme of this book.

For MPAs to function as a tool in Satoumi creation, individual MPAs need to be effective, and networks for MPAs need to be constructed. MPA networks include ecological networks, which stand for spatial and physical connections, and social networks, which signify the connections among people, organizations, and information (Kakuma 2017). Because constructing ecological networks of MPAs requires detailed information regarding the ecology of target organisms and the physical environment such as current, these networks are uncommon in Satoumi globally. However, international networks are being constructed with regard to the social networks.

1.7.3 Balance Between Ecosystem Conservation and Resource Use

For Satoumi creation, it is crucial to achieve the balance between ecosystem conservation and resource use. Chapters 2 and 3 discuss how the Western countries differ from Asian countries in terms of cultural background and that they tend to consider the protection of nature by separating humans from nature. For this reason, Chap. 2 analyzes that nature reserves experience insufficient resource use, while areas with human activities experience excessive resource use. Chapter 10 provides a critical analysis of the assertion that "the primary cause of coral reef ecosystem deterioration is fisheries, and fisheries need to be restricted strictly to achieve the recovery to the pristine state of the ecosystem." In this manner, Western countries have a tendency to prefer the preservation of the pristine nature, with some people hating human intervention in nature. This kind of mindset is clearly contradictory to the Satoumi concept. Satoumi creation requires the conservation of ecosystems through close involvement of people in the sea, at the same time as seeking the sustainable ways to use the resources.

1.7.4 Technical Issues of Satoumi

Partially because of the fact the Satoumi in the Seto Inland Sea initially drew attention in Japan, the primary technical issue of Satoumi was improving material circulation. In the book *Satoumi Theory* (Yanagi 2006), it is asserted that the establishment of Satoumi requires "the realization of the thick, long and smooth material circulation in the coastal sea." "For example, although the occurrence of red tide realizes temporally thick material circulation from nutrients to phytoplankton, the material circulation is short as most of the phytoplankton die without transferring the nutrients to higher zooplankton species. Moreover, dead phytoplankton cause oxygen deficient water masses on the sea floor, which destroy bottom-dwelling ecosystems, including benthos, thereby hindering smooth material circulation" (Yanagi 2006). In addition to the physical transport by flow and diffusion, biological transport also plays a major role in the material circulation in coastal areas. Fisheries promote the circulation of nutrients and organic matter. This is because the nutrients and organic matter released by humans become absorbed in phytoplankton and then stored in aquatic organisms, which are higher up on the food chain, followed by the collection by humans through fisheries (Kakuma 2011).

Many technical issues are present for active measures intended to enhance the biodiversity and productivity by direct human intervention. This is the aspect of Satoumi where the contribution of natural sciences is sought. Many chapters in this book provide case studies in which technical issues in active measures were solved by using scientific innovations.

1.7.5 Institutional Issues of Satoumi

In Satoumi where local people are involved closely, there are many institutional issues including the relationship between fishery rights and customs and ways of involvement of non-fisher people (local and urban residents) in Satoumi. Chapter 8 provides a detailed analysis of this matter (issues related to commons and local rules).

In Japan, except for special cases, common fishery rights are established in all areas of shallow waters where Satoumi creation is conducted. However, Okinawa has a community mindset that "the sea belongs to everyone," and the local residents have historically harvested resources in shallow coral reefs. In contrast, in other areas of Japan, with the increase of marine leisure, it is becoming more difficult to manage the coastal areas where fishers had been using based on their fishery rights (Hidaka 2016). Satoumi creation requires solving these institutional issues.

Once again, this book deeply analyzes and explains the diverse Satoumi within and outside Japan with regard to the specific issues of each area by looking at the multilateral aspects of Satoumi. We hope this book will deepen the readers'

understanding of the functions and issues of Satoumi, providing specific hints for Satoumi creation and making contributions to solving various issues of Satoumi in the world.

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Part I
Significance of Satoumi Concept and Growing Satoumi Actions

Chapter 2
The History and Future of Satoumi Concept

Tetsuo Yanagi

Abstract This chapter introduces the history of the emergence of the concept of Satoumi in Japan and its expansion not only in Japan but also in the world. The natural and sociological mechanisms by which Satoumi enhances biodiversity and productivity in coastal waters will be discussed using empirical verifications, with the discussions on the relationship between Satoumi and Ecosystem-Based Management (EBM), Community-Based Management (CBM), Marine Spatial Planning (MSP), and Integrated Coastal Management (ICM).

Keywords Coastal area · Human intervention · Productivity · Biodiversity · Primary production · Transparency

2.1 The Beginning of the Satoumi Theory

In 1998, in response to a request from the editorial board of the *Journal of Japan Society of Civil Engineers* and the *Journal of Japan Society on Water Environment* to "discuss the future direction of research on coastal seas," I wrote a short essay, claiming that "Since the marine pollution problem has been settled, and many fishers want to have 'rich seas' rather than 'clean seas,' 'Satoumi creation' should be the main direction of future research on coastal waters to realize the Satoyama-like way of life in coastal waters" (Yanagi 1998a, b). Satoyama refers to the forests with high biodiversity and productivity under human interventions. After that, I gave lectures on Satoumi in various parts of Japan as requested, but I received many comments from the participants of the lectures that it is impossible to realize Satoumi unless detailed concepts and methodologies are clarified. In 2006, I wrote a Japanese book entitled *Satoumi Theory*, in which I defined Satoumi as "coastal waters with high

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biodiversity and productivity through appropriate human interventions," and developed a detailed logic (Yanagi 2006).

2.2 Development of the Theory of Satoumi in Japan

After the publication of the *Satoumi Theory*, the creation of Satoumi was included in many of Japan's marine policies, such as the Strategy for an Environmental Nation in the 21st Century in 2007, the Third National Biodiversity Strategy in 2007, and the Basic Plan on Ocean Policy in 2008. The Ministry of the Environment (MOE) of Japan has designated eight coastal areas in Japan as model areas for the creation of Satoumi. At the end of FY2010, MOE prepared the "Satoumi Creation Support Manual" (Ministry of the Environment 2010).

The concept of Satoumi was spreading throughout Japan. However, some ecologists criticized us that biodiversity in Satoyama could be increased by human interventions, while biodiversity in coastal areas could be increased by doing nothing. Based on the results of the field experiments, it was concluded that there are two types of appropriate human interventions in the Satoumi: (1) human interventions to create new habitats for marine organisms and (2) human interventions to prevent marine vegetation such as seaweed beds from reaching its climax (Fig. 2.1). Adaptive management of these human interventions can increase biodiversity and productivity of coastal waters. We also conducted an empirical study on the effects of human resource management on the increase of biodiversity in coastal waters (Yanagi 2009).

From 2009 to 2012, the Japan Science and Technology Agency (JST) provided ca. 90-million-yen research funding for the "Construction of a Social System for the Restoration of the Marine Environment (Satoumi Creation)" project (Principal Investigator: Tetsuo Yanagi). In addition to increasing the scientific knowledge

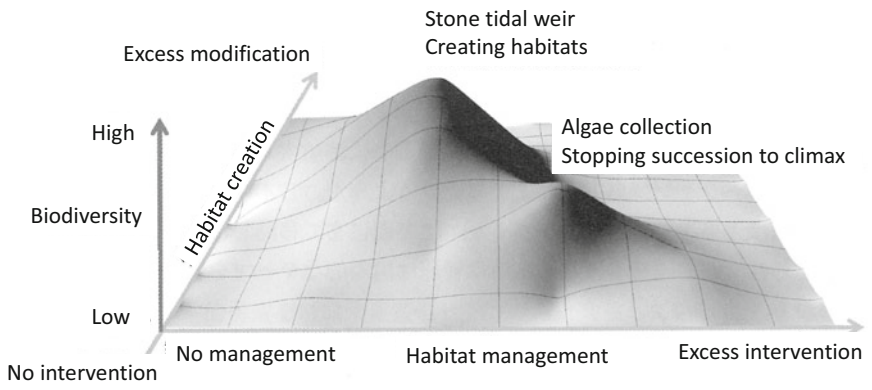


Fig. 2.1 Relationship between human interventions and biodiversity in Satoumi

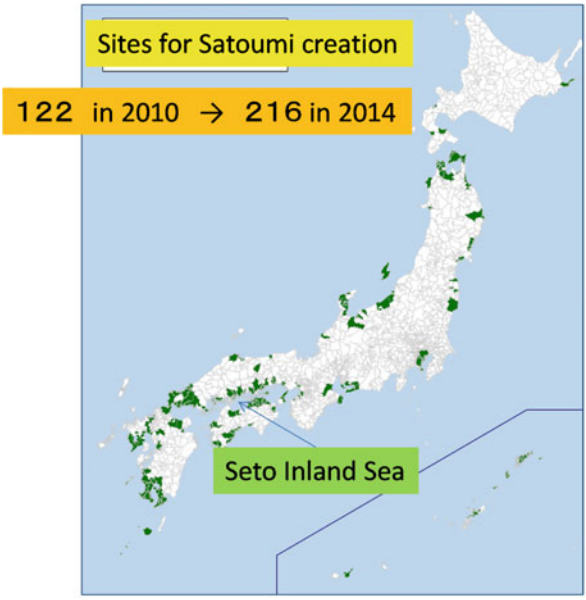


Fig. 2.2 Sites of Satoumi creation in Japan in 2014

necessary for the creation of Satoumi, a series of interviews were conducted on Satoumi-related activities in Japan and around the world. The results of this project and related research were summarized and published in *Satoumi Creation Theory* in Japanese (Yanagi 2010). In April 2012, the NPO Satoumi Creation Research Council was established (Satoumi Creation Research Council 2012).

In response to these movements, the *Journal of the Japanese Society of Fisheries Science* published a special issue entitled "My idea, sense, and approach to Satoumi Part I and Part II" in Volumes 79 (2013) and 80 (2014), in which the author and 12 other experts, including Satoyama experts, summarized and introduced their opinions (Yanagi 2013).

During this period, many people in Japan accepted the concept of Satoumi favorably. According to a questionnaire survey conducted by the Ministry of the Environment on local governments, the number of Satoumi promotion organizations increased from only 122 in 2010 to 214 in 2014 (Fig. 2.2, Ministry of the Environment 2014). They found more Satoumi sites in the southwestern part than the northeastern part in Japan, because the Satoumi concept had been expanded from the Seto Inland Sea (Yanagi 2006). As many kinds of Satoumi creation activities have been performed under different definitions in Japan, Hidaka (2016) introduced a new definition of Satoumi covering diverse activities as "Satoumi is a management structure for the conservation of the environment and resources in the coastal sea by local people and the government, or the coastal areas which are governed by such management structure."

2.3 Development of Satoumi Theory in the World

The Satoumi concept was first introduced to the world at the third conference of the Environmental Management of Enclosed Coastal Seas (EMECS) held in Stockholm, Sweden, in 1997. However, the response was mixed. "You are a servant of fishers! Scientists should explore the natural order without preconceptions. The Satoumi concept of conducting research for fishers is an evil way of science!" Of course, the argument never took off.

However, when I presented my research on Satoumi at the 7th EMECS held in Caen, France, in 2006, the chairperson (Prof. Ozan of Turkey) made the following evaluation at the summary meeting: "Satoumi is a symbiosis between human communities and coastal/marine areas—a more rational vision of co-existence." The situation in the coastal areas of Europe and the United States changed in the 2000s, and it became clear that the marine environment could not be conserved without appropriate human interventions. After returning from France, I immediately translated *Satoumi Theory* into English and published "Sato-Umi" (Yanagi 2007).

The first International Satoumi Workshop was held at the 8th EMECS in Shanghai in 2008, and since then, the Workshops have been held somewhere in the world every year (Table 2.1). Mainly through this series of international workshops, the Satoumi concept has been spreading around the world (workshop reports are available from the International EMECS Center n.d.).

Several Satoumi-related events were held at the Convention on Biological Diversity (CBD)-COP 10 held in Nagoya, Japan, in October 2010. After the conference, CBD Technical Series 61 "Biological and Cultural Diversity in Coastal Communities—Exploring the Potential of Satoumi in Implementing the Ecosystem Approach in the Japanese Archipelago" was published in 2011. This report explained the contributions of Satoumi activities in various areas in Japan to the increase of biodiversity in coastal areas. It stated that Satoumi is an expression on the CBD

Table 2.1 Locations of the International Satoumi Workshops and meetings

Year	Location
2008	Shanghai in China
2009	Manila in the Philippines
2010	Kanazawa in Japan
2011	Baltimore in the USA
2012	Hawaii in the USA
2013	Marmaris in Turkey
2014	Tokyo in Japan
2015	Da Nang in Vietnam
2016	Saint Petersburg in Russia
2017	Bordeaux in France
2018	Pattaya in Thailand
2019	Saint Lucia, Fiji, and Turkey

ecosystem approach, which is considered the primary framework for action under the CBD.

In 2011 and 2012, the United Nations University conducted the Satoyama-Satoumi Sub-global Assessment in Japan as a continuation of the Millennium Ecosystem Assessment conducted from 2001 to 2005, which evaluated the degradation of ecosystem services at global scales. Its report entitled *Satoyama-Satoumi Ecosystems and Human Well-Being* was published in 2012 (Duraiappah et al. 2012).

In 2012, I published *Japanese Commons in the Coastal Seas*, which was an English translation of *Satoumi Creation Theory* (Yanagi 2012). Also from 2012, as part of the North Pacific Marine Science Organization (PICES) project, the Fisheries Agency of Japan became the sponsor of the "Project for Establishing a Satoumi-type Fishery Management System in the Pacific Rim (2012–2016)." This project aimed to create a fishery management system model based on the concept of Satoumi by setting up model areas in the western, central, and eastern parts of the Pacific Ocean.

2.4 Satoumi and Western Approaches of Coastal Management

It is not easy to establish Satoumi concept as an international term similar to tsunami because the latter clearly refers to the natural phenomenon of "long waves generated by undersea earthquakes." In the case of Satoumi, it involves not only the natural science aspect of "the relationship between human interventions and biodiversity/productivity" but also the humanity aspect of "the relationship between humans and nature" and the social science aspect of "how people manage coastal waters." It is not easy for the people from different societies and cultures to share a common understanding of Satoumi.

For example, Christians believe that "we must preserve nature separately from human beings because God created nature separately from humans" (Fig. 2.3). The desired attitude of humans to nature is expressed by the word "stewardship." People ignore nature in the city, where most human activities are performed. A buffer zone is set up between areas of nature preservation and the city. As a result, under-use occurs in preserved areas and overuse in the city.

Asian people generally think that "Gods live everywhere in nature, and humans living in nature must co-exist with gods and nature." Wise-use is the best attitude. People even think that they may be reborn as other animals or even plants in their next lifetime and they must respect every form of lives in the nature (Fig. 2.3).

In terms of environmental management in coastal waters, Westerners have established a framework for coastal management based on various fundamental concepts such as Ecosystem-Based Management (EBM) and Community-Based Management (CBM). Satoumi is a more comprehensive approach to integrate Satoyama, Satochi (the broader land areas with human activities coexisting with

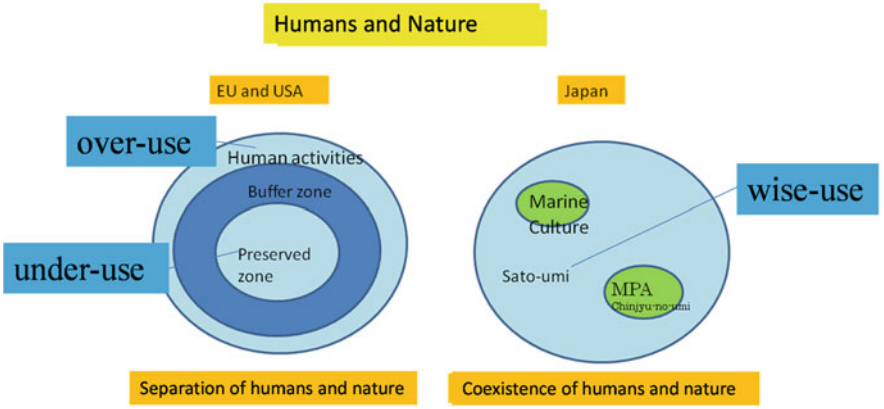


Fig. 2.3 Difference in perceptions of the relationship between human and nature among European and Asian people

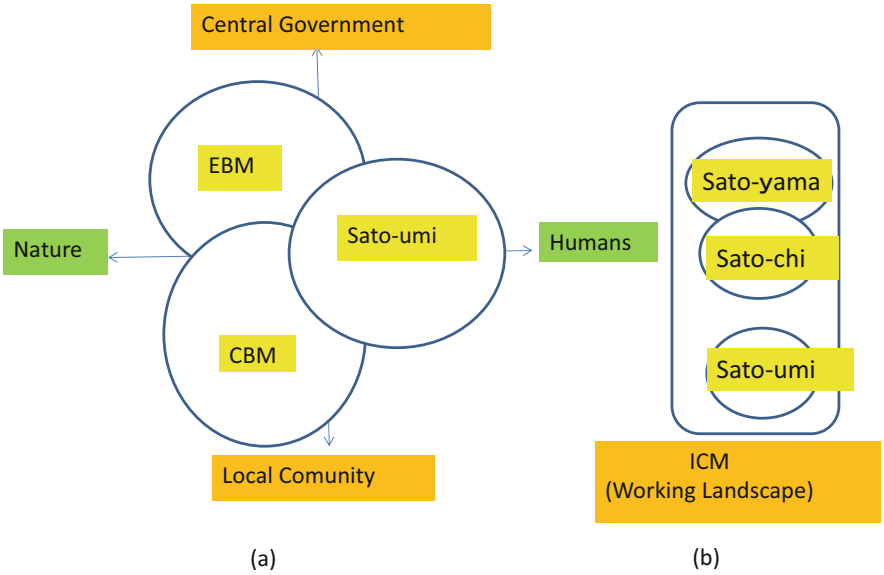


Fig. 2.4 Relationships of Satoumi, EBM, and CBM (**a**) and Satoumi and ICM (**b**)

terrestrial and aquatic nature), and Satoumi through Integrated Coastal Management (ICM) approaches (Fig. 2.4).

In the annual series of the International Satoumi Workshops, similarities and differences of these approaches have been discussed, asking what kind of research would be needed to build a globally valid and acceptable Satoumi concept. In the following sections, I discuss the relationship between Satoumi and EBM, CBM,

Marine Spatial Planning (MSP), and ICM, which have been clarified through discussions in the series of international workshops.

2.5 Satoumi and EBM

Water quality parameters such as COD (chemical oxygen demand), TP (total phosphorus), and TN (total nitrogen) have long been used as indicators of coastal zone management in Japan, because environmental policies such as effluent control at land-based sites can manage water quality parameters by making their concentrations conform to standard values. The total allowable catch (TAC) system is used to set the upper limit of catch for each fish species to protect resources.

On the other hand, in Europe and the United States, there has been a strong opinion that it is difficult to conserve the entire ecosystem and its services with such water quality parameters and TACs. The concept of Ecosystem-Based Management (EBM) has been proposed. For example, in the United States, EBM aimed at harmonizing nature conservation with logging, which might lead to the extinction of the owl, was initiated by the federal government under the Clinton administration in 1993, and since then, local collaborative efforts have been developed to optimize complex nature and human systems (Mori 2012).

However, EBM does not have an appropriate index to represent the entire coastal marine ecosystem. In the United States, the coastal ecosystem has been represented by indices such as the Submerged Aquatic Vegetation Index and the Oyster Production Index, which have been used for EBM in the Chesapeake Bay.

In contrast, Satoumi is currently proposing the following environmental indicators that integrate water quality and ecosystems.

First, we quantitatively identify the transparency and nutrient concentrations that maximize the primary production ($mgC/m^2/day$) of coastal waters to increase the biological productivity (Fig. 2.5). When the nutrient concentration is too high, red tide occurs in the upper layer, and the transparency decreases. In such a case, the primary production in the upper layer becomes large, but the phytoplankton density in the lower layer decreases because sunlight does not reach the lower layer, and the primary production in the whole water column remains small. If the nutrient concentration is too low and the phytoplankton density in the upper layer is low, the water clarity will be high, but the primary production of the water column will still be small because there are not enough nutrients to support the growth of phytoplankton. In contrast, when appropriate nutrient concentrations are provided, phytoplankton can proliferate in the upper and lower layers. In shallow water, attached diatoms, seagrass, and algae on the seafloor can also photosynthesize, resulting in a maximum primary production in the water column.

It is not easy to clarify the quantitative relationship between transparency and primary production in actual coastal waters. The only such data set in Japan currently available to the author is from the “Interdisciplinary Study on Sustainable Production of Important Fishery Resources and Environmental Conservation in the Seto

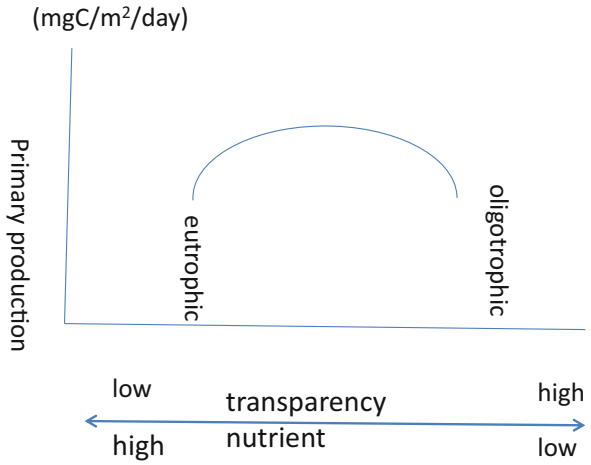


Fig. 2.5 Relationships between transparency (inversely proportional to nutrient concentration) and primary production

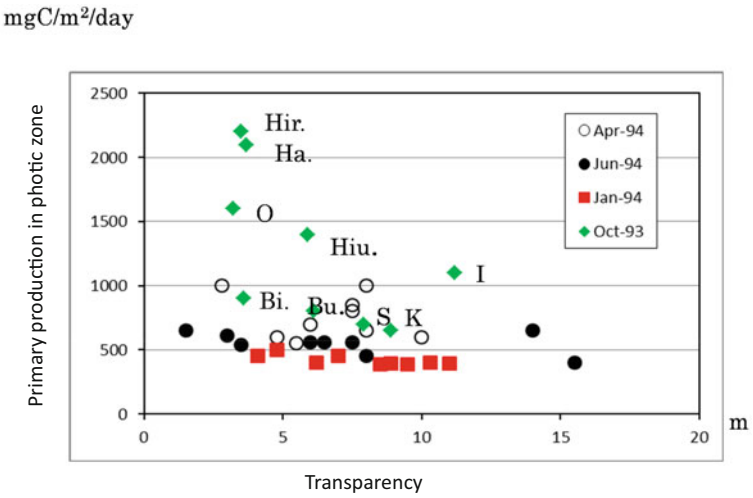


Fig. 2.6 Relationships between transparency and primary production in Seto Inland Sea over four seasons. *Hir* Hiroshima Bay; *Ha* Harima-nada; *O* Osaka Bay; *Hiu* Hiuchi-nada; *I* Iyo-nada; *Bi* Bisan Seto; *S* Suou-nada; *K* Kii Suido; *Bu* Bungo Suido

Inland Sea," a Nissei Foundation special research project conducted in 1992–1995 (Okaichi and Yanagi 1997). Figure 2.6 shows the relationship between primary production and transparency in the Seto Inland Sea over four seasons. This figure is based on transparency data (Hashimoto et al. 1996) and primary production data (Tada 1996; Yanagi 2016). The primary production in the Seto Inland Sea was low in winter, when water temperature was low, and in summer, when stratification had developed and nutrients in the photic zone were depleted. The geographic distribution in Fig. 2.6 shows high production in deep Hiroshima Bay, Osaka Bay, and the

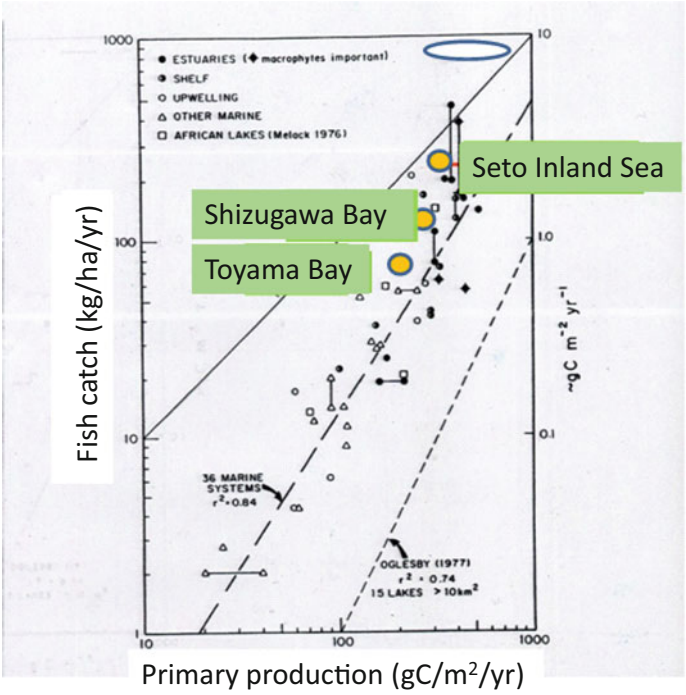


Fig. 2.7 Relationships between primary production and fish catch in various water bodies including the Seto Inland Sea, Shizugawa Bay, and Toyama Bay. (Modified from Nixson 1988)

northern part of the Harimanada and low production in the Bungo Suido and Kii Suido, which are close to the open sea.

However, the primary production on the vertical axis of this figure represents the production by suspended phytoplankton in the photic zone and excludes the primary production by attached diatoms, seaweeds, and algae on the seafloor. When light reaches the seafloor, primary production occurs not only in the water column but also on the seafloor. For example, the primary production of Takamatsu Tidal Flat in Kagawa Prefecture reached 1200 mgC m^{-2} day^{-1}, which was greater than the primary production of 600 mgC m^{-2} day^{-1} in the water column at a depth of 20 m in the offshore Bisan Seto (Kadoya 2014). The primary production of seagrass beds was about 4000 mgC m^{-2} day^{-1} (Nishijima, personal communication). If we add the primary production of seafloor-associated diatoms, seagrass, and algae, the distribution of Fig. 2.6, which is skewed to low transparency with high primary production, should be more similar to Fig. 2.5.

For now, Satoumi tentatively proposes using nutrient concentration and transparency as environmental indices to maximize the primary production in the water column (Fig. 2.7).

There is no one-to-one correspondence between the primary production and the catchable amount in fisheries. The higher the primary production, the higher the

catch tends to be. However, for the same primary production, the catch differs by more than one digit between stagnant waters such as lakes and tidal-dominated waters such as coastal waters (Nixson 1988). This is because the efficiency of nutrients produced by primary production to be transferred to organisms at higher food levels is greater in coastal waters than in lakes, where horizontal and vertical movements by tidal currents are absent. As a result, the catch per unit of primary production is larger in coastal waters than in lakes.

Let me give a simple example. A comparison of coastal waters and lakes with the same nutrient and organic matter concentrations (including suspended solids) shows that strong currents in coastal waters increase organic matter fluxes (mass transfer per unit time and unit area) and nutrient fluxes to filter-feeding benthic organisms, seaweeds, and algae. On the other hand, weak currents in lakes reduce the fluxes of organic matter and nutrients. As a result, the primary, secondary, and tertiary productivity of coastal waters is higher than that of lakes.

As a result, more fish catch (higher biological productivity) is possible in coastal waters with tidal phenomena. Of course, in windy lakes, there are times when mass fluxes due to blowing currents (wind-induced currents) become large, but the same is true for coastal waters. The continuous flow caused by tidal phenomena rather than the intermittent flow caused by wind forces determines the productivity of coastal waters and lakes.

The differences in the primary production of the Seto Inland Sea, Shizugawa Bay, and Toyama Bay shown in Fig. 2.7 are due to differences in nutrient concentrations and nutrient transport mechanisms shown in Fig. 2.8. In the Seto Inland Sea, phosphorus and nitrogen are supplied from the shore, seabed, and open sea, and the supplied nutrients (dissolved inorganic nutrients) are photosynthesized in the photic layer of approximately 20 m thick to produce organic matter and fed to zooplankton and other organisms. Zooplankton feces and phyto- and zooplankton carcasses (detritus) are decomposed as they sink to be converted to nutrients. The nutrients are then used for photosynthesis again when they are uplifted to the photic layer. Therefore, the concentration of nutrients and the frequencies of nutrients used for photosynthesis per unit time determine the primary production of the area. In the case of the Seto Inland Sea, the basic vertical circulation current is an estuarine circulation current in which riverine water flows toward the open sea in the surface layer and oceanic water flows toward the central part of the Seto Inland Sea in the bottom layer. The tidal velocity and vertical mixing at each strait are large, causing a high rate of upwelling of nutrients from the dark zone into the photic zone, resulting in a large primary production. In contrast, in Shizugawa Bay, where the thickness of the photic zone and the average depth are equal to about 20 m each, the intermittent mid-layer intrusion (ingress of open seawater into the middle layer rather than the upper or lower layers) is the basic component of the vertical circulation current. The nutrient load from the land is not as large as in the Seto Inland Sea, so the total phosphorus and nitrogen concentrations are not as high as in the Seto Inland Sea. The primary production depends on the nutrient concentration itself, in addition to the efficiency of nutrients used for photosynthesis per unit time. In Toyama Bay, the water depth is much greater (about 500 m compared to the photic zone thickness of

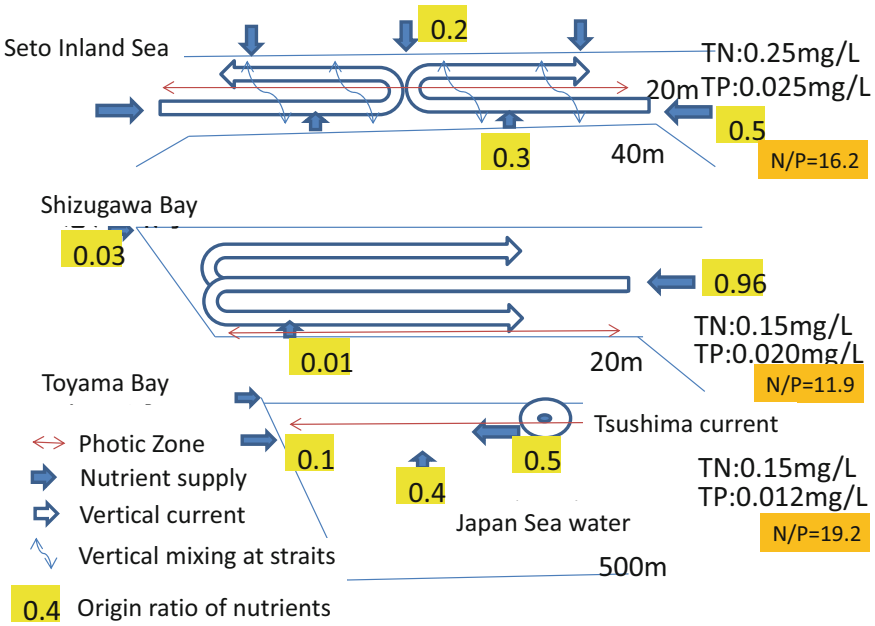


Fig. 2.8 Mechanisms of nutrient transportation in the Seto Inland Sea, Shizugawa Bay, and Toyama Bay, with photic layers of 30 m. TN, TP, and N/P represent amount of nitrogen, phosphate, and their molar ratio

about 20 m), and the rate of nutrients decomposed in the lower layer to return to the photic zone is low, resulting in the lowest primary production among the three areas.

In future, we will study what types of ecosystem structures and tidal flow structures lead to high primary production and high transfer efficiency to deliver nutrients (phosphorus and nitrogen) to large fish at the top of the food chain. We will propose the most appropriate method for "appropriate human interventions" to increase primary production and transfer efficiency in Satoumi. In other words, we are trying to integrate water quality management and EBM and to propose a method for managing coastal waters that will realize "thick, long, and smooth material cycles" (Yanagi 2006).

2.6 Satoumi and CBM

In the past, the central or local government was the major actors leading environmental management of coastal waters. However, such top-down management was often unsuccessful because it was difficult to obtain the cooperation of local communities. Therefore, CBM (Community-Based Management) is important, and

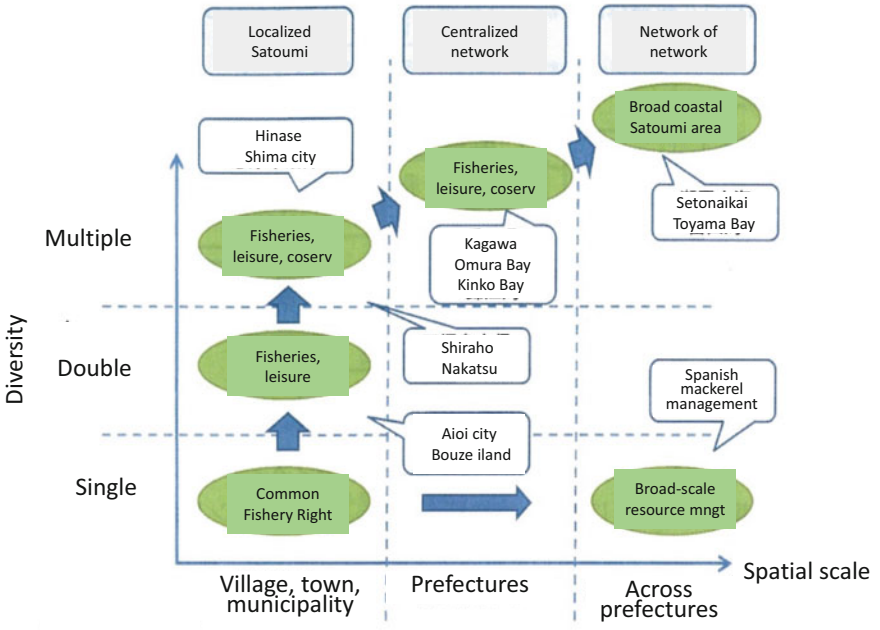


Fig. 2.9 Multilevel council system of Satoumi proposed by Hidaka (2016)

many people are now suggesting that coastal environmental management should be conducted bottom-up by local communities.

However, CBM also has its limitations. For example, sasi (Murai 1998), an excellent community-based natural resource management system in eastern Indonesia, is well followed by the local community, but intruders from other communities frequently violate the rules, poaching the fishery resources protected by the local community (Mosse 2008). To deal with such contradictions is difficult for the CBM alone. It is necessary to set up large-scale monitoring and enforcement systems across communities so that local, regional, and central governments can intervene appropriately to ensure the effectiveness of sasi.

In the Satoumi, a multilevel council system (Fig. 2.9) has been proposed to manage the environment and resources: a small-scale council to conserve the environment and resources of the local waters, a medium-scale council to manage the medium-scale waters, and a large-scale council to work at the national level (Hidaka 2016). The relationship between Marine Protected Area (MPA) and Satoumi is also discussed in these councils.

2.7 Satoumi and MSP

Marine Spatial Planning (MSP) is a process of coordinating the use of marine areas for various purposes (fishing, transportation, recreation, renewable energy including wind and wave power), similar to land use planning. MSP aims to produce the plan and spatial distribution of the use of marine areas to conserve ecosystem services and minimize conflicts among resource uses by mapping the use patterns on hydrographic charts (UNESCO Marine Spatial Planning Programme 2009).

The United Kingdom enacted the Marine and Coastal Access Act in 2009 to coordinate integrated and wholistic uses of coastal waters by MSP through close collaboration between local and central governments. The desired state of coastal waters in the United Kingdom was defined as "clean, healthy, safe, productive and biodiverse." The Marine Management Organization (MMO) was established in 2010 for MSP. Similarly, in Scotland, Marine Scotland was established in 2011 to conduct MSP in its coastal waters.

In the United States, President Obama launched the Interagency Ocean Policy Task Force in 2009 to promote ocean policy, including MSP. In 2008, Massachusetts enacted the Oceans Act, which established the Office of Ocean Energy and Environmental Policy to develop ocean resource management policies and work with NOAA (National Oceanic and Atmospheric Administration) to coordinate existing uses to balance healthy marine ecosystems with active economic activities. Similar efforts are underway in Rhode Island, California, Oregon, and Washington.

In Satoumi, the function of MSP is fulfilled in the multilevel council system described in the previous section, which includes government and researchers as relevant stakeholders (Hidaka 2016).

2.8 Satoumi and ICM

Coastal zone management cannot be done without integration, i.e., Integrated Coastal Management (ICM) must be implemented. In Satoumi, I believe that multifaceted integration processes below are essential.

1. Academic integration: Integration of natural sciences, social sciences, and humanities is necessary. Coastal ocean management cannot be achieved by knowledge of marine physics alone nor by knowledge of natural sciences integrating physics, chemistry, and biology. Coastal zone management can only be successfully achieved by integrating the results of the sciences (natural, social, and humanities), i.e., by successfully conducting interdisciplinary science.
2. Area integration: Coastal zone management cannot succeed by managing only the coastal zone. Water quality supporting the coastal marine environment is related to forests, villages, and rivers influencing coastal waters. Therefore, to maintain good water quality in the coastal zone, environmental management that

integrates the broader spatial scales including forest, village, river, and ocean is necessary.
3. Stakeholder integration: The integration of stakeholders related to different livelihoods and occupations, such as foresters, farmers, urban dwellers, and fishers, is necessary for the success of integrated management in the broader spatial scales.
4. Government integration: It is necessary to integrate the governments of municipalities at the local level, the government of prefectures at the regional level, the central government of the country, and the vertically crosscutting sections such as the divisions of public works, environment, agriculture, forestry, fisheries, economy, and industry within these governmental organizations.

A good example of ICM is the Fushino Catchment Area Committee in Yamaguchi Prefecture. Many local committees from the forest to the coastal sea along the Fushino River cooperate with each other over the conservation of the water environment of the Fushino River and the coastal sea (Seto Inland Sea Research Council 2007).

As a special session after the opening ceremony of the 11th EMECS in 2016, the "ICM and Satoumi" Workshop was held. The general discussion was activated regarding various topics of ICM. The workshop concluded the needs to continue international workshops regarding ICM and Satoumi.

2.9 Toward Clean and Productive Coastal Seas

Year-to-year variations in average transparency and yearly fish catch in the Seto Inland Sea are shown in Fig. 2.10. Transparency decreased until the mid-1980s during the period of rapid economic growth in Japan. In contrast, the fish catch increased until the mid-1980s. Since then, transparency has increased due to the inaction of total phosphate (TP) and total nitrogen (TN) load reduction law, but the fish catch decreased. The relationship between transparency and catch is not one-to-one relationship, because the temporal variability of the catch has a history (hysteresis: the catch does not depend only on the transparency at particular time but is determined by long-term fluctuations in transparency over the past several years). In Fig. 2.10, although the transparency is the same, the catch in the eutrophic period (with decreasing transparency) is higher than the oligotrophic period (with increasing transparency). The reasons for this phenomenon are as follows: (1) anoxic water masses during eutrophication destroyed the benthos ecosystem and reduced the transfer efficiency in the detritus food chain; (2) reclamation conducted in the eutrophic period caused the loss of tidal flats and seaweed beds, which are reproduction sites for fishery resources, and reduced the amount of resources; and (3) jellyfish increased and zooplankton decreased to reduce transfer of nutrients to predators at higher levels of food chain. However, these hypotheses have not yet been quantitatively confirmed.

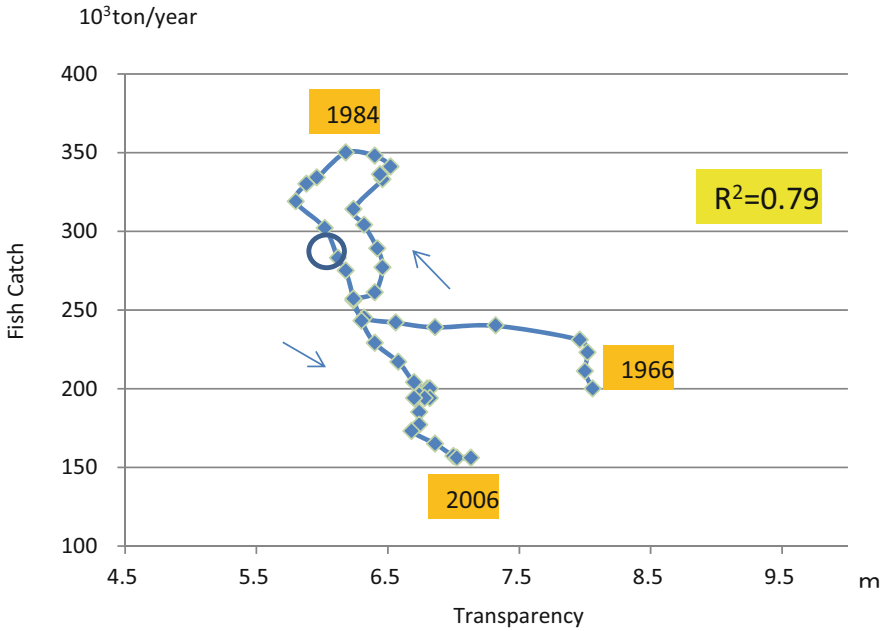
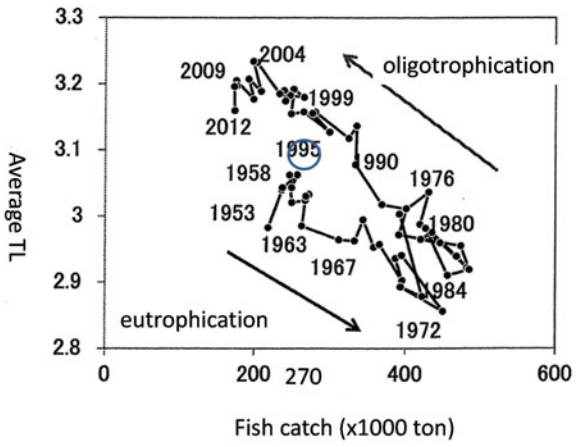


Fig. 2.10 Year-to-year variation of transparency and fish catch in the Seto Inland Sea. Dots show the 5-year running mean. Circle shows the target transparency (6 m) and fish catch (270×10^3 tons year^{-1})

Fig. 2.11 Average trophic level of caught fish and fish catch in the Seto Inland Sea. Circle shows the target fish catch (270×10^3 tons year^{-1}) and TL (3.1)



Not only the fish catch but also the relation between transparency and the trophic level (TL) of caught fish differs during both periods in the Seto Inland Sea as shown in Fig. 2.11. Average TL decreased during the eutrophic period because the catch of plankton-feeding fish such as anchovy (TL = 2.5) increased. On the other hand, average TL has increased during the oligotrophic period because the catch of

plankton feeder has decreased and that of higher trophic level fish has relatively increased.

The reason for such difference in TL in both periods can be explained by the difference in the ecosystem structures surrounding caught fishes, which is mainly determined by the relationship between the growth rate of zooplankton and the biomass of phytoplankton (chlorophyll a concentration). The growth rate of zooplankton is saturated at certain phytoplankton biomass concentration (Uye and Shibuno 1992). The excess phytoplankton in the eutrophication period dies and sinks to the bottom layer to cause hypoxia. Hypoxia kills the eggs of zooplankton and decreases the transfer efficiency to the higher trophic levels including fish. On the other hand, most phytoplankton are grazed by zooplankton during the oligotrophic period, and the transfer efficiency to higher trophic levels becomes high.

The Seto Inland Sea Water Quality General Survey conducted by the Ministry of Land, Infrastructure, Transport and Tourism revealed the relationship between transparency and chlorophyll a (chl.a) concentration in the Seto Inland Sea. A chl. a concentration of 4.5 μg L^{-1} corresponded to a transparency of 6 m. We propose that the target transparency for a clean and productive Seto Inland Sea should be 6 m, with the target fish catch of 270×10^3 tons $year^{-1}$ and the target trophic level (TL) of 3.1. The transparency of 6 m corresponded to total phosphate (TP) = 0.028 mg L^{-1} and total nitrogen (TN) = 0.28 mg L^{-1}. The analyses of relationships between TP concentration and TP loads from the land and TN concentration and TN load from the land in the Seto Inland Sea revealed that the TP load of 13 tons day^{-1} and TN load of 260 tons day^{-1} corresponded to a transparency of 6 m. These observations suggest that we must go back to the mid-1980s from the viewpoint of the total load reduction policy; in other words, the policy in the Seto Inland Sea is too advanced now.

In conclusion, we propose a clean and productive Seto Inland Sea with a transparency of 6 m, a fish catch of 270×10^3 tons $year^{-1}$, an average trophic level of caught fish of 3.1, a TP concentration of 0.028 mg L^{-1}, a TN concentration of 0.28 mg L^{-1}, a TP load from land of 13 tons $year^{-1}$ and a TN load from land of 260 tons $year^{-1}$. The target transparency and other parameters such as fish catch, TL, TP and TN concentrations do not correspond one-to-one as shown in Fig. 2.10. Therefore, when we apply these quantitative approaches to other Satoumi areas to create clean and productive coastal seas, we must conduct adaptive management on the basis of continuous environmental monitoring. We also have to rehabilitate tidal flats, sea weeds and sea grass beds, and coral reefs, which are important for fish recruitment and habitat for marine biota. These habitats have continuously decreased in coastal areas in the world. By combining these adaptive activities, we will be able to create a clean and productive Satoumi for sustainable futures.

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Chapter 3
Global Effect of the Satoumi Concept: Harmony of Human Society with the Ocean Biome

Michael P. Crosby

Abstract Human philosophies for interactions with the environment have, at least in the past, been generally divided between major themes of either (a) human separation from nature, with humans and nature comprising two separate and often opposing elements, or (b) a state of harmony between humans and the environment, with humans as an integral part of the environment. In great part, many of the most widely viewed concepts for marine protected areas (MPAs) around the world have stemmed from the former human-environment philosophy, while the concept of Satoumi was born from the latter human-environment philosophy. However, a shared evolution of the Satoumi concept with science-based resource management as a foundation for MPAs may provide a successful strategy for achieving provisions of the Convention on Biological Diversity and UN Sustainable Development Goals across three dimensions: social, economic, and environmental. A resulting hybrid MPA management structure utilizing positive aspects of both top-down central government-driven and bottom-up local community-driven approaches, both interwoven with innovations of science, may be an ideal solution for long-term conservation and sustainable use of marine resources while fully engaging the principles of Satoumi.

Keywords Biodiversity · Conservation · MPA · ILEK · SDGs

3.1 Environmental Philosophy and the Satoumi Concept in the West and Japan

It has been stated that "When it comes to the ocean, it's the common heritage of humankind" (Thompson in UN News Centre 2017). However, cultural perspectives and concepts of the human relationship with nature significantly influence their

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interactions with the environment (and by extension to the ecology of that environment) in which they exist (White 1967; Callicott and McRae 2014). For example, European/North American (Western) and Asian (Eastern) philosophies for the interactions of humans and the environment have, at least in the past, exhibited differential approaches (Rummel 1975; Randerson 2015). A major theme of historic Western environmental philosophy is human separation from nature, with humans and nature comprising two separate and often opposing elements. However, Aldo Leopold has often been thought of as the originator for the philosophy of environmental ethics and redefining conservation as a state of harmony between humans and the environment (Leopold 1950). Odin has argued that the environmental ethic of Leopold can also be grounded by a land aesthetic in the Japanese Buddhist perception of nature (Odin 2014). Asian environmental philosophy has generally had a theme that humans and the environment must harmonize, with humans as an integral part of the environment. It is from this environmental philosophy that the concept of Satoumi had been born.

As presented by Tetsuo Yanagi, the term "Satoumi" referred to the concept of a coastal sea with high biological productivity and high biodiversity due to human activities (Yanagi 1998, 2005, 2007). Given the literal translation of the phrase as village communities (sato) associated with the sea (umi), Satoumi has also been discussed in the context of a symbiotic relationship between human activities and the ocean (Hénocque 2015). Both of these concepts build on a long history in Japan, from the early Edo Period under the Tokugawa shogunate, of Satoumi practiced as human use and management of the coastal seas for high productivity while maintaining high biodiversity (Komatsu and Yanagi 2015). It is, therefore, not surprising that the broad concept of Satoumi has been employed in various forms throughout Japan since Yanagi urged a renewed application of this philosophy at the end of the twentieth century.

The application of Satoumi, as coastal community-based resource management that combines both scientific knowledge and traditional understanding of the local environment, was utilized in reviving the Seto Inland Sea via a marine ranching project (Tanaka and Ota 2015). Successful establishment of Satoumi can be employed to identify appropriate shoreline and coastal sea area manipulations (i.e., nutrient inputs, biogeochemical cycling, water circulation/upwelling/downwelling, physiochemical parameters, geomorphic topography) to increase sustainable fisheries production and biodiversity (Yanagi 2008). Conservation efforts to protect the sargassum seaweed beds that provide spawning grounds for sandfish (*Arctoscopus japonicus*) in Akita, Japan, are a good example of local fisheries management that highlights traditional practices of the Satoumi (Akimichi and Sugiyama 2011). A severely degraded Ago Bay in Japan was restored through implementation of Satoumi principles including significant engagement of local grassroots community groups for installation of artificial tidal flats that control nutrient fluxes and water exchange between offshore and inshore producing sediment parameters within the optimal range for macro-benthos biodiversity (Matsuda and Kokubu 2011). Basically, restoring Ago Bay water, sediment, and biodiversity conditions closer to

pre-industrial conditions was achieved by more, rather than less, human action on the environment.

3.2 Perspectives for Integration of Satoumi with Marine Protected Areas

3.2.1 Integration of MPA Mechanisms Is Needed

Marine protected areas (MPAs) have become an increasingly important mechanism to advance the protection of marine biodiversity. In great part, many of the most widely viewed concepts of human interactions with marine and coastal areas, particularly for MPAs, stem from the major theme of historic Western environmental philosophy (discussed earlier in this chapter). Several international, national, and state/local level mechanisms exist that serve to advance the management objectives of MPAs. In the international sphere, these include the Man and the Biosphere Program, the International Union for Conservation of Nature (IUCN), the Convention on Biological Diversity, the Regional Seas Program, and IMO Sensitive Sea Areas. In the United States, such mechanisms exist in NOAA's Marine Sanctuaries and National Estuarine Research Reserve System programs and the National Park Service's marine and coastal parks. Virtually all US MPAs were established to promote biodiversity conservation in combination with varying degrees of sustainable use of natural and cultural resources (Eichbaum et al. 1996). These areas generally incorporate research, monitoring, and training activities in support of conservation and sustainable use objectives. The managers of these protected areas face the challenging task of balancing these objectives in the context of inherent uncertainty of natural systems and the political and social pressures of human systems (Crosby et al. 2000a, b). In the absence of a truly functional globally integrated network of MPAs that is essential for the comprehensive conservation and sustainable use of marine biodiversity, there is a critical lack of integration between and even within many of these programs (Eichbaum et al. 1996). The challenge facing the world is to integrate these programs into a true and robust system for conserving and sustainably utilizing marine biological diversity and resources while also including a Satoumi perspective of human communities as part of the broader marine and coastal ecosystem.

3.2.2 The US National Level MPA Systems

The United States hosts several national level systems of MPAs, including US Man and the Biosphere Reserves System, National Marine Sanctuaries Program, National Park Service, National Wildlife Refuge System, and numerous state and local park,

refuge, and reserve systems including the federal-state partnership National Estuarine Research Reserve System (discussed in greater detail in the following section). Some of these MPAs are multiple-use regarding resource extraction (such as the Florida Keys National Marine Sanctuaries), while others strive for a more wilderness status (such as Pt. Lobos State Park in California).

A national federal government agency, NOAA, administers the National Marine Sanctuaries Program. National Marine Sanctuaries are federally designated area within US waters that protects areas of the marine environment with special conservation, recreational, ecological, historical, cultural, archeological, scientific, educational, or aesthetic qualities. The National Marine Sanctuaries System consists of 14 MPAs that encompass more than 783,000 square miles (2,030,000 km^2). Individual areas range from less than 1 to 583,000 square miles (3 to 1,509,963 km^2). The program began after the 1969 Santa Barbara oil spill off the coast of California brought the plight of marine ecosystems to national attention. The US Congress passed the Marine Protection, Research, and Sanctuaries Act in 1972, which allowed for the creation of National Marine Sanctuaries. The resources protected range from coral reef ecosystems in American Samoa, Florida, Hawaii, and Texas to shipwrecks in the Great Lakes and the Atlantic Ocean. The Papahānaumokuākea Marine National Monument, in the Northwest Hawaiian Islands, is a World Heritage site that is jointly administered by NOAA, in conjunction with the US Fish and Wildlife Service and the State of Hawaii.

Designation as a National Marine Sanctuaries does not automatically prohibit fishing and other activities. Recreational and commercial fishing is allowed in some sanctuaries. It is possible to restrict consumptive or destructive activities through the initial designation process and NOAA actions. NOAA manages sanctuaries for multiple uses provided the US Secretary of Commerce deems the uses compatible with resource protection. The National Marine Sanctuaries Act does not prohibit any type of use but leaves it up to the Secretary (a Presidential appointee) to determine through a public process which activities will be allowed and what regulations will apply to various uses. NOAA coordinates management of a National Marine Sanctuaries with the State (for State waters within the MPA) and other appropriate federal agencies. As an example, the Florida Keys National Marine Sanctuaries coordinates with the State of Florida, US Army Corps of Engineers, US Environmental Protection Agency, National Park Service, US Fish and Wildlife Service, and South Atlantic and Gulf Fishery Management Councils for establishing regulations that authorize research, education, or salvage/recovery operations, commercial fishing, recreational fishing, trawling, collection of aquarium fish, aquaculture, and otherwise prohibited or restricted activities within this MPA.

3.2.3 US National-State-Local Partnership MPAs

In the United States, national, state, and local governments also collaborate in MPA partnerships. The US National Estuarine Research Reserve System (NERRS) is an

example of a partnership between national government, through NOAA, and coastal state governments under the federal Coastal Zone Management Act. The NERRS network consists of 29 coastal sites designated to protect and study over 1.3 million acres of estuarine systems. NOAA provides funding and national guidance, but each NERRS site is managed on a daily basis by a lead state agency or university with input from local partners. Each site undertakes the initiatives needed to keep the estuary healthy. Reserve-based research and monitoring data are used to aid conservation and management efforts on local and national levels. Local and state officials are better equipped to introduce local data into the decision-making process as a result of this federal-state partnership.

Five of the eight California Channel Islands, and more than 1200 mi^2 of the surrounding seabed, are protected by several partnering MPA conservation designations. The area is recognized internationally as a Biosphere Reserve, nationally as a US National Park and a US National Marine Sanctuaries, and locally as three State Ecological Reserves and two Areas of Special Biological Concern. These islands bridge two biogeographical provinces and, in a remarkably small space, harbor the biologic diversity of 1500 km of North American coast. The nearby confluence of ocean currents brings nutrients up from the dark seabed into bright sunlight, building one of the most productive food webs on earth. Humans take more sea life from the eight Channel Islands than nature can replace. While many species targeted by fishing are virtually disappearing, others are undergoing radical boom and bust cycles. Incredibly productive kelp forest ecosystems have been reduced to barren rock covered by un-fished species that were released from competition and predation and additionally stressed by normal extreme events, such as El Niño. New management strategies are needed to achieve legislated MPA goals and objectives (Crosby et al. 2000b).

3.2.4 Development of a National MPA System by Presidential Decree

Recognizing the significant role that MPAs can play in conserving marine resources in the United States and the need for additional MPA coordination and capacity building, a Presidential Executive Order No. 13158 of May 26, 2000, called for the development of a National System of Marine Protected Areas (NOAA 2015). To provide a blueprint for building the US National System of MPAs, the Presidential Order of 2000 called for the development of a framework for a National System of MPAs and directed the establishment of a National MPA Center within NOAA to lead the system's development and implementation. The original *Framework for the National System of MPAs of the United States of America* was developed between 2005 and 2008 and was updated in 2015. The Order called for a national system extending beyond federal sites, requiring collaboration with coastal states and territories, tribes, Regional Fishery Management Councils, and other entities. The

Order further specified that the national system should be scientifically based, comprehensive and represent the nation's diverse marine ecosystems and natural and cultural resources. The Order defines an "MPA" as "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (NOAA 2015). This inclusive definition is different from the definition used by the World Conservation Union (IUCN) and adopted by many countries, which excludes areas managed for fisheries management (what the United States defines as sustainable production MPAs).

3.2.5 *Definition of MPAs and MPA Objectives*

Japan's Ministry of the Environment formulated a Marine Biodiversity Conservation Strategy in 2011 that defines marine protected areas as follows: marine areas designated and managed by law or other effective means, in consideration of use modalities, aimed at the conservation of marine biodiversity supporting the sound structure and function of marine ecosystems and ensuring the sustainable use of marine ecosystem services (Amako 2015). This definition specifically highlights support of sustainable use that by extension requires maintenance of healthy ecosystems.

The fact that MPAs can accomplish a broad range of objectives and have different meanings to different people underscores the imperative that MPA planners and advocates work to clearly define targeted objectives for MPA networks and individual MPAs (Jones 1994; Murray et al. 1999; Agardy 2000; Crosby et al. 2000a, b). MPAs include people and occasionally unique cultures. Cultural parameters are especially important to consider, and can be protected through MPAs, in areas having significant populations of indigenous peoples with traditional connections to the marine environment (Crosby et al. 2000b; Ward et al. 2001).

3.2.6 *Traditional Management Methods and Translation and Circulation of Knowledge*

The application of traditional methods and local environmental knowledge of conservation in the monitoring and management of marine resources can result in sustainable resource use even where subsistence harvesting is allowed in a protected area (Crosby et al. 2002). Traditional indigenous management practices should be respected and considered when establishing management strategies for coral reefs, given that indigenous peoples have maintained sustainable yields while harvesting coral reef resources for generations in many Pacific Island nations (Crosby et al. 2002). Where there is continuing local use or custody over marine resources, the

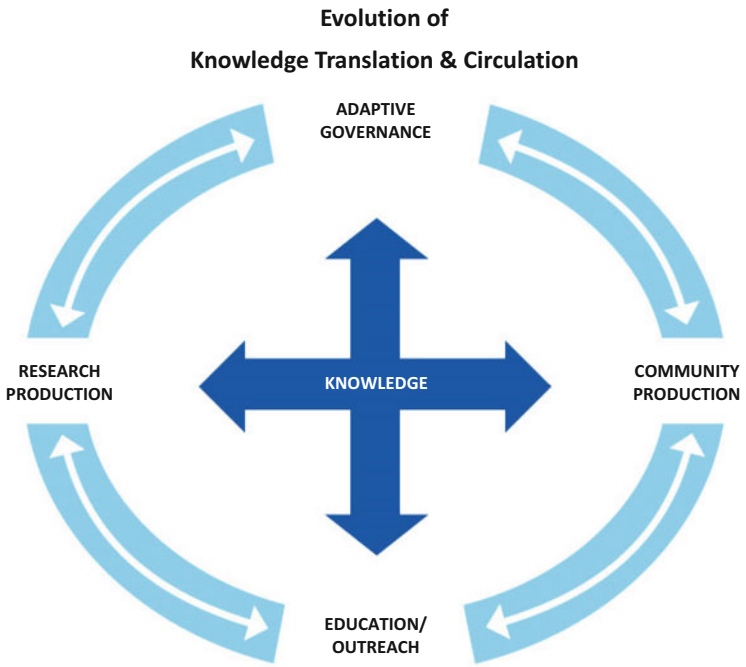

Fig. 3.1 The evolution of knowledge translation and circulation between and among traditional knowledge and formal scientific research stakeholders

likelihood of establishing effective coral reef management strategies depends to a very large extent on voluntary acceptance of the management measures. With few exceptions, examples of effectively managed marine and coastal protected areas give responsibility to local users in the management process (Kelleher et al. 1995; Crosby et al. 2000b). The use of traditional skills in the management of coral reef protected areas should be encouraged.

A critical need exists for the formation of *integrated local environmental knowledge* through improved translation and transfer of information among and between scientists, the public, and resource managers (Crosby et al. 2018; see Chap. 1). The key to success in achieving this goal is an increased level of understanding and awareness of the value of an evolution for knowledge translation and circulation between and among diverse stakeholders, including those with traditional knowledge and formal scientific researchers with different types of knowledge (Fig. 3.1).

3.2.7 *Integration of No-Take Zones and Multiple Use in MPAs*

In many areas of the world, the cultural identity of the local peoples is intimately linked with traditional uses of the marine environment. As a member of the US Coral Reef Task Force (CRTF), the former Governor Sunia of American Samoa expressed his concern for the rights of traditional uses of marine resources in the islands. The Governor made a formal request that the specific multiple-use MPA design presented in Fig. 3.2 (see Crosby et al. 2000b; Salm and Clark 1984) be the preferred option for implementing the 20% no-take coral reef MPA policy of the CRTF, in order to protect the rights of indigenous peoples to periodic cultural and subsistence use in some areas within MPAs (US CRTF 2000). Governor Sunia was particularly concerned with ensuring that indigenous peoples have access to conduct traditional extractive uses within a broader multiple-use MPA context.

In another example of the values of multiple-use MPA with no-take zones, the Kaho'olawe Island Reserve Commission in Hawaii developed a two-zone

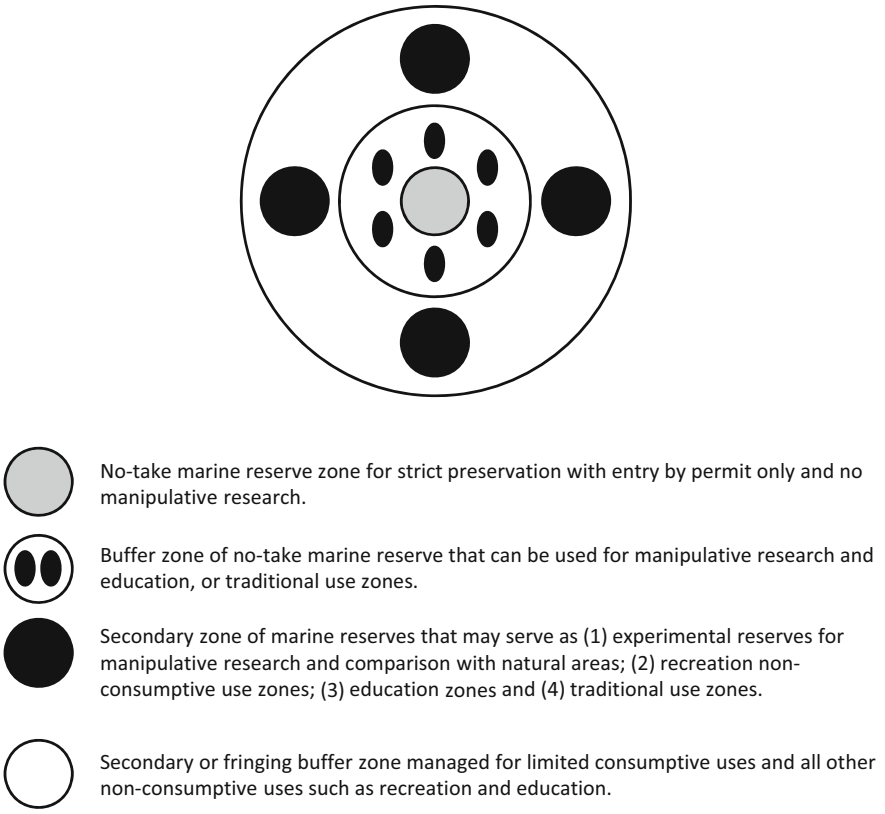

Fig. 3.2 Schematic representation of a generic zoning strategy in a multi-use marine protected area

management strategy that allows for subsistence gathering of marine resources for specifically approved cultural, religious, and education activities by "Native Hawaiians" (Crosby et al. 2000b). Trans-boundary, multiple-use MPAs are also proving a unique vehicle for improving Middle East regional coordination and cooperation in addressing common goals with clear benefits well beyond conservation of marine biodiversity (Crosby et al. 2000a; Loya et al. 1999). The Soufriere Marine Management Area, St. Lucia (a multiple-use area including no-take marine reserves, fishing priority zones, and other use zones), is yet another example that was initially established as a tool to resolve conflicts among that area's users (i.e., fishermen, tourists, yachters, sea bathers, divers) and is considered a success in this regard (Agardy et al. 2003).

3.2.8 Evolution of Satoumi Local Practices with Science Innovation for Global Impact (See Chaps. 5 and 13)

1. **Lessons from Okinawa and Florida**

   Local Okinawa communities of Shiraho and Sekisei lagoon have, over the centuries, developed a Satoumi culture intimately linked to the coral reef ecosystem and adapted to an abundant but sustainable use of its resources (Kakuma and Kamimura 2011; see Chap. 5). This state of traditional equilibrium for the coral reefs now faces increasing stressors that are occurring on a global scale. Local fishing communities reached a consensus on the establishment of marine protected areas to help reduce human impacts but also implemented more "active" measures for protection of the lagoons including controlling populations of crown-of-thorns starfish and constructing biodiversity-enhancing habitats of traditional stone fishing weirs (*ishihimi*). While preliminary data on the effectiveness of these actions for biodiversity is encouraging (Kakuma and Kamimura 2011), the challenges to coral survival from widespread coral disease, increasing ocean temperatures, and acidification will require that innovative science and coral restoration technologies, such as developed by Mote Marine Laboratory (see Chap. 13), also be incorporated in the Satoumi strategy of Shiraho and Sekisei lagoon. Berque and Matsuda (2013) also concluded that hands-on approaches by local communities are the key to conserve or restore their marine environment, but technological support and scientific knowledge are also necessary for the local-scale innovation in Satoumi approaches for marine biodiversity management.
2. **Satoumi Concept to Achieve Integrated Resource Management**

   The need for better management of MPAs in particular, and the broader seascape in general, is inescapable (Crosby 1995). Marine habitats and resources, especially, have been assumed to be almost unlimited and that if one habitat became degraded or a particular fisheries resource depleted, there always would be another to replace it. Ludwig et al. (1993) have observed that "...there is

remarkable consistency in the history of resource exploitation: resources are inevitably over-exploited, often to the point of collapse or extinction." A number of reasons were given for this consistency, including the wealth or prospect of wealth-generating power, the difficulty in reaching a consensus on scientific understanding, and the enormous complexity and natural variability of natural marine and coastal systems.

One of the key recommendations that was put forth by Ludwig et al. (1993) for future natural resource management principles is to include human motivation and responses as part of the system to be studied and managed. We should try to avoid the "tragedy of the commons" (the Hardin (1968) hypothesis that common resources are inevitably overexploited; also see Chap. 8) in the utilization of marine and coastal resources. In doing so, however, natural resource decisions have traditionally emphasized achieving the management goals of a particular agency, organization, or interest group in addressing particular human needs (such as the need for timber, water, fisheries, or recreation) in a particular management unit (such as public rangelands, water management districts, or public marine and coastal waters) (UNEP 1995). The shortsightedness of this approach has become apparent in recent years, as the demand for marine and coastal resources has increased. The Satoumi concept may provide a more comprehensive and integrated approach to the management of common resources.

3. **Satoumi Concept to Achieve UN Sustainable Development Goals**

Mizuta and Vlachopoulou (2017) have suggested that there are several similarities between the "17 Sustainable Development Goals" (SDGs) that were adopted by the United Nations General Assembly (United Nations 2015, 2016) and the goals of the Satoumi, as they are both committed to sustainable development in three dimensions, social, economic, and environmental, despite the fact that these might often be considered as conflicting notions and ideas. The core concept of Satoumi is the synergetic coexistence of humans and nature within the boundaries of a coastal ecosystem. Traditional knowledge is also merged with modern science as part of the modern Satoumi strategy to guide human actions toward wise use of the coast and marine resources. Such an arrangement allows for recognition of cultural heritage and establishment of a responsible production pattern and environmental conservation. Coastal users are expected to experience economic growth while ensuring long-term continuity of ecosystem services through responsible use, which reflects in both environmentally and economically sustainable and resilient communities and society. The close similarities between Satoumi and SDGs become evident (Fig. 3.3), as they both advocate for development through sustainable human-ecosystem interrelations.

Vierros (2011) has proposed that Satoumi, both as a concept and a management strategy, provides a culturally appropriate method for implementing provisions of the Convention on Biological Diversity (CBD), especially as related to the CBD ecosystem approach, traditional knowledge, innovations and practices, and biodiversity. In Okinawa (Shah et al. 2017), American Samoa (Crosby et al. 2002), and many other Pacific Islands, there is a strong culture of interdependence

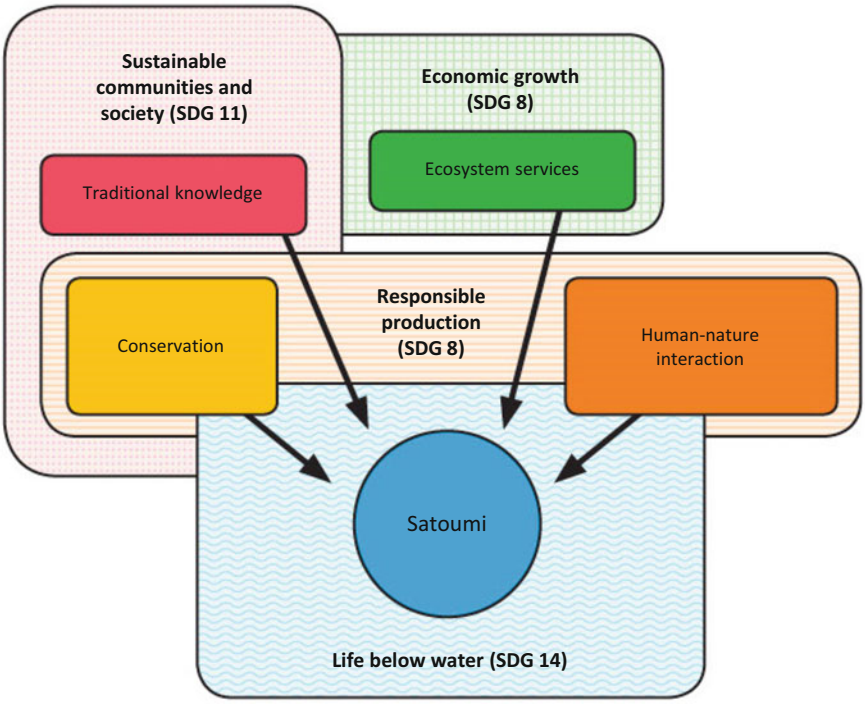

Fig. 3.3 Relationship between the Satoumi fundamental ideas (colored shapes) and the SDGs (patterned shapes), both aiming at the realization of sustainable coastal communities. Overlapping shapes indicate direct impact in each other

between local communities and the marine ecosystem that reflects the philosophy of Satoumi, especially as related to perspectives for marine protected areas. In Okinawa, local community "willingness to pay" for implementation of marine protected areas (MPAs) that would increase recreational fishing was significantly ($p < 0.05$) stronger if the MPAs were going to be designated and administered through local organizations (bottom-up Satoumi approach) as opposed to central governments (top-down approach) (Shah et al. 2017).

A hybrid MPA management structure utilizing positive aspects of both top-down central government-driven and bottom-up local community-driven approaches, both interwoven with innovations of science, may be an ideal solution for long-term conservation and sustainable use of marine resources while fully engaging the principles of Satoumi. The Satoumi concept has enormous potential for aiding in efforts to harmonize human activity in marine and coastal ecosystems with sustainable use and conservation of marine habitats and biodiversity around the world, but perhaps particularly so with an evolution of the MPA concept, and grassroots community engagement in enhancing marine ecosystems for high productivity and biodiversity.

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Chapter 4
Roles of Women in Satoumi

Darien D. Mizuta and Eirini I. Vlachopoulou

Abstract The small-scale fisheries and aquaculture sectors have been traditionally perceived as a male-dominated environment; yet, women play a multitude of essential roles not only to support and maintain the industry but also to rejuvenate it through innovation. This essay examines the diverse roles of women in the process of satoumi co-creation in Japan, by exploring women-led examples of creating linkages between the community and the coastal environment. The role of women in promoting fair and equitable collaborations of diverse actors in satoumi co-creation processes will be discussed through a lens of challenges and opportunities for participatory processes.

Keywords Satoumi · Gender equality · Women diver · Fisheries · Resource management

4.1 Fisheries in Satoumi

Satoumi are seascapes or "coastal area[s] where biological productivity and biodiversity have increased through human interaction," according to the most widely used definition (Yanagi 1998). They can be further described as dynamic mosaics of managed socio-ecological systems producing ecosystem services (Saito and Shibata 2012), with two components identified: people and nature. Despite the existence of different definitions for the satoumi term, key elements emerge, including "ecosystem

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types," "goods and services," "human-ecological interactions," and "ecosystem management" (Saito and Shibata 2012). As marine conservation is an integral part of the satoumi framework, the satoumi concept provides a management strategy that fits the Convention on Biological Diversity (CBD) program on marine and coastal biodiversity. It constitutes an implementation process of the CBD Ecosystem Approach that incorporates traditional knowledge and cultural historical context in the concepts of conservation and sustainable use of marine resources (Vierros 2011).

Following the original definition of the satoumi seascapes, apart from different habitats and actors, coastal and marine areas of satoumi encompass a plethora of leisurely human activities such as sea bathing, shellfish gathering, and nature observation. Yet, the most widespread activities and the ones with a strikingly clear connection with all the aforementioned satoumi-related keywords are fisheries and aquaculture. Based on the evident importance of such activities, this chapter focuses on fisheries- and aquaculture-related activities taking place within the satoumi context as viewed through a gender lens.

In Japan, where the term "satoumi" was coined, women's participation in satoumi activities related to fisheries first came to the limelight around 1950, when the first organized women's fisheries groups were formed. Official recognition came in the mid-1950s, when these groups were finally integrated into Fisheries Cooperative Associations (FCAs)—the basic management unit in fisheries communities—as a parallel group, albeit largely in a tokenistic fashion. This movement, originally limited to the local or regional level, was elevated to the national level with the establishment of the National Fisheries Cooperative Women's Department Liaison Council (NFCWDLC) in 1959 (Seki 2020). Yet, recognition of the role of women in the sector still remained tokenistic.

Importantly, in several parts of Japan, many FCAs still function with one member representing each household, which means women in fisheries communities are usually represented by their husbands. Several events and actions followed to highlight women's participation in fisheries (Fig. 4.1). However, little has changed in coastal communities, where patriarchal leadership still hinders the recognition of women as main actors in the fisheries sector, even though incentives for women's participation in fisheries and equality in fisheries job recognition were heavily promoted by the 4th Basic Plan for Gender Equality and the Fisheries Basic Plan 2017 (Soejima and Frangoudes 2019; Fig. 4.1), although with little success.

4.2 Gender Roles in Satoumi: Women as Indirect Actors in Fisheries Activities

Even though the prevalence of traditional roles in Japan and a patriarchal approach reinforce the idea of the fishing profession as predominantly male-dominated, with limited space for female participation, women's roles in fishing communities and their direct and indirect contributions have been crucial for the long-term viability of Japanese small-scale fisheries.

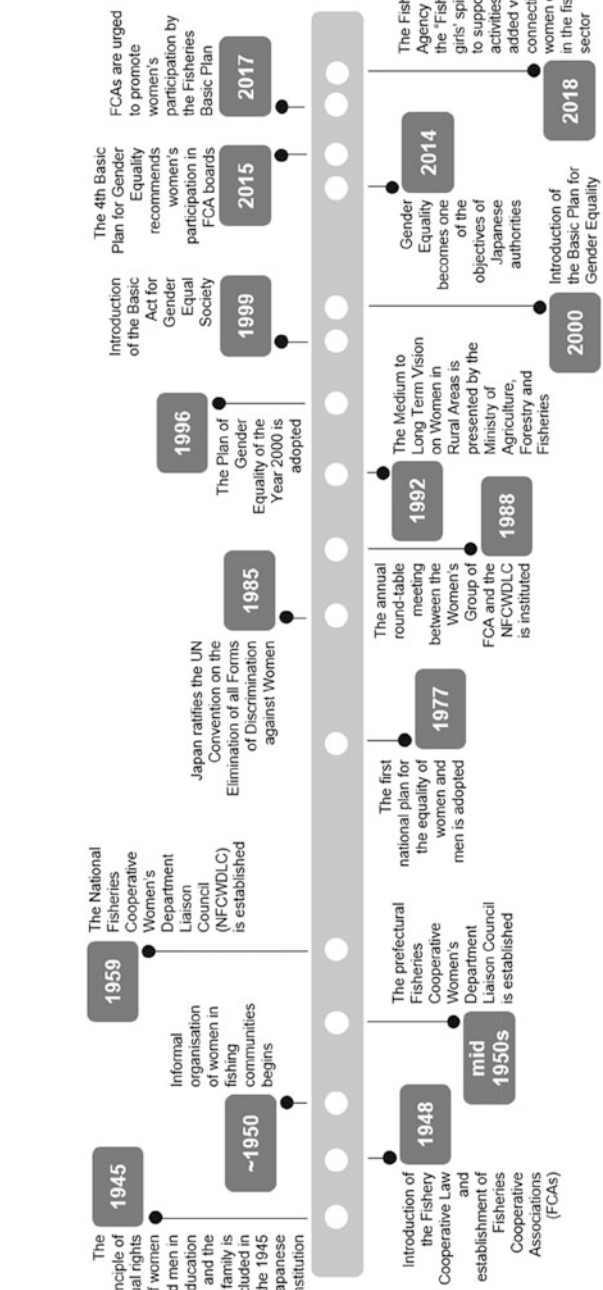

Fig. 4.1 Timeline of milestones related to women's participation in the fisheries and aquaculture industry in Japan. Adapted from Seki (2020) and Soejima and Frangoudes (2020)

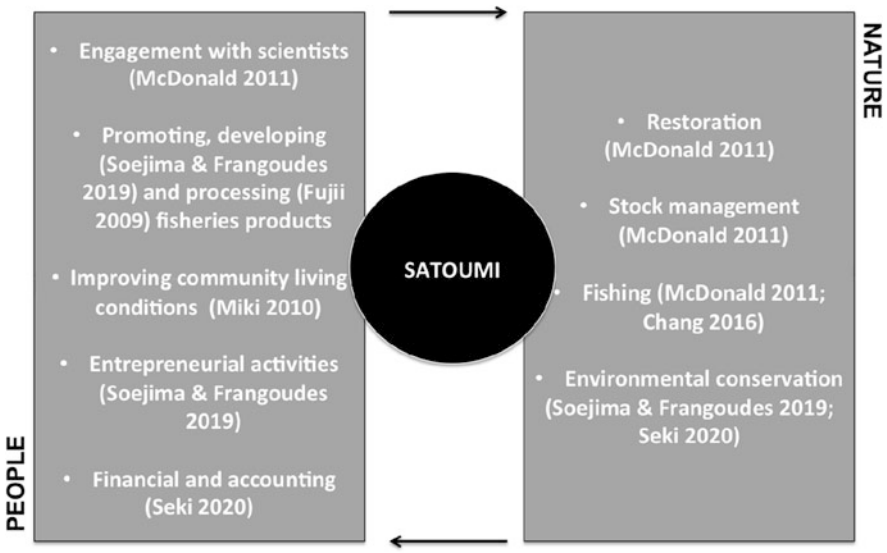

Fig. 4.2 Women's roles in fisheries activities within the two components (nature and people) of satoumi. The arrows indicate continuous interactions between components

Historically, women have been directly responsible for a wide array of tasks that ensure the prosperity of the coastal communities in which they belong (Fig. 4.2). From traditional roles related to motherhood and household management (National Association of Fisheries Cooperatives Women's Groups 1989), feeding their families, and reducing household expenses to increasingly more "niche" tasks, such as coastal habitat preservation and maintenance (e.g., coastal cleanups), women in fishing communities shoulder multiple crucial responsibilities that might not be evident at first sight when considering gender roles in satoumi (Miki 2010; Soejima and Frangoudes 2019; Seki 2020). Community well-being is often at the forefront of women's activities. One such example would be the organization of fire brigades by groups of women to fill in for the absence of men who would spend long hours at sea (Seki 2020) or a fundraising initiative for orphans of fishers who died at sea (Soejima and Frangoudes 2019).

Despite not having significant formally recognized roles in the Japanese fisheries sector, women have been proactive about supporting and promoting the values of fishing communities, often adopting novel approaches and ideas, including initiatives in marine conservation. As an example, in the 1970s, women's groups noticed the impact of pollution caused by detergents on coastal habitats and initiated the movement to substitute harmful cleaning substances with natural soap (Soejima and Frangoudes 2019). Similarly, in 1996, they adopted the idea of the connection between the forests, the rivers, and the sea and took action to promote it (Seki 2020). They also often perform restoration initiatives, such as acquisition of (species) seeds and juveniles to release later in nature (McDonald 2011).

Fig. 4.3 Test kitchen for new seafood products developed by women and local seafood shop where women work as sales associates (visible on the back of the picture), both part of the FCA in the fisheries community in Rausu, Hokkaido. (Photo credit: E.I. Vlachopoulou)

Apart from the peripheral support that women provide, they also contribute directly to the fisheries sector, mostly with tasks based on land (Fig. 4.2). According to the Fishing Census of 2018, out of more than 150,000 fishers in Japan, only 11.5% were women, and most of them either participated in fishing trips with their husbands or were divers themselves who actively practice marine species stock management ("ama divers," further discussed later; McDonald 2011; Seki 2020). However, the percentage of women's participation skyrockets when considering land-based roles, even reaching 62% for employment in fish processing plants (Seki 2020). It is noteworthy that within the processing sector, women often lead the development of new products, fostering innovation in the industry. In fact, women have been promoting seafood consumption since 1985, in response to declining trends of seafood consumption in Japan (Soejima and Frangoudes 2019). Furthermore, women routinely staff the local shops, where they promote the local fisheries products—often developed by themselves—like in the community of Rausu in Hokkaido where farmed seaweed is the primary seafood product (Fig. 4.3).

In addition to the aforementioned roles, women offer essential tangible support to fisheries operations in a multitude of other ways, with particularly important, financial, and accounting responsibilities (Seki 2020). Yet, women are still largely excluded from the decision-making process that guides the local fishing communities, comprising only 0.5% of FCA management (Seki 2020; Soejima and Frangoudes 2019, 2020).

Nevertheless, there have been reported cases of women's entrepreneurship where businesses relating to seafood companies or restaurants were painstakingly built and then marginalized by members within the same local FCA (Soejima and Frangoudes 2019).

4.3 Ama (Women Divers): Women as Direct Actors in Fishing Activities

Women divers, called "ama"[1] in Japan and "haenyeo" in South Korea, constitute a profound example of women at the forefront of satoumi activities in fisheries communities. Ama divers are traditional free divers that fish mainly for abalone, sea urchins, and sea cucumbers, and their livelihoods are deeply intertwined with their environment. The profession is hereditary, passed down through generations, starting with training during the early teenage years and extending to elderly age. In fact, currently, most active divers are in their 60s or over; yet, they still usually dive daily in the warmer seasons and up until it is physiologically impossible due to low temperatures during the winter.

A typical working day in an ama community,[2] specifically in Mie, begins in the early morning with the public announcement of the species allowed to be harvested on that particular day. The selection is based on ongoing monitoring of the status of a list of target species.

As ama work in groups, during the colder months, they gather in their warming hut by the shore (Fig. 4.4a), where they start a fire to warm their bodies and prepare for the long hours of diving (Yoshimura 2020), in a ritual that appears to fight hypothermia. Most ama change into wetsuits there. Wetsuits are ubiquitous nowadays, although in the past, ama would dive covered only in a cloth in the summer months. A male colleague, usually the husband of one of the ama in the group, takes them to the diving spot, where they spend the next several hours diving. They repurpose simple household objects to fashion buoys and floating nets, used to bring their harvest to the surface and store it in floating nets (Fig. 4.4b–f). A usual diving day lasts 1–3 h, although daily harvest time and duration for ama divers often depends on regulations collectively discussed for each target species (McDonald 2011; Yoshimura 2020).

4.3.1 Ama Divers as Sustainability and TEK Stewards in Satoumi

Satoumi are managed based on a mix of traditional ecological knowledge (TEK) and modern science (Saito and Shibata 2012; Mizuta and Vlachopoulou 2017). It is fairly common for fisheries communities in Japan to receive constant updates from and interact with the scientific community, since the work of governmental research agencies aims to align with pressing issues in the industry. Management of these

[1] The terms "women divers," "ama," and "ama divers" are used interchangeably throughout this essay.

[2] This essay uses, in its majority, the example of the ama communities in Mie Prefecture, based on the authors' personal observations and research in 2015 and 2016.

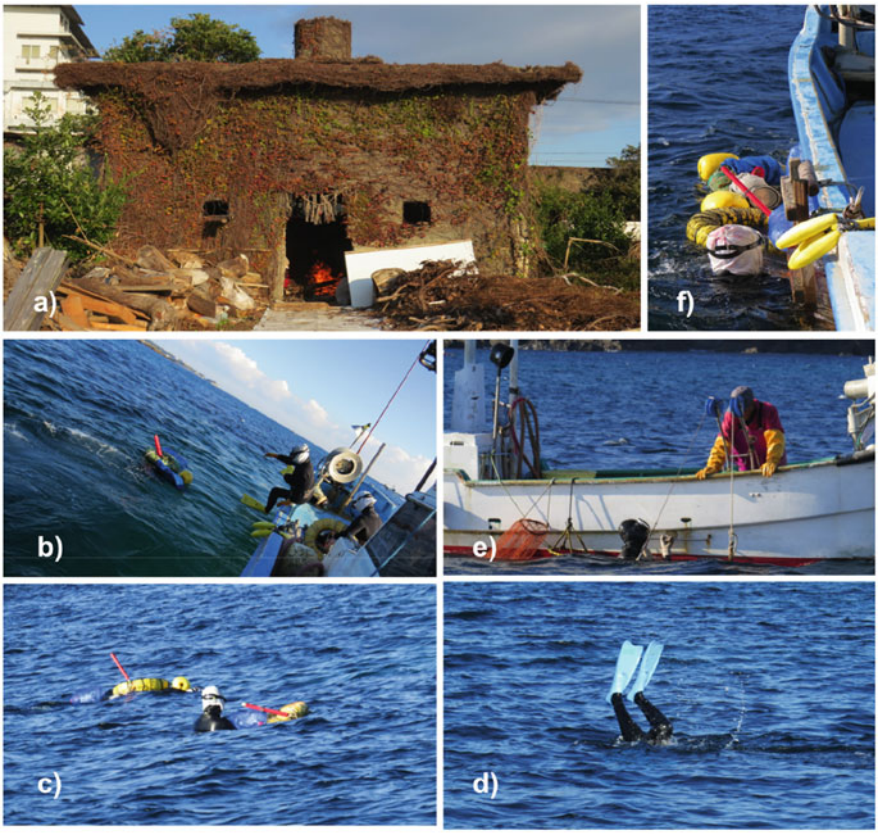

Fig. 4.4 Daily activities of ama in Mie Prefecture, Japan. Counterclockwise from the top left: (**a**) A traditional ama hut (*amagoya*) where fire is lit to warm the divers' bodies in preparation for diving in colder seasons. (**b**) Ama jump from support boat to prepare for the free dive. (**c**) Ama diving in groups, with support buoys to store the harvest after each submersion. (**d**) Effort to submerge by body impulse. (**e**) An ama discusses the diving conditions with a man on the support boat. (**f**) Ama recover and rest by the side of the boat that returned to transport them to shore at the end of a day-long diving session. (Photo credit: D.D. Mizuta)

seascapes incorporates also the knowledge of the main actors in the local environment, including not only fishermen but also women divers.

Hatfield and Hong (2019) highlighted that women divers have a long-standing reciprocal relationship with their environment and engage in TEK practices that require a deep understanding of sustainable practices, environmental changes, developments, and historical nuances. The divers have environmental acuity and a perception of trends in environmental changes, including changes triggered by climate change; they employ sustainability efforts and refine cultural practices. Resource management decisions are collectively debated, decided, and regulated by the community association, and they reportedly cooperate with scientists to

Fig. 4.5 Traditional measuring instrument (*sunbou*) to confirm whether the harvested specimen abides by the regulations imposed, as shown in a museum exhibit. (Photo credit: D.D. Mizuta)

address pressing issues, such as climate change impact on the fish stocks they target (McDonald 2011; Yoshimura 2020; Fig. 4.2). They employ strict policies and accountability for work, such as the aforementioned practices of daily identification of allowed harvested species, daily harvest time, the harvest grounds, and species size allowed for harvest (Yoshimura 2020; Fig. 4.5).

These intricate relations between women divers and nature, rooted in the hereditary knowledge passed from generation to generation, along with the cultural significance of the traditions that they practiced, have been officially recognized, at least in the case of South Korea, as the haenyeo have been awarded UNESCO Intangible Cultural Heritage Status. A long-running initiative to do the same for ama divers has been established, with the aim to maintain the profession through time and showcase the inherent sustainable principles that guide the ama's fishing practices (Kogure 2016).

4.4 Lack of Recognition of Women's Contributions to Satoumi

Women's contributions, both as indirect and direct actors, to satoumi seascapes are undeniable. Yet, the significance of these contributions suffers from a perpetuated lack of recognition, based on outdated gender role perceptions, reflected both within and outside their communities. For instance, in patriarchal fishing communities, as in most traditional food production societies, women's labor is often not accounted for in statistics, and women often constitute non-wage laborers, in contrast with women divers' communities, where ama divers are the primary wage earners (UNSCN 1989; McDonald 2006). This financial reward limitation makes the sector unattractive for women and discourages them from seeking relevant employment opportunities, potentially justifying, at least partially, the stagnation patterns in the number of women working in fisheries communities (Fig. 4.6, Rausu Town 2015).

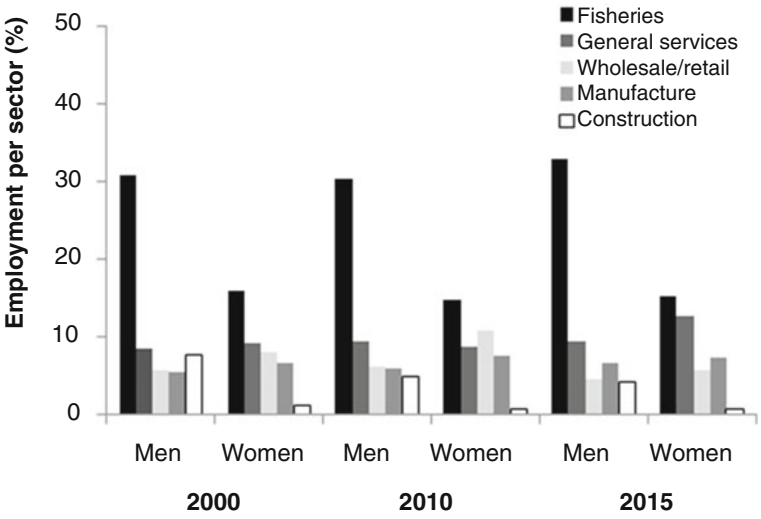

Fig. 4.6 Employment per sector in Rausu, Hokkaido, Japan (Rausu Town 2015)

In South Korea, women divers consistently rank lower in terms of societal status as fisheries workers, while at the same time being culturally idolized, often even heavily eroticized, through the lens of tourism (Chang 2016). A similar pattern was reported toward women divers in Japan (Kikuchi 2016). Chang (2016) stated that the divers themselves expressed contradictory feelings toward their profession by being proud of earning an income but also aware of and suffering from the marginalized niche they occupy in society.

Men in women divers' fisheries communities tend to play a secondary role in relation to the actual in situ fishing and harvest activity yet occupy the vast majority of managerial positions relating to trade. Although the work of the ama is an essential part of their communities' livelihood, the power linked to business management and trade control is in the hands of their male partners, usually their spouses, who handle the sale of the harvest and relevant financial negotiations. This dichotomy indicates a significant lack of female agency. Still, according to Martinez (2004), the ascribed status of women in relation to men in ama communities has historically been perceived as actually higher than for other women in the Japanese society. This elevated status, however, does not offset the impact of the expectation for women in fisheries to be represented by the household head, most commonly their husbands (Kusakabe 2017; Soejima and Frangoudes 2019, 2020).

The divers have occasionally justified their acceptance of the status quo and, therefore, their lack of exercised authority in trade-related matters, by stating that it gives them time to enjoy resting, cooking, and socializing in the hut while the daily catch is sold, before returning home from their fishing activities. The separation of labor roles across gender lines, with financial and technical management being

dominated by men and fishing activities performed by women, seems to remain largely unchallenged at the community level.

A possible overlooked outcome of women's collectivism in fisheries, through amas' traditional way of work, is increased resilience. According to Takakura (2021), usually, individualistic fishing operates offshore, while cooperative, collective fishing takes place closer to the coast. His investigation on the importance of collectivist initiatives after the disturbing events of the Great East Japan Earthquake and Tsunami in 2011 showed the vital role that collectivism plays not only during the disaster recovery period but also simultaneously as a crucial structure in fishing communities that allows resilience to persist by accommodating socio-environmental diversity, when resources and individualistic fishing are not suitable. One example would be the case of Kesennuma Bay, Miyagi Prefecture, where collective initiatives enabled the rebuilding of the local fisheries and aquaculture community after the tsunami devastation while embracing a more resilient and sustainable approach for the future (Vlachopoulou and Mizuta 2018). It is obvious that collectivist approaches to fishing are an important part of recovery and resilience processes after a catastrophic event. In the case of the ama, however, unlike the aforementioned example that collectivist action was taken in response to a single catastrophic event, collectivism is a common practice and not a one-off reaction. As collectivism is practiced on a daily basis, it permeates the relevant fishing communities, increasing their robustness in terms of resilience. Furthermore, collectivism directly relates to stability, income, positive self-esteem, and emotional sentiments (Takakura 2021). As a result, the ama, who are active fishing actors, also contribute to adaptability, on top of community well-being and cohesion-enhancing services that have traditionally been part of women's roles in coastal communities.

4.5 Leveraging Women's Participation in Satoumi

Women's roles in the food production process have been reinforced by long cultural traditions, with women globally assuming the main responsibility for the determination and fulfillment of the household's nutritional needs (UNSCN 1989). The gender aspect has been shown to have a significant impact on consumers' choices with regard to a balanced diet, with women being in general more knowledgeable about the consumption of healthy food and how to combine it in meals (Ishida and Ishida 2021). Therefore, women's continued assumption of roles in the preparation of meals and seafood product development may be perceived as reasonable and understandable, or even a natural arrangement, as this perception is driven by cultural conditioning. Empowerment of women in food production is even acknowledged as critical to biodiversity and an achievement of equitable resource access (McDonald 2011). Women have indeed developed specific skillsets relevant to food production and might gravitate toward related employment opportunities, especially in environments where limited alternatives might exist. However, considerably

enhancing women's agency in sectors where they are already active is an essential first step toward a more equitable society.

As Soejima and Frangoudes (2019) emphasize, historically, in the Japanese society, a greater value is assigned to men's fishing over that of women's fisheries activities. Thus, expansion of women's leadership in other activities should continue to be fostered, even if the rate of its adoption might be slow. Successful examples described in this chapter highlight the fact that women play essential roles not only in ensuring and promoting community cohesion but also in spearheading innovative and sustainable fishing activities. Support for women's expanded leadership along with strong partnerships between women and men within fisheries communities has thus far led to improved resource management and sustained fisheries sector development. This is not surprising, as gender equality has been identified as a key component of the health of marine socio-ecological systems (Friedman et al. 2020).

Underestimation of women's roles in the fisheries sector is an issue worldwide, resulting in food insecurity and poverty, and hampering economic development (FAO 2016). Despite the fact that we concentrate our discourse on the case study of Japan in this essay, examples of satoumi activities can be found in many parts of the globe, and analyzing them through this gender lens is likely to produce similar results in different locations of the world (FAO 2015; Tilley et al. 2021). In the last report on world fisheries and aquaculture, FAO discloses that the proportion of women in the workforce equals to 19% in aquaculture and 12% in fisheries, with roles throughout the fish value chain (FAO 2020); yet, additional sources from non-governmental organizations reporting to FAO indicate that women constitute as much as 50% of the seafood workforce if both the primary and secondary sectors are considered (Kusakabe 2017; FAO 2020). The most common posts of women in satoumi, namely, skilled and time-consuming tasks such as small-scale production, post-harvest industrial and artisanal processing value addition, marketing, and sales, constitute also women's mainstream fisheries roles globally.

In the worldwide sphere, besides its importance to CBD, women's participation in fisheries and satoumi directly relates to several Sustainable Development Goals (SDGs), especially SDG5 that calls for "achievement of gender equality and empowerment of all women and girls." Enabling women's access to resources and acknowledgment of unpaid care and satellite work in fisheries advances female empowerment and social recognition and is a de facto contribution to all other social discourses and related SDG5 targets, such as combating female discrimination, violence, and harmful practices against women and promoting women's participation in leadership, as well as women's access to technology (Kusakabe 2017; Williams 2017).

Conclusively, encouragement and proper support of women's work in fisheries is paramount. Even though the working conditions faced by women and the opportunities available to them in the satoumi context have been continuously improving and increasing, faster and more extensive action is necessary. FAO (2016) suggested a series of actions to improve gender equality in the fisheries sector. When compared and combined with the knowledge from the present review, it is evident that several of those guidelines apply directly to communities in satoumi seascapes, including:

- Gender awareness training
- Collection of gender-disaggregated data on contributions to fisheries subsectors (fishing and aquaculture) and inclusion in statistics to better guide policy and laws
- Consideration of gender aspects in policy-making, instead of the current common practice of introducing gender-blind policies
- Fostering women's networks for access to local, national, and international markets
- Promoting women's participation in decision-making and policy-making in participatory approaches and leadership roles
- Promoting fisheries development programs and training that also serve women's priorities

As the fisheries sector reshapes and adapts to challenges posed by resource depletion, climate change, unbalanced aquaculture development, and inequitable trade (FAO 2016), it should prioritize the equal integration of all key actors that support the development of the sector; and women have continuously and progressively contributed to guaranteeing fisheries sustainability and, thus, the legacy of the satoumi framework.

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Part II
Enhancing Ecosystem Function by Direct Human Intervention

Chapter 5
Enlivening Ecosystems with Human Hands: Building Satoumi Through Coral Reef Culture

Masahito Kamimura and C. Anne Claus

Abstract In Shiraho Village on Ishigaki Island in southwestern Okinawa, WWF-Japan and the local community created collaborative conservation during over a decade of work. At the outset, these two groups had very different ideas about how to address regional issues. WWF, a nature conservation organization, considers the preservation of precious coral reefs worldwide to be a top priority. Shiraho villagers, having experienced regional conflicts because of a thwarted airport development on top of their coral reef, emphasized cultural inheritance and community regeneration as their priorities. In this chapter, we consider the ways that socionatures of "satoumi" and "coral reef culture," which represent intertwined and interdependent nature ideologies, helped to further collaborative conservation in the context of these differing priorities. We first discuss the socionatural context in Shiraho that underlies the emergence and development of coral reef culture specifically at WWF. We then outline a few projects that are associated with the concept of coral reef culture and retrospectively address the 16-year endeavor of WWF's collaborative conservation projects in Shiraho. In doing so, we illustrate how the circumstances of a socionature's rise are critical to whether it resonates for conservation aims, even as a socionature's interpretations can, at times, be incommensurate. Finally, we return to the question of whether the development of socionatures are likely to further conservation aims more broadly.

Keywords Marine conservation · Tidal weir · Coral reefs · Socionature · Okinawa · Biocultural diversity

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5.1 WWF in Shiraho

Satoumi, a socionature, is a concept that became critical to developing effective collaboration in Shiraho. Socionatures (also referred to as nature/cultures) are nature ideologies in which nature and culture are recognized as intertwined and interdependent (Bear, The International Encyclopedia of Geography: People, the Earth, Environment, and Technology, AAG and Wiley-Blackwell, 2017). Socionatures are also examples of places where "biocultural diversity" flourishes. Biocultural diversity, defined as "a dynamic, place-based aspect of nature arising from links and feedbacks between human cultural diversity and biological diversity," is a term recently integrated into the work of UNESCO (United Nations Educational, Scientific, and Cultural Organization) to help guide and shape conservation policy interventions (Bridgewater and Rotherham 2019). The cultivated and biodiverse seascapes of Satoumi are one example of a socionature, but other examples of socionatures are those recognized by indigenous peoples. These terms all overlap in substantial ways, and we group them under the umbrella of socionature here.

In spite of rising interest among scholars and practitioners in socionatures, not much is written about the diversity of socionature concepts, the heterogeneous ways in which specific socionatures are understood and interpreted, and whether those diverse interpretations have significant repercussions for conservation practice—questions that are critical as organizations like UNESCO and the IUCN (International Union for Conservation of Nature) increasingly endorse such ideas. In Shiraho, for example, the socionature of Satoumi was utilized in tandem with a locally developed concept of coral reef culture in order to affect conservation practice. Elaborated by WWF in collaboration with Shiraho residents, the concept of coral reef culture both articulates and describes a specific socionature as it also makes new objects and agents of conservation work possible. At the same time, coral reef culture (which we consider to be affiliated with Satoumi) could not be developed or made legible without the work of WWF that sought to recognize and create Satoumi.

In this chapter, we consider the ways that socionatures help to further collaborative conservation through describing the ways that coral reef culture was enacted and interpreted in Shiraho. We first discuss the socionatural context in Shiraho that underlies the emergence and development of coral reef culture specifically at WWF. We then outline a few projects that are associated with the concept of coral reef culture and retrospectively address the 16-year endeavor of WWF's collaborative conservation projects in Shiraho. In doing so, we illustrate how the circumstances of this socionature's rise are critical to whether it resonated for conservation aims, even as this socionature's interpretations were, at times, incommensurate. Finally, we return to the question of whether the development of socionatures like coral reef culture are likely to further conservation aims more broadly.

One of the co-authors, Masahito Kamimura, lived and worked in Shiraho as a WWF staff member from January 2004 to March 2016. The other co-author, C.

Anne Claus, is a cultural anthropologist who lived in Shiraho and researched the work of WWF for a period of 18 months between 2009 and 2015.

In the year 2000, WWF (the World Wide Fund for Nature), an international organization that addresses environmental conservation in over 100 countries around the world, established Shiraho Sango Mura (Coral Village) in Shiraho, on Ishigaki Island. Initially, WWF was concerned about the impacts on coral reef ecosystems of a new airport that was being built north of Shiraho village. Protecting the living coral reef was their central concern. After some time, runoff of topsoil (through farming) became an issue for corals that are suffocated by the small soil particles of Okinawa's characteristic red soil (*akatsuchi*). Farming is significant for a large number of local residents who cultivate sugarcane among other crops. Over time agriculturalists used the sea less frequently, and these conditions, when viewed alongside the rapid development of the island, help to explain how the relationship between people and the ocean faded.

At Sango Mura, conservation efforts focused on historical relationships with the sea that referred back to a time when farmers had deep involvement with coral reefs and "coral reef culture." Between 2004 and 2016, the work of Sango Mura sought to create mechanisms for farmers to engage in ocean conservation activities. As we will illustrate, framing Sango Mura's work as reinforcement of "coral reef culture" made it possible to undertake activities not only within the realm of what is often considered to be nature conservation at WWF but also development activities that supported Shiraho's culture and economy (Kamimura and Yamazaki 2015).

Yet, even though Shiraho is a small village, it would be erroneous to assume that everyone who participated in coral reef culture activities had the same understandings of the term. As American anthropologist Anna Tsing notes in her discussion of conservation in Southeast Asia, "Parties who work together may or may not be similar and may or may not have common understandings of the problem and the product. The more different they are, the more they must reach for barely overlapping understandings of the situation" (Tsing 2005). Promoting the idea of "coral reef culture" involved cooperation that relied on some overlapping understandings while still recognizing and allowing for differences in interpretation.

5.2 Shiraho and "Coral Reef Culture"

Shiraho is located in the southeastern part of Ishigaki Island which faces the Pacific Ocean (Fig. 5.1). The village is long-established, having been founded around the fourteenth century during the age of the Ryukyu Kingdom. Its cultivated land area is currently the largest in Ishigaki Island, and agriculture and livestock are the primary industries. Since the new Ishigaki airport opened in 2013, businesses that are common in urban areas like rental car businesses, lodgings, and restaurants have established themselves. Apartment buildings were constructed in anticipation of housing airport workers, so the number of migrants from outside the island has recently increased. In May 2016, the population was 1600.

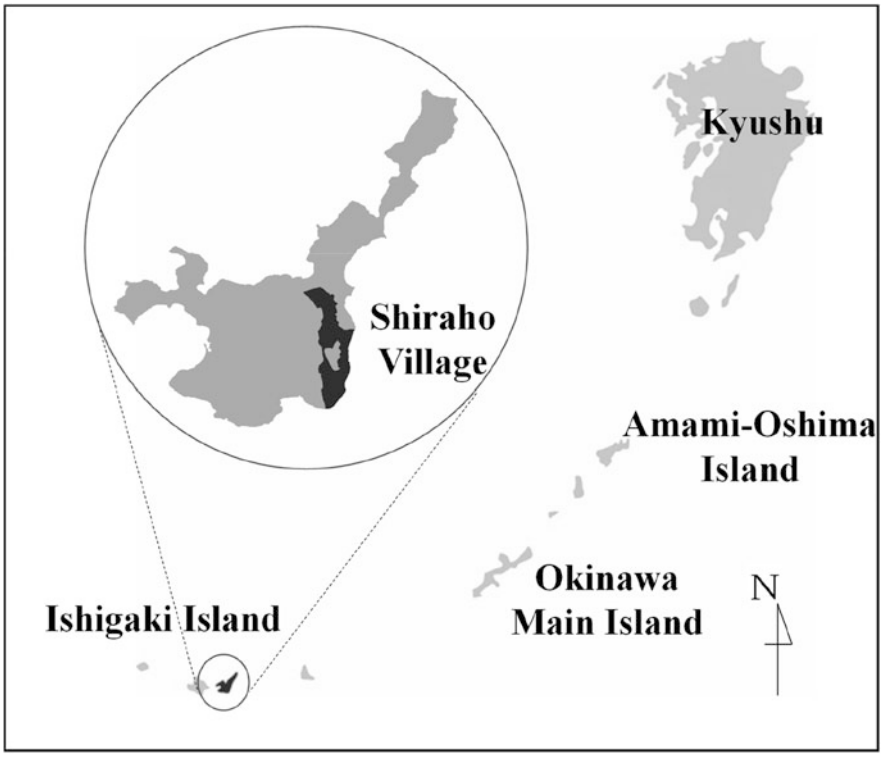

Fig. 5.1 Location of Shiraho village in Ishigaki Island

The traditional lifestyle of Shiraho was closely related to the coral reef. About 12 km of reef spreads out from the village's shore, and residents have nurtured and passed down wisdom that utilizes the blessings of the sea. Yaeyamans today call this way of life "coral reef culture," a term highlighted by Osamu Shimamura, a local teacher who has long supported nature conservation in Yaeyama (Shimamura and Ishigaki 1988). Interviews with residents of Shiraho carried out by Sango Mura further revealed close relationships of villagers to the coral reef. In this chapter, we define "coral reef culture" as this culture that is supported by various ecosystem services of the coral reef.

Coral reef culture is connected not only to food, clothing, and shelter but also to industry, festivals, and leisure among other things (Table 5.1). In Okinawa, various kinds of fishing are undertaken in the shallow sea. When the tide has ebbed, anyone who can walk is able to descend to the sea (without a boat or even the ability to swim) and collect shellfish, seaweed, and tidal fish that then can be eaten. Corals are also visible in the stone walls of the village that surround houses. Corals often appear in the distinctive red tiled roofs of Okinawan houses, for which the stucco that holds the tiles together is made by firing table corals found in Shiraho's reef. Until reversion from US to Japanese control in 1972, this stucco was produced in Shiraho. Corals are often also used as stepping stones and foundation stones. Corals that wash

Table 5.1 Coral's ecosystem service and its relation to the living "coral reef culture"

Category	Manifestation in coral reef culture
Clothing	Foliage and plants from along the shore utilized as materials for articles of everyday use Cloth that is woven and then soaked in the sea and dyed Buttons made from "*takase*" shells
Food	"*Inkachi*" built in the shallow sea the square stone wall where fish are caught using the ebb and flow of the tides Making use of coastal plants like *adan* palm hearts for food Agricultural land that originates from rich soils that contain weathered corals Seaweeds and sea cucumbers that wash up on the seashore, utilized as fertilizers Fishing that can be done in the shallow sea at low tide Gathering seaweeds and fishing during breaks in the agricultural calendar Production of black sugar using limestone created from corals Making salt and nigari (used to make tofu) from boiling down seawater
Shelter	Coral reef working as a natural breakwater that protects the island from strong waves Make use of corals as cornerstones, stepping stones, and well enclosures Use of corals spread over gardens Use the fired coral as plaster in the distinctive Okinawan tile roofs To make stone walls that encircle houses
Rituals and festivals	Shells and corals used as ornaments and ritualistic amulets Gods coming from the sea, villagers throwing misfortunes into the sea Purification of dead bodies with seawater
Performing arts	Folk songs and old songs related to the sea and fishing
Tourism	Snorkeling and marine sports
Research	Used as a site for research
Education	Used as site of environmental education for children
Conservation	Volunteers work there to protect the coral reef

Note: The information in this table was collected and compiled by one of the co-authors, Kamimura, based on interviews with Shiraho villagers

up on beaches are spread in gardens that are often found in Okinawan courtyards, where it is said that they reflect the sunlight and brighten the interiors of houses.

The sea is significant in other ways that reference rituals and festivals, too. The salt that is important in offerings to gods and ancestors is made by boiling seawater. Incense burners that are used in local shrines utilize sand from the beach early in the morning before anyone has stepped on it. During the agricultural festival, the gods are thanked for coming from the eastern sea and delivering bumper crops. Villagers dance and sing songs about "inkera," everyone's sea, acknowledging the collaborative fishing that occurs in the coral reef.

In addition to traditional ties to coral reefs, in recent years, it has become more common to use the reefs as places for sightseeing and leisure. Shiraho's reef is also used as a place for academic research, environmental education, and environmental conservation activities, all of which help to create and recreate relationships with the reef. It is through these activities that coral reef culture is recognized and elaborated.

5.3 Degradation of Coral Reefs and Crisis of "Coral Reef Culture"

Shiraho's coral reef is known as the world's largest blue coral colony, and in 2007, it was designated as part of the Iriomote-Ishigaki National Park. Degradation of the coral reef has been confirmed by surveys conducted by Sango Mura since it was established in 2000, and the coral remains threatened. One of the causes of degradation is coral bleaching, caused by increasing seawater temperatures which is an effect of climate change. Between 1997 and 1998, coral bleaching occurred worldwide, and significant damage was also confirmed in Shiraho's coral reefs. Since then, abnormally high temperatures have been frequently recorded, and large-scale coral bleaching was confirmed again in 2007 and 2016.

In addition to that global environmental problem, the localized environmental load from the land also contributes to coral degradation, which is a factor that influences the ability of corals to regenerate after they have been damaged by bleaching events. Terrestrial runoff is a significant issue for coral reefs in Okinawa particularly that of red soil (*akatsuchi*). Red soil dissolves easily in water and is comprised of fine particles, and it impacts the coral reef after frequent subtropical weather events of torrential rains and typhoons. Not only does red soil impact the transparency of seawater, impeding photosynthesis of the algae that live on corals, but also when it settles on the reef it can suffocate the corals and inhibit the fixation of coral larvae on the ocean floor. Government subsidies promote sugarcane cultivation and agriculture production in Ishigaki. Thus finding support for countermeasures like reducing the area of planting to prevent red soil runoff takes time to unfold (Kamimura 2012). Sango Mura monitoring of the red soil sediment in the reef shows that "the conditions are very serious and the coral reef is bordering on unhealthy" (WWF 2017). The use of chemical fertilizers, the dissemination of agricultural chemicals, and the deterioration of water quality due to eutrophication and domestic wastewater also contribute to the declining condition of the coral reef.

The diminishment of the coral is related to reduced blessings of the coral reef. Shiraho villagers have noted that the amount of their catch, fish, octopus, and shellfish, has declined in comparison with the past. If these conditions continue, the way of life that comprises coral reef culture may be lost. Declining corals will have a serious impact on the lives of local communities, in addition to the deterioration of marine habitats and animals.

5.4 The Airport Problem and Coral Protection

Shiraho's coral reef is recognized by the prefecture for its significant sightseeing (Okinawan Prefectural Government web-site 2017). In addition to tourism, Shiraho's coral reef hosts many researchers and students under rules that have been established for regional and researchers' usage (Japan Coral Reef Society

web-site 2017). Although the reef is recognized for its importance by many people today, there was a time when the goal to "protect the reef" was not widely shared. Specifically, between the time the new airport plan was decided (in 2000) and ground officially broke on the airport construction (December 2006), there seemed to be reticence to pursue coral conservation activities. Sango Mura was established during this time (in April of 2000), and the sustainable community development project was also launched during this time (in April of 2004).

These circumstances can be better understood by considering the longer trajectory of the New Ishigaki Airport's planning and development. In 1979, a plan to reclaim Shiraho's coral reef and construct the New Ishigaki Airport was announced. Shiraho's self-governing organization, the Shiraho Community Center, held an unprecedented meeting and unanimously resolved to oppose the plan. Small opposition movements against this large-scale public construction project developed throughout Ishigaki Island, Okinawa Prefecture, and the rest of Japan as well. In the process, the value of Shiraho's coral reef was recognized globally particularly once scientific surveys had confirmed that the world's largest blue coral colony was located there. WWF-Japan became involved in the opposition movement by supporting academic research on the reef.

However, this attention to Shiraho's reef was also problematic. For Shiraho residents, the sea was an important place closely related to their daily lives. What was attended to in the airport struggle was the academic value of the precious ocean, however. Both of these aspects of the reef's importance are arguably worth protecting, but during this long struggle, the question of protection *for whom* became important. The prolongation of the airport problem caused a rift in the village, creating factions of those who were for and against the airport construction, and in 1985, those who supported the airport established a separate Community Center. Thus, for 10 years until the Community Centers were reintegrated in 1995, Shiraho had the unusual situation of being a small village of 1600 that held 2 separate harvest festivals and coming-of-age ceremonies, among other significant events.

These divisions also created reticence to generate or participate in community development and coral reef conservation activities. Since the airport problem had been primarily framed as an issue for protecting the coral reef, there was a perception that supporting coral protection also required opposition to the airport. This changed the relationship between villagers and their sea. The presence of corals in the sea had become part of what made the sea inaccessible to some villagers.

In 2000, the Shiraho Community Center and residents consented to a new plan to build the New Ishigaki Airport not in the sea but on land north of Shiraho village. Building on top of the coral reef had been avoided. The Shiraho Community Center decided to develop a plan for regional development focusing on 16 measures, and they decided that they would not foment any further divisions in the village. Measures that explicitly targeted coral reef preservation or protection separated from daily life were not seen favorably.

5.5 Creating Socionature with Farmers

When Sango Mura first opened, they drafted recommendations to the government about how to reduce the environmental burden associated with the construction of the New Ishigaki Airport, responded to the environmental assessment of the region, and conducted awareness-raising activities about the scientific value of Shiraho's coral reefs. In addition, in order to strengthen the case for implementing countermeasures to prevent red soil runoff from agricultural lands which they had anticipated to be a big issue for coral reefs, they started monitoring red soil sediment in the reef. However, because of the issues discussed above, there were few villagers participating in the activities of Sango Mura. There was little participation in activities that were framed as "coral protection."

One of the co-authors (Kamimura) started to work at Sango Mura in January of 2004 and, at that time, determined that Sango Mura's position should be to respect the local agreement to build the airport on land north of the village. Once Kamimura began living in Shiraho and taking part in various village activities as a resident himself, his perspective on the issues that faced village residents became clearer to him. He thought that it was important to listen to the concerns of local residents and to promote cooperation for sustainable development. In addition to coral conservation then, Kamimura was convinced that the best path toward coral conservation would be created through emphasizing dialogue with local residents. In order to realize collaborative conservation, a long-term approach that integrates environmental, social, and economic concerns was determined to be most effective (WWF Japan 2016). Particularly because Shiraho residents are proud of their traditions and regional culture, Sango Mura decided to work on activities that captured how coral reefs were significant within cultural and historical ideas.

Sango Mura revised its approach. Previously, those who were involved at Sango Mura were primarily those residents who worked in the sea like fishermen, divers, and people who came from outside of the prefecture because of prevalent ideas about the importance of Shiraho's sea. In addition to those people, Kamimura emphasized expanding Sango Mura's work to create relationships with those Shiraho residents who had not previously been involved in Sango Mura's efforts, especially those who were involved in decision-making in Shiraho. Residents of Shiraho are roughly divided into five historical categories based on where they are from. Among those categories, those who are "*sabupito*" (longest historical residence) are the most populous and are also those who are most active in traditional rituals and festivals. Many of them are farmers. Meanwhile many fishermen have relatively recently moved to Shiraho from Miyako Islands before or after the Pacific War. Sango Mura proceeded with their projects while considering the relationship between residents in these areas. Sango Mura further became an intermediary support organization by cultivating partnerships between diverse regional officials and administrative agencies.

In the beginning, this new work at Sango Mura was framed as sustainable community development, but eventually, they decided, in order to increase its resonance to those inside and outside of the region, they would use the words "Satoumi" and "coral

reef culture." These are not approaches that necessarily equate with "coral conservation," but Sango Mura considered these terms to be more suitable to express the aims of those projects that were designed to be taken over by local residents. Both concepts are socionatures in that they recognize the intertwining of nature and culture. Further, given the villager interests in history and culture, these terms allowed for more holistic understandings of nature relationships. Coral reef culture in particular is a local term that resonated with villagers, and it could further be elaborated to articulate Shiraho-specific socionatural ideas. Cultivating and further describing this socionature was important for conservation in Shiraho because it expanded the activities of Sango Mura to involve people who valued the sea in various ways and also allowed for the support of cultural and economic activities in the region. Elaborating on coral reef culture was also important for communicating about the socionatural significance of the sea to WWF staff in Tokyo, whose financial support was important. Within WWF-Japan, this way of thinking about the work at Sango Mura took some time to be accepted.

Sango Mura did this work in a few stages. They sought to create activities that would lead to renewed involvement in stewarding the coral sea, creating awareness of conservation as a result. They translated and redefined nature preservation activities based on natural science knowledge, reinterpreting conservation in ways that aligned with regional traditional knowledge and decision-making processes, in order to encourage participation in conservation activities independent of Sango Mura. Sango Mura then stepped back and participated as residents took more leadership. Finally residents carried out community activities related to coral reefs by themselves.

5.6 Activities that Support the Revitalization of Coral Reef Culture

A few examples of the activities that Sango Mura implemented demonstrate the significance of coral reef culture to conservation in Shiraho. Common to these activities is that they demonstrate the relationship between Shiraho's history and environment—Shiraho's socionature—so that people involved are aware of the connections between their lives and their surroundings.

5.6.1 Creating Local Conservation Institutions

In response to the crisis facing coral reefs and coral reef culture, an organization made up of local residents was established in Shiraho in 2005 (Shiraho Conservation Council for Bountiful Seas, hereafter "the Council"). The Council considered the coral reef to be an asset of the whole village and aimed to revitalize the area through

Council Board Members (Appointed and Elected)
Article 12: The Chairman, the vice-chairman, directors, and controllers shall be appointed by the members at the general meeting. The number of elected officers shall be determined as follows according to the qualifications of the members. However, when multiple credentials overlap, a person is elected as one representative.
(1) Shiraho Community Center board member (2 people)
(2) Shiraho Haari Association board member (3 people)
(3) Fishing Boat Owner (1 person)
(4) Tourist Lodge Owner (1 person)
(5) Agricultural Committee board member (1 person)
(6) Women's Association member (1 person)
(7) Young Adult Association (1 person)
(8) Livestock Association (1 person)
(9) Shiraho farmer (1 person)
(10) Members stipulated in Articles 4, 5, 6 (up to 4 people)

Fig. 5.2 Shiraho Conservation Council for Bountiful Seas board members

conservation and sustainable use of coral reefs. They consulted and collaborated in order to conserve and utilize the sea.

Board members were not only representatives of those who regularly used the sea, like members of the Shiraho Haari Association which is mainly composed of fishermen who gather to put on an annual festival of the sea and snorkel business operators. The Board also included those who were not directly involved in the ocean for their jobs, like the director of the Shiraho Community Center, the Agricultural Association, the Women's Association, the Youth Association, and the Livestock Industry Association, among others (Fig. 5.2). Those decisions of who should be on the Board of the Council were made while considering the complicated historical circumstances of the airport struggle, and some more detail about that is helpful.

Historically, in Shiraho, the nearshore sea was available to anyone in the village, even those who were not fishermen, and those attachments were strong. Before Okinawa reverted from US to Japanese control in 1972, many fishermen from Miyako (a nearby island group to the east of Ishigaki) began to migrate to Shiraho. At the time when the Council was established, those fishermen and snorkel business owners largely came from outside of Shiraho (even though in some cases they had been living there for decades at that point). The fishermen were one of the groups of people who maintained strong opposition to the airport and played a main role in the opposition movement, advocating for their rights and the protection of the sea. At the same time, some of the fishermen started inns and tourism projects that became successful because of the airport opposition movement and the associated press about it, so they were then criticized for utilizing the ocean for their personal profit. Those who were not really involved in the opposition movement found it difficult to use the ocean because of that longer history and a sense that they had not fought for the right to use it. Once the decision had been made to move past that history and promote activities that would benefit the whole community, creating a place to coordinate and collaborate within the context of these complicated relationships of different residents to the sea became indispensable.

With these considerations in mind, Sango Mura thought that it would be best if the Council's activities were led by organizations that were officially part of the

Shiraho Community Center, which is the core village governing structure. Consensus of diverse groups seemed key to the Council's work. In addition, Sango Mura was aware that some of the activities that would help to stem coral reef degradation were land-based and would need to involve farmers, like reducing the amount of red soil runoff from agricultural lands. For this reason, participation on the Council from the Agricultural Association and the Livestock Industry Association was significant. By reaffirming that coral reefs were assets to the entire region not just to fishers, the organization aimed to promote conservation and sustainable use of the reef.

In 2006, the Shiraho Community Center established "Yurateiku Charter" in order to lay out a policy for new village development in the era of the New Airport. Coral reef conservation was positioned as one of the seven policies to work on in this charter. "Yurateiku" is a word from Shiraho's language that means "coming together" and was seen as being representative of the temperament of Shiraho villagers and thus adopted as the title of the charter. In 2007, the Council was recognized as an official participating organization of the Shiraho Community Center. Sango Mura interpreted this to mean that the conservation of coral reefs was acknowledged as one of the village activities that should be addressed in the region.

5.6.2 *Creating a Symbol of Coral Reef Culture: Restoration of a Traditional Stationary Fishing Equipment* "Inkachi *(Stone Tidal Weir)*"

One symbol of coral reef culture, *inkachi* (as it is called in Shiraho) is a traditional fixed fishing gear located along the shore. Asahitaro Nishimura, the ocean folklorist, called *inkachi* "a fossilized living fishing implement," as the stone walls are built in the shallow sea in the shape of a semicircle or square and use the ebb and flow of the sea to trap fish (Nishimura 1979). Fish that remain in the *inkachi* are unable to return to the deep sea as the tide goes out, and they are then caught with nets or harpoons or by hand. Prof. Masataka Tawa of Kwansei Gakuin University, who researches coastal fishing, notes the use of similar fishing gear in East Asia (Taiwan and Korea), Southeast Asia (Philippines and Indonesia), tidelands of various parts of the South Pacific, and coral reef islands. Similar fishing gear can also be found in the English islands, around the Atlantic Ocean along France and Spain, and on the periphery of Australia (Tawa 2007, 2014).

The history of *inkachi* in Shiraho is very old and believed to have existed before the big Meiwa Tsunami in 1771 (a common historical reference point even today). At one time, there used to be at least 13 *inkachi* in Shiraho. *Inkachi* in Shiraho were built by farmers adjacent to their agricultural fields. The *inkachi* represent this cultural heritage of an era during which villagers were self-sufficient and lived as farmer-fishers (Kamimura 2007). In interviews with Shiraho residents, there were many pleasant memories of the *inkachi* which left impressions of fondness for the

sea. After the war, *inkachi* fell out of use because of increased popularity of fishing nets and of an influx of specialized professional fishermen from the Miyako Islands.

The restoration of the *inkachi* was unanimously resolved at the first meeting of the Council on September 5, 2005. Since the fishing equipment had been used by farmers in Shiraho, Sango Mura hoped that the restoration project would give farmers the opportunity to reconfirm their connection with the sea.

There were a variety of hurdles for the restoration because the *inkachi* had not been used for a long time and not much was known about the remains of *inkachi* on Shiraho's coast. Thus, problems had to be solved one after another: consensus about the form of the project, coastal use and fishery rights, administrative cooperation with fishery cooperatives, establishment of the place of restoration and the size of the *inkachi*, stone procurement, masonry methods, the work system, and so on.

The greatest challenge was concern about the environmental impact caused by restoring the *inkachi* and the influence that it might have on corals, concerns that had been pointed out by WWF-Japan. At Sango Mura, they surveyed experts and researchers who had conducted research in Shiraho's reef and came up with countermeasures to avert or mitigate the potential environmental burden that the *inkachi* would create. What emerged were 51 items in 10 categories. To address those concerns, Sango Mura developed seven countermeasures, changing the construction method, fine-tuning the place the *inkachi* would be installed, and dealing with specific conditions that could potentially unfold at the time the *inkachi* was built (Table 5.2).

Table 5.2 The evaluation and maintenance measures of the environmental influence accompanied with the inkachi

	An environmental assessment and maintenance measures
Change of tidal current	The change in tidal current due to the construction of the inkachi was clarified by simulation, and the position and structure with less influence were adopted
Impact of red soil on coral	Conduct a monitoring survey of the amount of red soil deposited, and if it is confirmed that the coral off the coast of the restoration site of the inkachi has died, the inkachi will be removed
Impact on the coral inside the inkachi	Investigate the corals in the inkachi restoration area and confirm that there are similar species in the vicinity that do not affect the survival of the species. No entry during restoration work to areas where coral appears frequently
Impact on fish	Do masonry avoiding *Stegastes albifasciatus* habitat
Impact on sea turtles	Install an opening that allows sea turtles to enter and exit sufficiently Reduce the impact on sea turtle feeding grounds
Impact on quality of sediment	If an increase in sediment accumulation is observed in or around the inkachi and it is considered to have an adverse effect on the environment, measures such as improvement and movement of the opening will be attempted. If there is no improvement, remove the inkachi
Social impact	Provide sufficient explanation, discussion, and public relations. In addition, explanations and announcements will be given to those who collect algae in the inkachi restoration area

Source: Council of Shiraho Sakana-waku umi (2005)

Fig. 5.3 Restored inkachi (stone tidal weir) in Shiraho in 2006

The restoration project was large in scope and involved pupils, students, and the PTAs of Shiraho elementary and junior high schools. Since it was completed in October 2006, it has been used as a place for nature experiences and environmental education for local children (Kamimura 2007, Fig. 5.3).

5.6.3 Greenbelt Project: Preventing Red Soil Runoff

The greenbelt project to prevent red soil sediment from entering the reef began as a proposal from junior high school students who had fished at the *inkachi* as part of a school outing. Currently, it is a program of the local NPO's study tour to experience coral reef preservation.

This project was conceived of in 2007 because, although the students had anticipated catching a lot of fish at the *inkachi* on their school outing, only four fish were caught at that time. In an evaluation meeting about the experience, the students wondered if red soil runoff had led to the deterioration of the reef and further if they could participate in a project that would prevent the runoff. At the time in Okinawa, there were greenbelt installation projects underway, and, in Ishigaki, seedlings of shell ginger were provided by the government for free so that greenbelts could be planted. However, it was difficult to obtain cooperation from farmers for

greenbelt planting because of the labor cost and also because planting the shell ginger around the perimeter of a field reduces the area that can be in crops and creates obstacles for agricultural machinery. These conditions had prevented any progress on these measures in Shiraho.

The Council then decided that, with the students, they would visit the farmers individually to secure agreement from them on the installation of the greenbelts, then procure seedlings of shell ginger from Ishigaki City, and encourage junior high school students to plant them as volunteers. In 2008, Sango Mura received a donation from a company and provided financial support for seedlings. Sango Mura decided to purchase seedlings from the Shiraho district in order to make the expenses for conservation activities circulate within the area. Compared to the vast farmland that lines the Todoroki River basin, the planting fields were limited to a few places every year, but in this way, local activities for conservation had begun at last.

The greenbelt project has prompted new initiatives, reflecting the ideas of local residents and farmers. One is an effort to create commercial value out of the greenbelt plant, described below. Another development was that *itobasho* (*Musa liukiuensis*) was also planted as a greenbelt plant in addition to shell gingers. Even as other aspects of the project developed, Sango Mura faced an issue of finding farmers who would plant shell ginger. Some farmers were not opposed to the greenbelt but preferred to plant *itobasho*. *Itobasho* had been planted around the farmland of Shiraho previously. The leaves of *itobasho* were used to wrap the rice cakes made in each household and offered at the Agricultural Festival (*hounensai*) for a good harvest. In addition, the fibers from its stems were made into threads as materials for Basho cloth.

Farmers had these positive cultural associations with *itobasho*, and some also had expectations that the economic value would increase in the future as the habitat of *itobasho* decreased. Planting *itobasho* was carried out as an agriculture and green landscape project organized by the Shiraho Yurateiku Charter Promotion Committee and was later integrated into the greenbelt project. The ability to choose what species to plant in the greenbelt makes it more desirable, and farmers who prefer to plant *itobasho* are increasing since they are more viable and also have windbreak effects.

Greenbelt planting activities began with junior high school student volunteers and then developed into a member tour of WWF-Japan, a training experience for donor companies, and a coral reef conservation experience program in school excursions for junior high schools and high schools from mainland Japan. Participants in these events are required to pay some fees, which are allotted to the cost of planting activities (personnel expenses, seedlings, management costs after planting, etc.). This enabled Sango Mura to engage in conservation while procuring funds for the region. Greenbelt planting has also been integrated into a study tour organized by NPO Natsupana that was founded by Shiraho residents in 2012, giving opportunities to participate in coral reef conservation to visitors from all over the country.

5.6.4 *"Shiraho Sunday Market"*

Shiraho Sunday Market is a direct sale market of local producers that was launched by Sango Mura in September 2005. The initial goal was to create a venue in which the blessings of familiar nature like coral reefs and the traditional wisdom needed to use them could be foregrounded. Initially, the market was held once a month, but with increasing numbers of visitors and steadily achieved good results, it has been held once a week in Sango Mura's courtyard since the summer of 2012. When Natsupana was founded, the NPO took over the market management from Sango Mura. Since 2016, a percentage of the sales at the market has been used for NPO Natsupana's activity funds to contribute to Shiraho's coral reef conservation. The market is managed by Shiraho Sunday Market Cooperative Association which is a mutual aid organization comprised of the sellers.

Shiraho Sunday Market members have worked with Sango Mura to develop a variety of products that contribute to the conservation of coral reefs, with sales proceeds used for the funds. One of them is a product developed out of the shell gingers planted in the greenbelts. Installing greenbelts (as described above) creates an economic burden for farmers because although they prevent soil runoff, they also lead to a reduction in planting area. Therefore, Sango Mura decided to help develop products such as floral waters and herb teas made from shell gingers that would create an economic return for cooperating farmers. These products were developed in collaboration with the sellers of Sunday Market. Sango Mura shared the cost, purchased the manufacturing equipment, supported various procedures necessary for development, and also mediated technical advice from outside experts. In the fiscal year 2014, Shiraho Yurateiku Charter Promotion Committee and NPO Natsupana obtained grants from the Ministry of Internal Affairs and Communications to establish a manufacturing system of the products and opened a processing plant for the shell ginger. As a result of this work, two products were developed: a room spray and herbal tea. Both of these items are regarded as products of NPO Natsupana, who entered into a license agreement with the sellers of Sunday Market so that the sales profit is used as funds for NPO activities. Since September 2016, local community vitalization volunteers in Ishigaki City have been appointed to the Shiraho community as responsible for the development, manufacturing, and promotion of further coral-reef-conservation-type products.

These activities that began with the aim of localizing the circulation of various resources within the region have now been widely evaluated by scholars and conservationists from all over the country. For example, the IUCN positions Shiraho's activities as one of their nature-based solutions.

5.7 Succession of "Coral Reef Culture" and Its Effects

5.7.1 *Improvement of Biodiversity by Restoration of* Inkachi

Many residents participated in the restoration of the "*inkachi*" which is a symbol of the era when coral reefs and people were closely related, and students of elementary and junior high schools in Shiraho have regularly fished in the *inkachi*. Moreover, the *inkachi* area has been utilized for nature observation events and environmental surveys. These activities nurture a new relationship between coral reefs and people. In addition, various ripple effects are manifested: the measures against red soil runoff, the release of clam seedlings, the creation of new business, and so on. These can be considered as part of the effects of the *inkachi's* restoration.

An environmental survey that Sango Mura conducted before and after restoration of the *inkachi* confirmed an increase in the number of fish species and the population. The number of fish appearances increased by ten species (25%) compared to before construction; thus, it can be said that the number increased due to the reconstruction of the *inkachi*. Looking additionally at the changes that are visible in swimming surveys, similar species of fish appear, but the number of individuals observed was twice as many as before the construction. This increase in fish population seems to be due to the considerable increase in the suitable rocky environment for fish at the sea bottom where sand and gravel have accumulated because of the restoration of the inkachi (WWF Coral Reef Conservation and Research Centre, 2014). As a result, Shiraho's *inkachi* has been noted as one of the examples of "coastal sea with high biodiversity and productivity enhanced through human interaction," which is defined by Tetsuo Yanagi, one of the co-editors of this book, who is a Satoumi advocate (Yanagi, 2007; Yanagi 2013).

5.7.2 *Co-creating Sustainable Local Forms of Engagement*

Activities that have been worked on in the Shiraho area can be regarded as efforts to realize Satoumi. The *inkachi* was restored as an active measure to incorporate the blessings of coral reef into the residents' lives. Sango Mura researched and delineated aspects of sustainable resource utilization from traditional lifestyles ("coral reef culture") and created the Sunday Market as one mechanism to help perpetuate it. Sango Mura has deepened exchanges with researchers and experts in various fields and considered how community development activities can be produced in ways that acknowledge both local knowledge and scientific knowledge. Although we could not introduce it in detail in this chapter, the "Shiraho Yurateiku Charter" aims to realize a good relationship between people and nature by establishing a vision of what village development should look like.

Looking back over the restoration of *inkachi* in 2006, it can be said that the relationship between the sea and the people was regained mainly because local

people took active parts and worked on the sea of coral reefs that historically were a collectively owned treasure in the area (Kamimura, 2014). Even after the restored *inkachi* was damaged by a typhoon in 2013 which temporarily suspended fishing experiences there, repair operations were resumed by the students of Shiraho Junior High School, and fishing experience events were also started again, thanks to Natsupana's involvement in 2016. Kamimura strongly feels that the original vision to "restore *inkachi* so it can be designated as a cultural property in 100 years" is a significant activity that will encourage Shiraho residents to restore and utilize their sea.

5.8 Satoumi, Coral Reef Culture, and Diverse Socionatures

What do terms like Satoumi and coral reef culture do? How do they enable collaborations that were previously not possible? And what objects and agents do they allow for? These are important questions that merit academic investigation. According to Anna Tsing, who conducted research on collaborative conservation in Indonesia, "collaborations bring misunderstandings into the core of alliance. In the process, they make wide-ranging links possible: they are the stuff of global ties. They are also the stuff of emergent politics: they make new objects and agents possible" (Tsing 2005).

In pointing to the nuances in coral reef culture, this chapter outlines the various objects and agents that were made possible by the development of this socionature in Shiraho. In Shiraho, historical circumstances of coral preservation and the airport opposition movement created challenging conditions for enacting collaborative conservation. Sango Mura, by refocusing on locally developed socionatures, connected local lifestyles to conservation activities and created new agents (like farmers and Sunday Market sellers) and objects (like traditional relationships, the *inkachi*, and the greenbelt) that allowed for collaborative conservation to unfold. "Coral reef culture" became a valid concept and a policy for environmental groups who promoted conservation of coral reefs in cooperation with the community. This concept enabled local people to concretely imagine that the purpose of conservation was not to attack their lives and lifestyles but rather to understand the positions of the local community, taking their lifestyles into consideration. By developing the idea of coral reef culture, Sango Mura reconstructed the relationship between environmental groups with residents, and between fishermen and farmers, so that Sango Mura could set up conservation activities mainly organized and undertaken by the local community.

In the act of elaborating coral reef culture and its relationship to Satoumi, Sango Mura made these concepts legible to villagers who were better able to appreciate and understand how conservation could enliven their community. They also made the work of Sango Mura legible to others working in conservation and sustainable development who understood the significance of cultural understandings for creating feasible and sustainable conservation projects. Yet, these concepts were not fully

recognizable to all conservationists within WWF. For some, this reorientation from "nature" (i.e., the coral reef) to "socionature" (i.e., coral reef culture) seemed like it was outside of the scope of the work that WWF should be doing. This raises questions about the degree to which collaborations depend on commensurable understandings of key concepts for all who are involved in conservation projects. Like Anna Tsing found in her research, commensurate understandings of socionatures do not appear to be necessary for collaborations to productively unfold. Based on these findings, we suggest that more research into the diversity of socionatures and their operationalization is helpful for better understanding culturally attuned conservation and will likely aid in the development of other collaborative conservation projects.

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Chapter 6
Restoring Eelgrass Beds and Culturing Oysters

Tetsuo Yanagi

Abstract Hinase, Okayama Prefecture, is the Satoumi of eelgrass and oysters. In Hinase, which is known as the "sacred ground of eelgrass bed restoration," fishers have been working for more than 30 years and have succeeded in restoring the eelgrass beds. This has increased the catch of fish associated with eelgrass beds as well as stabilized oyster farming production. In addition, the Hinase Fishery Cooperative has long been involved in collecting debris from the seafloor and direct selling to the public by the women's group. This chapter also introduces the National Eelgrass Summit held in Hinase in 2016 and the Blue Carbon Movement.

Keywords Eelgrass bed · Oyster farming · Seagrass restoration · Hinase · Blue carbon · Seabed debris

6.1 Outline of Fisheries in Hinase

The Hinase Town, Bizen City, located in the southeastern part of Okayama Prefecture (Fig. 6.1), has a population of about 11,000 people and was once known as "A Thousand Fisher Household's Town." In the late nineteenth century, 90% of the 830 households in the town were engaged in fisheries (Tanaka 2014), but the current number of fishers is less than 2% of the town's population.

The Hinase Fishery Cooperative is a medium-sized fishery cooperative with 76 regular members and 64 associate members (as of June 2017). The cooperative is known as the one that invented Spanish mackerel drift nets and small fixed nets, and in the past, people migrated to other parts of Japan with the technology of small fixed nets (called "Tsubo nets" in Hinase). These fixed nets are known as "Bizen nets" in many places. In particular, many small fixed net fishers in Yamaguchi, Oita, and Fukuoka Prefecture migrated from Hinase.

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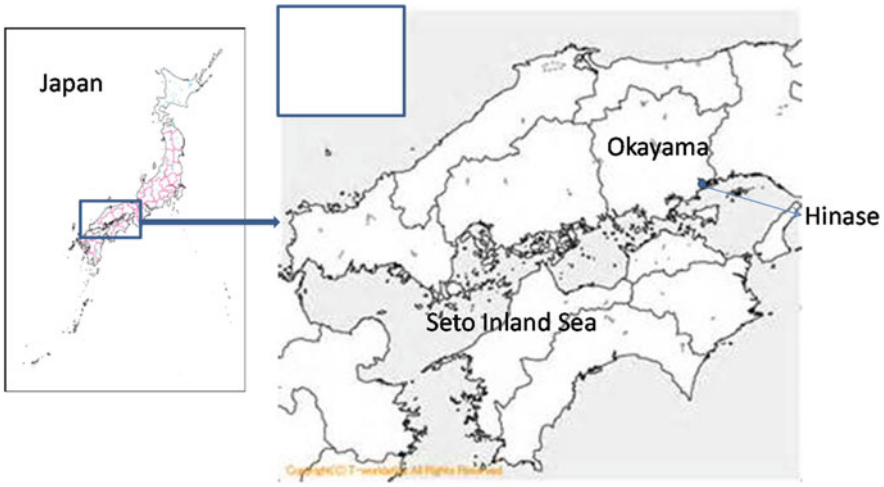

Fig. 6.1 The Seto Inland Sea and Hinase Town

They migrated because they had no choice but to move to other places if they wanted to fish. The Hinase Fishery Cooperative has a principle of one member per household, and the second son or younger cannot become a regular member of the cooperative. Utilizing the technique of Spanish mackerel drift nets, from the end of the Taisho era (1912–1926) to the beginning of the Showa era (1926–1989), the fishers went to Korea and Dalian, China, in pursuit of Spanish mackerel.

In recent years, however, the catch has declined and the fishers are aging. At present, the main activities are oyster farming (about 50 households), small bottom trawling (about 50 vessels), and small fixed nets (about 50 nets).

6.2 Restoration of Eelgrass Beds

6.2.1 Functions of Eelgrass Beds and Their Decline

Eelgrass beds are formed on the sandy and muddy sea bottom of calm inner bays. Eelgrass reduces tidal currents and intense lights and provides spawning grounds for cuttlefish and hiding places for small fish. In addition, the microalgae and small animals on the eelgrass leaves become a good food source, making them important nursery grounds for various juvenile fish.

In the 1950s to the 1980s, as pollution and reclamation of the Seto Inland Sea progressed, the area of eelgrass beds around Hinase gradually decreased. The area of eelgrass beds decreased dramatically from about 590 hectares (hereafter “ha”) in 1950 to about 12 ha in 1985 (Fig. 6.2). In particular, eelgrass was lost on a large scale

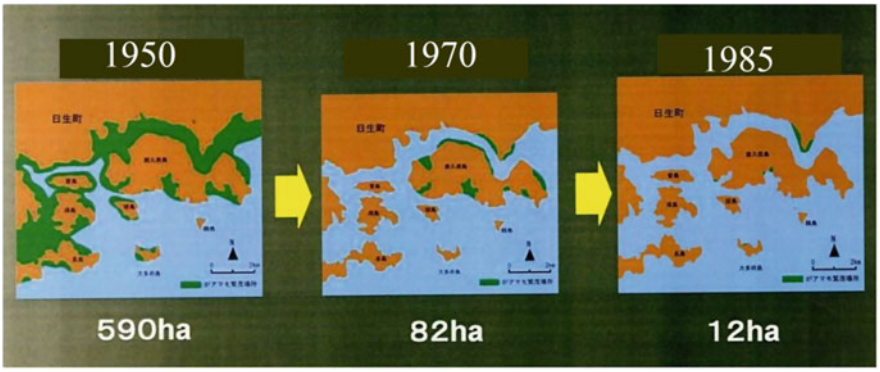

Fig. 6.2 Decrease of eelgrass beds in the Hinase fishing grounds

during the second Muroto typhoon in 1961, and combined with the subsequent deterioration of the environment, the eelgrass beds did not recover.

In the 1950s to the 1960s, under the leadership of the Fisheries Agency, various fish juveniles were released in the vicinity of Hinase. However, the catch did not increase. Tsubo netting is a waiting-fishing method in which nets are set in the path of fish to be caught. Through many years of fishing experience, the Tsubo net fishers were familiar with the life histories of various fish and their migration routes due to growth and seasonal changes (Tanaka 2014). If the environment of the sea area where fish juveniles grow and migrate is not suitable, the release of fish juveniles is ineffective. The main reason for the fish catches not increasing was assumed to be the decrease in eelgrass beds. Therefore, with the guidance and cooperation of Okayama Prefectural Fisheries Experiment Station, voluntarily eelgrass bed restoration tests began in 1985.

6.2.2 Ecology of Eelgrass

Eelgrass is a seagrass that produces flowers and seeds (Fig. 6.3). These seeds germinate and grow to eelgrass plants, while the underground stems divide in winter and spring, and the stems grow from spring to early summer. Eelgrass flower branches separate from the plants and drift to the sea surface around June, and the seeds fall to the seafloor. If the site is suitable for eelgrass growth, the seeds germinate from November to January and continue to grow until July.

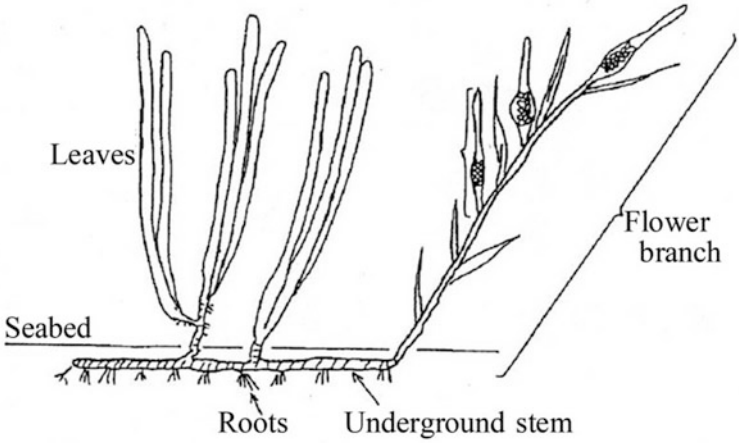

Fig. 6.3 Eelgrass

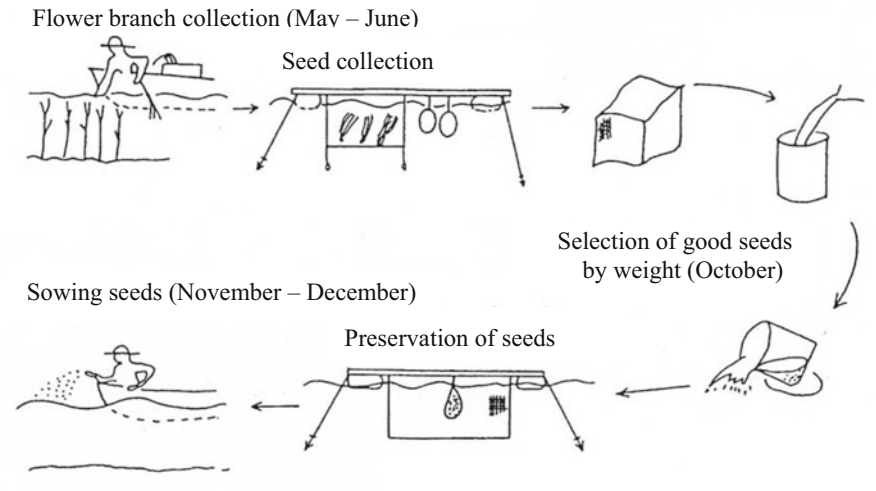

Fig. 6.4 Method for sowing eelgrass seeds

6.2.3 Creation of Eelgrass Beds

There are two methods for creating eelgrass beds: seeding and transplanting. The Hinase Fishery Cooperative mainly adopted the seeding method. In May and June of each year, flower branches (reproductive branches) are pulled out of the eelgrass, placed in onion nets, and hung on oyster rafts for seed collection and preservation. In October, heavy, high-quality seeds are selected, and in November and December,

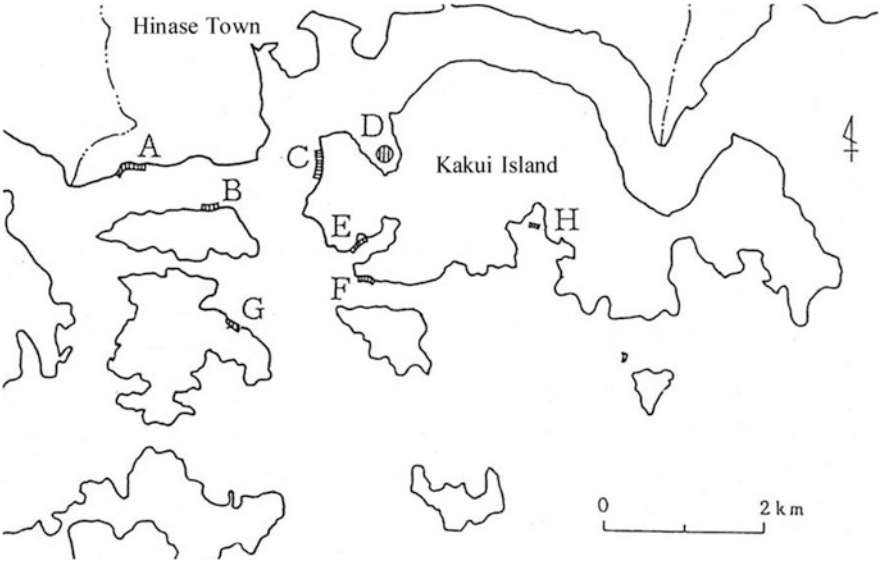

Fig. 6.5 Areas for sowing eelgrass seed (A–H)

these seeds are sown in the sea area where the eelgrass beds have disappeared (Fig. 6.4).

In 1985, 150,000 seeds were sown. The number of seeds sown each year increased to 2.2 million in 1989, and by 2015, more than 100 million seeds had been sown. Figure 6.5 shows the eight sea areas from A to H where the seeds were sown. Eelgrass used to thrive in Sea Area A on the mainland, but by 1985, it had completely disappeared. Eelgrass seeds were first sown in Sea Area A in 1985, and in the spring of the following year, eelgrass growth was confirmed, with as many as 20 eelgrass plants growing in a 50 cm square. In 1986 and 1987, eelgrass seeds were sown in B, which is located off A, and a small amount of eelgrass is still growing there. In C of Kakui Island, the largest island in Hinase Town, eelgrass did not grow after sowing. Eelgrass grew in E, F, and G after sowing, but did not grow in H because the seafloor was sandy.

Based on the above results, the fishers of Hinase acquired knowledge that the suitable places to sow eelgrass seeds are (1) where the tidal currents are weak enough to prevent the seeds from being washed away; (2) where the seafloor is sandy-muddy for the eelgrass roots to grow; (3) where eelgrass used to grow and where even a small amount of eelgrass is growing; and (4) where the water depth is 0.5–1.0 m at low tide and the seafloor is well exposed to sunlight. However, it was not clear whether the eelgrass would thrive or not, until 2–3 years after seeding (Naruse 1990).

In 1986, seeding was started in Sea Area D, but at first, eelgrass could not grow because the seafloor was covered with sludge-like soft mud due to pollution. When the bottom sediment was improved by spreading zeolite, a sediment conditioner, eelgrass grew only in the areas where zeolite was spread. After that, oyster shells

replaced the sediment conditioner, which are cheaper and can be obtained locally in large quantities.

The oyster shells were not only useful for improving the bottom sediment for eelgrass but also for improving the habitat for various benthic and attached organisms. It has been known for a long time among fishers that oyster shell deposits provide good fishing grounds with various organisms, and the wisdom of these fishers led to the development of oyster shell-based artificial reefs and various oyster shell utilization technologies (Tanaka 2014).

6.2.4 Increase of Eelgrass Beds

The creation of eelgrass beds by seeding and improving the bottom sediment has continued for more than 30 years. According to the members of the Hinase Fishery Cooperative, the reason for the continuation of these activities was the "personality and energy" of the late Mr. Kazuo Honda, the former head of the Fishery Cooperative, who was the leader of the Tsubo netting. At first, the eelgrass beds, which had dwindled to 12 ha by 1985, did not increase. Some typhoons devastated the eelgrass that had grown there. However, 20 years after the start of the activities, the eelgrass suddenly began to increase, recovering to about 120 ha in 2007, about 200 ha in 2011, and about 250 ha in 2015 (Fig. 6.6). At the same time, the catches of crabs, cuttlefish, and sea bream, which are closely related to eelgrass beds, increased

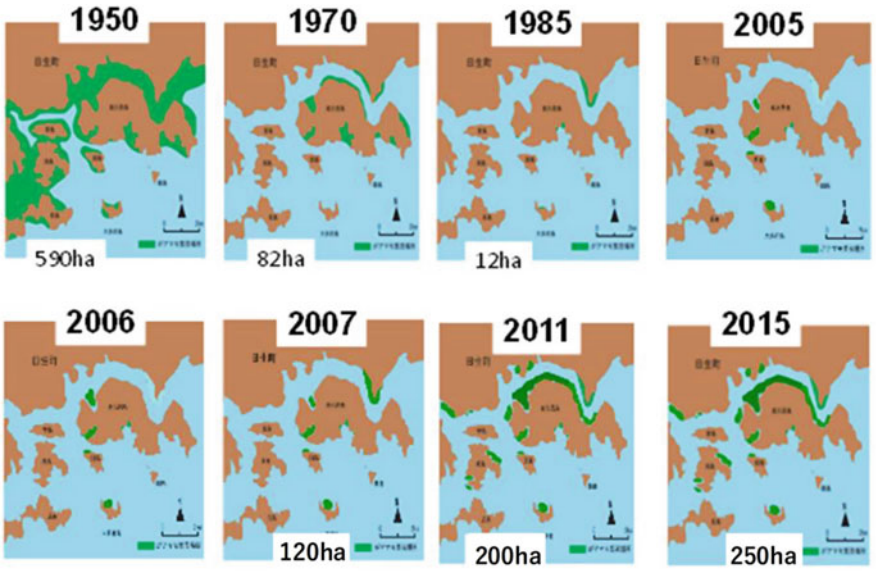

Fig. 6.6 Changes in eelgrass bed areas in the Hinase fishing grounds

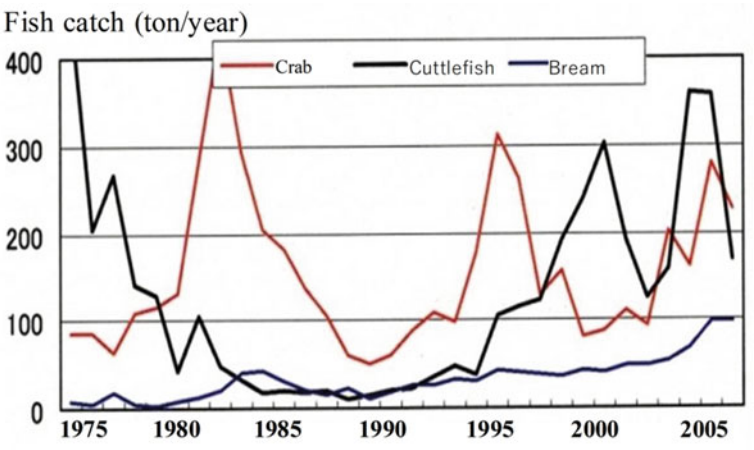

Fig. 6.7 Variation in fish catch using small trawl nets in the Hinase fishing grounds

(Fig. 6.7). The catch of prawns also visibly increased, and a shrimp (called Moebi) that seemed extinct locally began to be caught (Tanaka 2014).

This increase in the area of eelgrass beds has been influenced by the recent increase in the transparency of this sea area due to the regulation of nutrient influx throughout the Seto Inland Sea. Based on this success, eelgrass bed creation tests were conducted in this area from 1998 to 2001 in cooperation with the Marino Forum 21, and guidelines for eelgrass bed creation technology were developed, outlining the basic concept of eelgrass bed restoration, survey methods for identifying limiting factors, and monitoring and maintenance methods (Marino Forum 21 2001). The movement to restore eelgrass beds, which began in Hinase, spread throughout the prefecture, and eelgrass beds that had declined to 549 ha in 1989 recovered to 1221 ha in 2007 (Tanaka 2014).

6.2.5 Integrated Coastal Zone Management Council and Satoumi Creation Research Council

In 2011, the Hinase Integrated Coastal Zone Management Council was established with Bizen City as the secretariat. In addition to the governments of Okayama Prefecture and Bizen City, the council includes representatives of fishers from Hinase Fishery Cooperative and other fishery cooperatives, local chambers of commerce, corporate representatives, researchers from universities and NPOs, and teachers from Hinase Junior High School. They have discussed rules and regulations for water quality management in the catchment area that flows into the Hinase fishing grounds, marine environment conservation, and environmental monitoring.

The NPO Satoumi Creation Research Council, of which the author is the vice president, is also deeply involved in the creation of the Satoumi of Hinase. As a former fisheries extension officer in Okayama Prefecture, Mr. Takehiro Tanaka supported the creation of eelgrass beds initiated by Mr. Honda and others and also led the creation of the Satoumi of Hinase as a bilateral knowledge translator (see Chap. 1). In May 2012, in order for not only fishers but also the general public to take part in the activities to restore the eelgrass beds in Hinase, the Hinase Fishery Cooperative, Okayama Prefectural Government, Okayama Co-op, and Satoumi Creation Research Council made an agreement on eelgrass bed restoration. Since this agreement, many children (mostly children of Okayama Co-op members) have been participating in the works of collecting flower branches of eelgrass, sorting the seeds, and sowing them.

6.3 Oyster Farming

Initially, the restoration of eelgrass beds was aimed at recovering the catch of the Tsubo nets. As eelgrass beds increased, the catch of shrimps and fish by Tsubo netting also increased, but the number of the Tsubo net fishers has been decreasing. Instead, increased eelgrass beds have been functioning to stabilize the production of oyster farming, the main activity in Hinase. In fact, the production of oyster farming has been stable for five consecutive years since 2008, when the eelgrass beds began to visibly recover (Fig. 6.8). Oyster farmers see this stabilization as a benefit of

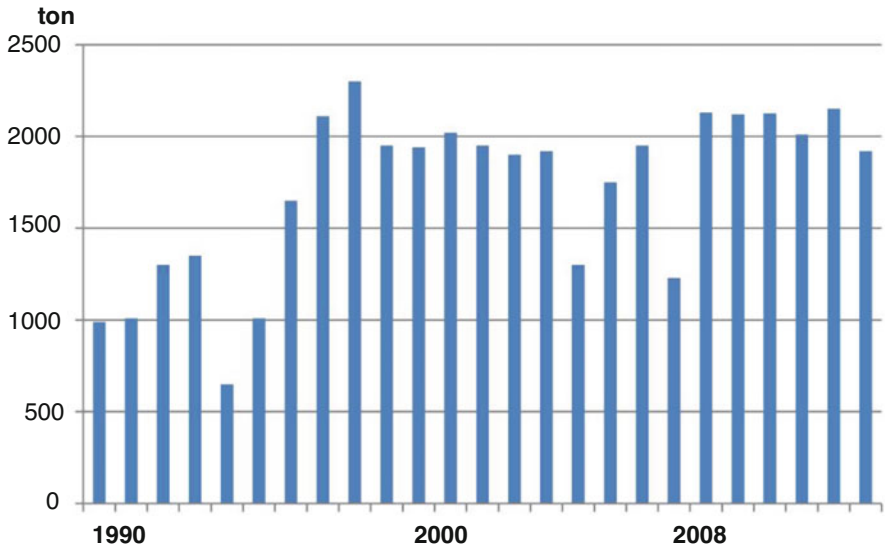

Fig. 6.8 Year-to-year variation in cultured oyster harvests in Hinase from 1989 to 2013

eelgrass beds (Tanaka 2014). The restoration activity of eelgrass bed, which was started by the Tsubo net fishers, had been taken over by the youth group of the Hinase Fishery Cooperative and is now an initiative of the entire Fishery Cooperative, including the oyster farmers.

The oyster farming of the Fishery Cooperative is conducted concurrently with coastal fisheries in the winter when the catches of small bottom trawl and small set net decrease. Okayama Prefecture is the second largest producer of oysters in Japan, and Hinase is the main producer. The first oyster farming was conducted in 1963. The number of oyster farmers increased in the 1980s, and the Okayama oyster brand was established in the mid-1990s.

There is a symbiotic relationship between eelgrass beds and oyster farming. Oyster farming provides the following benefits to eelgrass: (1) oyster rafts attenuate wave heights from offshore, preventing eelgrass roots from being washed away, and (2) farmed oysters feed on phytoplankton and other suspended matter in the sea, increasing transparency and helping eelgrass expand into deeper areas. On the other hand, eelgrass provides the following benefits to oyster farming: (1) it spreads its leaves near the sea surface, forming drapes, to reduce the increase in water temperature during the summer; (2) diatoms and small animals attached to the eelgrass leaves are detached from the leaves by waves and drift in seawater, where farmed oysters ingest them, improving the growth rate of oysters; and (3) it increases the dissolved oxygen, stabilizing the growth of oysters. In fact, the high water temperature-induced death rate of the farmed oysters in the summer decreased, and their growth rate improved as the eelgrass beds increased in Hinase.

In addition, oyster farmers and bottom trawlers consult with each other to plow the seabed underneath the rafts with bottom trawl nets when oyster rafts are removed between March and October, because plowing the seabed with bottom trawl nets decomposes organic matter such as oyster feces that have accumulated on the seabed and it improves the environment of farming areas.

6.4 Carrying Back Seabed Debris

For the fishers of small-scale bottom trawling, which is mainly conducted from spring to autumn, the seabed debris caught in their nets has been a source of concern. The quality of the catch deteriorates when debris is mixed in, and a great deal of labor is required for sorting. It is also difficult to release the small fish caught with debris for resource management. The small-scale bottom trawl fishers of the Hinase Fishery Cooperative have been taking back seabed debris for more than 30 years since the early 1980s. In 1982–1984, the Cooperative was commissioned by the Fisheries Agency's Coastal Fishing Ground Improvement and Development Project and mobilized 253 vessels and 413 people over 3 years. The total area of the activities was 11.4 km^2, and 182.1 m^3 of seabed debris (40% flammable and 60% inflammable) was brought back (Fig. 6.9) and disposed of at the cleaning plant in Hinase Town. The total cost was 9.79 million yen (about 90,000 US$). In 1986, a

Fig. 6.9 Seabed debris retrieved by small bottom trawlers of the Hinase Fishery Cooperative

commissioned project contract was signed between the Hinase Town and the Fishery Cooperative, and the Fishery Cooperative was responsible for taking back the seabed debris, while the Town was responsible for disposing it.

Since then, the Fishery Cooperative has been voluntarily and continuously collecting the seabed debris. In the beginning, when debris collection was started, the amount of debris collected per day reached 12 tons, but recently, it has decreased to about 5 kg per day, and there were times when almost no debris was collected. However, during the rainy season and typhoons, a large amount of debris temporarily flows into the fishing grounds, and the fishers say that they cannot stop taking it back to land. In addition, since the enforcement of the Home Appliance Recycling Law in 2001, large electrical appliances such as refrigerators, air conditioners, and televisions are increasingly caught in the bottom trawl nets and becoming a new problem.

6.5 Direct Selling

At present, half of the catch of the Hinase Fishery Cooperative is auctioned in the local market, and half is sold directly at the “Gomi no Ichi” (five tastes market) run by the Cooperative (Figs. 6.10 and 6.11). The market started in 1967 as a direct sale

Fig. 6.10 "Gomi no Ichi" (five tastes market) of the Hinase Fishery Cooperative

to provide local residents with unsold fish from the market, using the Cooperative's market facility after the auction. Later, in the late 1970s, as the number of tourists and other visitors increased, it became a major shipping destination for fishers (Tanaka 2014). As the fishers' wives sell the fish directly, they can understand the types and quantities of fish that sell well and communicate with their husbands, enabling them to supply fish according to the market, thereby realizing waste-free resource utilization and higher fish prices (Tanaka 2014). Because of its proximity to Kyoto, Osaka, and Kobe, the market attracts many customers by cars during its opening hours of 10 a.m. to 6 p.m. daily. The small-scale bottom trawling catches are sold along with locally produced oysters in this market.

In 1999, the Hinase Fishery Cooperative built a direct selling store with an oyster-grilling hut and a restaurant under the management of the Cooperative, which has become the centerpiece of tourism facilities in the region (Tanaka 2014). The Cooperative enhances the brand power of the Hinase fishers' products through the image of the term "Satoumi." The same is true for the Onna Village Fishery Cooperative, which is using the term "Satoumi" to brand Mozuku (seaweed)

Fig. 6.11 Interior of the Gomi no Ichi

produced in Onna Village and is working with co-ops in the capital region to promote Mozuku sales (see Chap. 11).

6.6 National Eelgrass Summit

On June 3–5, 2016, the "National Eelgrass Summit 2016 in Bizen" under the theme of "Creation of Satoyama and Satoumi Brands: Linking Communities and Generations" was held at the Hinase Fishery Cooperative and the Hinase Civic Hall.

In June 3, as a pre-event, a joint symposium of the Liaison Council of Coastal Environmental Societies, "The Road to Eelgrass Bed Restoration in Japan: Past and Future," was held, and then 150 students of Hinase Junior High School and general participants conducted "Mission to Collect Drifting Eelgrass."

In the morning of June 4, the first part, "Thirty Years of Eelgrass Bed Restoration Activities: Review and Future Prospects," consisted of two keynote speeches: "Characteristics of Eelgrass Bed Restoration in Hinase, Okayama Prefecture: Utilization of Past Lessons and Experiences of the Fisheries Industry and Wide-Area Human Connections," by Associate Professor Satoko Seino of Kyushu University, and "Marine Learning from People and the Sea: Challenges of Hinase Junior High School," by Takashi Fujita, a teacher at Hinase Junior High School. The students of

Hinase Junior High School followed a play entitled "People Sowing Seeds in the Sea," which dealt with the eelgrass bed restoration activities in Hinase over the past 30 years. Then, a panel discussion entitled "Voices of the Guardians of the Sea" by six fishers from Hinase and Mr. Tanaka, Secretary General of the Satoumi Creation Research Council, was held.

In the afternoon of June 4, as the second part, Professor Ichiro Imai of Hokkaido University reviewed the history of eelgrass bed restoration and summarized the current status and challenges of eelgrass bed restoration technology as a result of the previous day's joint symposium. Seven panelists followed a panel discussion entitled "Efforts in Various Parts of Japan: Creating Satoumi to Link Communities." Then, in the third part, "Disseminating Satoyama and Satoumi Brands: Connecting Communities and Generations," a Director of Japan Broadcasting Corporation Kyosuke Inoue gave a keynote speech on "From Satoyama Capitalism to Satoumi Capital Theory." Six panelists followed a panel discussion "Creating Satoumi and Satoyama Brands: Linking Regions and Generations," and the panelists and audience actively exchanged opinions.

In the morning of June 5, the "Summit of High School Students for the Restoration of Seaside Nature" was held, with case reports by students of Okayama City Ogushi Elementary School and Hinase Junior High School, followed by presentations by high school students from 12 schools across Japan. After that, a declaration was adopted at the closing ceremony, and the 3-day Summit, which was attended by about 2000 people, came to an end.

6.7 Blue Carbon

In Hinase, eelgrass and oysters have the potential to become "blue carbon" (Nellemann et al. 2009). The term blue carbon was coined by the United Nations Environment Programme (UNEP) in 2009 and refers to carbon stored in marine ecosystems, similar to carbon stored in forests on land (green carbon). In Hinase, CCS (carbon capture and storage) is being carried out as the blue carbon.

The amount of drifting eelgrass collected by the fishers of the Hinase Fishery Cooperative and the students of Hinase Junior High School is about 30 tons/year or 1.2 tons C/year. After collecting the seeds from eelgrass, it is buried in fields and pots to be used as fertilizer for "Ama-vege" (eelgrass-fertilized vegetables: specialty products in Hinase).

According to actual measurements at the eelgrass bed in Lake Huren, Hokkaido, the carbon concentration and sedimentation rate of the eelgrass bed sediment were 25 mg C/g and 0.2 g/cm^2/year, respectively (personal communication from Professor Shigeru Kadoya, Hokkaido University). If we apply these values to the eelgrass bed in Hinase, the current area of the eelgrass bed in Hinase is 250 ha (Fig. 6.6) = 250 × 10^4 m^2, so the sedimentation rate is 5000 tons/year, and the amount of carbon stored is 125 tons C/year.

The amount of oyster shells collected by the Hinase Fishery Cooperative is about 2.5×10^4 m^3/year = 5.0×10^3 tons/year = 50 tons C/year. The oyster shells are stored in an underwater storage facility near the Hinase port for 1 year to decompose the organic matter on the surface of the oyster shells and then cleaned and sold as soil conditioner for agriculture, poultry feed, and bottom conditioner in various areas of the Seto Inland Sea. The fishers of Hinase believe that the oyster shells also become the blue carbon. However, the production of oyster shell is expressed by the following process: "$Ca + 2HCO_3 = CaCO_3 + H_2O + CO_2$." This means that unit oyster shell production is accompanied with unit carbon emission. Therefore, we cannot include the 50 tons C/year in the CCS. Consequently, the total amount of CCS in Hinase is 126 tons C/year.

On the other hand, the average carbon emission per household in Japan is 1400 kg C/year (Japan Center for Global Warming 2017), so if we multiply this figure by the number of households in the fishing village of Hinase, which is 140 (number of regular and associate members of the Cooperative), the carbon emission of the fishing village is 196 tons C/year. This figure indicates that the 126 tons of CCS captured and stored in Hinase is equivalent to about 64% of the carbon emission. If the stored carbon increases with the expansion of eelgrass beds and the carbon emission decreases with the increase in renewable energy use, the Hinase community would become the "Carbon-Neutral Community" in the near future.

6.8 Future Development of Satoumi in Hinase: Sixth Industrialization

In Hinase, fishers have been sowing eelgrass seeds and improve the bottom sediment for more than 30 years and have succeeded in restoring the eelgrass beds. This has contributed greatly to stabilizing the production of oyster farming, which is the main pillar of the Hinase Fishery Cooperative. Hinase can be evaluated as the area where active measures (see Chap. 1) for the Satoumi creation are the most successful in Japan. Also, the active measure of taking back the debris from the seabed has been continued for more than 30 years, and the direct selling of fish at the Gomi no Ichi market, which is a passive measure, has contributed to the revitalization of the local economy. I hope Hinase will continue to lead the way in the Satoumi creation in Japan.

The late Mr. Kazuo Honda said "We cannot expect an increase in fish catches and fish prices in the future, and we cannot sustain the fishing village just by catching fish. We should bring city dwellers to the fishing village in various ways, such as recreational fishing, shellfish gathering, and on-site learning, and have them buy local fish and oysters on their way home." His successor, the current executive committee of the Hinase Fishery Cooperative, has the same idea and is trying to create a sustainable Hinase Town. To survive, it may be necessary to develop the

so-called sixth industry combining primary (fishing), secondary (fish processing), and tertiary (direct selling, tourism) industries in the Satoumi of Hinase.

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Chapter 7
Reviving Abandoned Aquaculture Ponds and Coastal Areas by Integrated Multi-trophic Aquaculture

Suhendar I. Sachoemar and Tetsuo Yanagi

Abstract In Indonesia, the Japanese Satoumi concept was adopted as a national policy for reconstructing areas where many aquaculture ponds had been abandoned due to the spread of diseases. With the participation of local residents, the integrated multi-trophic aquaculture (IMTA) technology was developed to improve the aquaculture environment and increase productivity by culturing shrimps, fish, seaweed, and bivalves in a closed system. This technology is now being deployed throughout Indonesia. In the open coastal waters, the development of the IMTA technology for fish and seaweeds had started.

Keywords IMTA · Indonesia's Satoumi · Sustainable aquaculture · Mangrove

7.1 Aquaculture and Satoumi Concept in Indonesia

Indonesia is the largest archipelago in the world. Its coastline is about 95,181 km (KKP 2011) with a sea area of 5.4 million km^2. Indonesia has 1.2 million hectares (hereafter ha) of brackish-water area, but only 37.5% of them are used for aquaculture activities. In the brackish water, shrimp, milkfish, tilapia, grouper, and seaweed *Gracilaria* spp. can be cultivated. For marine culture, the current potential area is 4.5 million ha; however, only about 2% is used. The low aquaculture use is mainly due to lack of capital and technology and environmental degradation in some areas (DJPB KKP 2004a, b; Sachoemar et al. 2014). In coastal waters, the seaweed cottonii (*Kappaphycus alvarezii* or *Eucheuma cottonii*) and spinosum (*E. spinosum*), saltwater tilapia, shrimps, and groupers can be cultivated.

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E. cottonii and *E. spinosum* are cultivated mainly to produce carrageenan, which is used as a food additive, etc.

The main cause of low aquaculture use in brackish waters is environmental degradation caused by overuse in the 1980s. Many aquaculture ponds were abandoned due to the spread of diseases (Sachoemar et al. 2014). It occurred almost in the whole coastal area from the western to the eastern part of Indonesia e.g., eastern coastal area of Sumatera, northern coastal area of Java, and coastal areas of Kalimantan and South Sulawesi. This situation can be seen not only in Indonesia but also in other Southeast Asian countries such as Taiwan, the Philippines, and Thailand. The main destinations for cultured shrimp are Japan and the United States, and the mangrove forests along the coast have been cut down to make shrimp ponds, creating a major environmental problem.

In the 2000s, the Government of Indonesia's Agency for the Assessment and Application of Technology and the Provincial Government of West Java launched a project to reconstruct the coastal areas of West Java, where plenty of abandoned shrimp ponds were located. After completing his doctorate at Kyushu University in 2002, Sachoemar (one of the authors) returned to Indonesia to work as a researcher at the Agency and was put in charge of this restoration project. He thought that it would be appropriate to base this reconstruction project on the Satoumi concept that he learned at Kyushu University.

For Indonesia, it is an urgent issue to aim for a balance between natural resource development and environmental conservation based on the Satoumi concept, in relation to the global trend of how to deal with global environmental problems such as global warming and overexploitation of natural resources (Yanagi 2008). Aquaculture in brackish and coastal waters needs to be conducted more sustainably, with the participation of local residents and with high productivity and environmental conservation in mind. To create such Satoumi in Indonesia, it is necessary to develop Satoumi concept that takes into account typical habitats and the natural environment of Indonesia.

The habitats of the Indonesian coastal waters vary greatly from west to east. For example, the seabed in the west is mainly muddy, while in the east, it is sandy. These differences greatly affect the types and methods of aquaculture at the sites. In the western brackish waters, the main species of cultivated seaweed is *Gracilaria* spp., while in the eastern coastal waters, the main species is cottonii. The cultivation methods are also different. In the western part of the country, closed aquaculture system in ponds in brackish water is used, while in the eastern part, open aquaculture system in wide coastal areas along the coastline is mainly used.

7.2 Development of Sustainable Aquaculture Technology

More than two decades ago, the northern coastal area of Java and some parts of South Sulawesi were to be a center of shrimp production and important regions for the economic growth in the western and eastern part of Indonesia. However, the

rapid development of shrimp farming in these regions has caused environmental damage (Ongkosono 1992; Praseno 1995; Nurdjana 1997). Since 1985, land along the coastal area within these regions has gradually been converted into shrimp ponds with intensification system followed by mangrove deforestation. In the early stages, this system has contributed greatly to the production of shrimp for the regions with an average productivity of more than 4 tons/ha with the black tiger species (*Penaeus monodon*). However, after a decade, shrimp productivity decreased dramatically to less than 1.5 tons/ha. The main reason for this decrease is that the shrimp ponds have lost the organic decomposition function of the diminished mangrove forests, and the water quality has deteriorated significantly, reducing the environmental capacity for shrimp farming. This resulted in a high incidence of diseases and a series of shrimp die-offs in the early stages of aquaculture (Phillips et al. 1993). In the early 2000s, shrimp farming in Indonesia and other Southeast Asian countries recovered with the introduction of a new species, vannamei (*Litopenaeus vannamei*). While black tiger can only use the bottom of the pond, vannamei can be cultivated intensively in the water column with production reaching 150 ton/ha with super intensive method.

However, the outbreak of a serious fish disease affecting young shrimp (20–40 days after hatching), known as early mortality syndrome (EMS) or acute hepatopancreatic necrosis syndrome (AHPNS), caused a sharp decline in shrimp production. EMS is caused by a special virus (*Vibrio parahaemolyticus*), which releases highly toxic substances. As a result, Thailand's shrimp production declined by 47% and Vietnam's by 43% in 2011–2013 (undercurrentnews.com, 2013).

On the other hand, Indonesia banned the import of juvenile shrimp from Southeast Asian countries and paid attention to the ecological environment of the aquaculture ponds to prevent the outbreak of shrimp diseases, resulting in a 42% increase in shrimp production in 2011–2013, in contrast to other Southeast Asian countries. In 2014, Indonesia's annual shrimp production reached 645,000 tons, the largest in Southeast Asia, with Vietnam second at 569,000 tons, Thailand third at 220,000 tons, the Philippines fourth at 75,000 tons, and Myanmar fifth at 53,000 tons.

However, there were still several abandoned ponds, and to enable a more stable and sustainable shrimp production, integrated multi-trophic aquaculture (IMTA) project was implemented based on Satoumi concept. The project was part of the national project GAPRA (Indonesian acronym for "Development Action Plan for the North Coast of West Java").

IMTA has been called a "green technology" or "zero emission technology" (Chopin 2006; Neori et al. 2004; Troell et al. 2003). Shifting from monoculture to IMTA can increase productivity and prevent environmental degradation (Sachoemar et al. 2014). Organic matters such as fish and shrimp feces are used by bivalves, and inorganic nutrients are assimilated by seaweeds, thus stabilizing the water quality in the aquaculture ponds. These conditions create a new balance in the ecosystem (Chopin et al. 2004; Neori et al. 2001). If this technology is successfully applied at the national level, brackish ponds and coastal waters throughout Indonesia will be properly used, and the national income will be increased.

7.3 Closed System Integrated Multi-trophic Aquaculture Model

An experiment to clarify the sustainable model of closed system integrated multi-trophic aquaculture (CSIMTA) was conducted during 4 months from June to September 2010 in the brackish-water pond area of the northern coastal Karawang, West Java, Indonesia (Fig. 7.1). This experiment was conducted as an Indonesian version of the Satoumi creation (Yanagi 2012) to establish sustainable aquaculture methods, involving local residents.

The experiment used four aquaculture models using 500 m^2 pond of each with three replications (Fig. 7.1). Model-1 (P-1) contains the seeds of black tiger shrimp with density of 5 shrimps/m^2. Model-2 (P-2) contains the seeds of tilapia and black tiger shrimp with a density of each 5 fish and shrimps/m^2. Model-3 (P-3) contains the same density with P-2 of tilapia and black tiger shrimp, with additional seaweed (*Gracilaria* sp.) in the longline system with a density of 0.1 kg/m^2. Model-4 (P-4) contains the same composition and density with P-3 of tilapia, black tiger shrimp, and seaweed with additional benthic organisms of green mussel (*Perna viridis* sp.) in

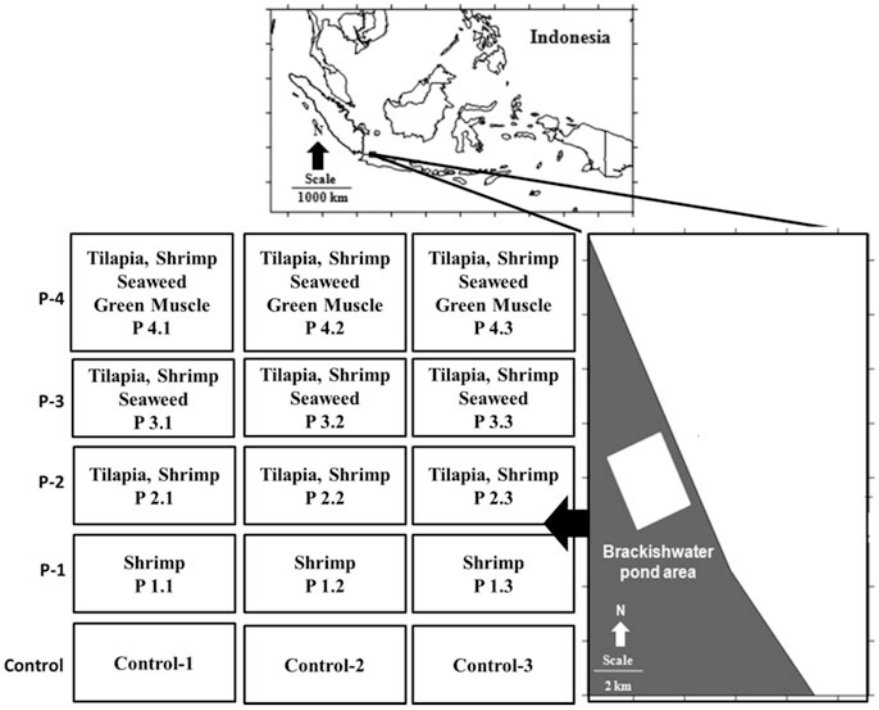

Fig. 7.1 Site location and experimental design of the "integrated multi-trophic aquaculture (IMTA)" in the northern coastal area of Karawang (Sachoemar et al. 2014)

Fig. 7.2 Target species of CSIMTA

Table 7.1 Water qualities of each brackish-water pond model (Sachoemar et al. 2014)

Brackish-water pond model	Temperature (°C)	Salinity (ppt)	pH	DO (ppm)	TSS (mg/L)	BOD_5 (mg/L)
P-1	30.81	24.94	7.92	6.28	36.50	1.66
P-2	30.77	23.11	7.87	6.27	22.33	0.71
P-3	30.92	22.48	7.90	6.74	22.83	0.24
P-4	30.94	22.91	7.91	7.11	18.00	1.18
Control	30.60	20.30	8.05	6.65	38.00	0.71

the longline system with a density of 0.1 kg/m^2 (Fig. 7.2). And as a control, we used ponds without organisms (Sachoemar et al. 2014).

7.3.1 Water Quality

The water qualities (temperature, salinity, pH, DO, TSS, BOD_5, DIN, and DIP) of four models and control are shown in Table 7.1. The figures indicate that water qualities for all models are normal to support aquaculture organism lives. Each pond is located inland within a few hundred meters of the coastline and is connected to the sea by a channel. However, seawater from the channel is pumped up manually into the ponds, so there is a little seawater exchange.

Interestingly, the results of P-3 and P-4 show relatively low salinity but relatively high temperature and DO (dissolved oxygen). The high DO is due to active photosynthesis of seaweed. This is in contrast to the results of P-1 and P-2 where no seaweed was cultivated. The low TSS (total suspended sediments) in P-4 is due to the feeding of TSS by green mussels. These results indicate that IMTA is effective in improving water quality in aquaculture ponds.

Furthermore, according to the water quality data shown in Fig. 7.3, the DIN (dissolved inorganic nitrogen) concentration in P-4 is lower than that in the control pond and is the lowest value. This suggests that in P-4, green mussels are consumers of suspended matter and seaweeds are consumers of inorganic nutrients, contributing to a smooth material cycle in the pond (see Chap. 2).

In IMTA, organic suspended matters such as residual feed and feces are consumed by mussels, and inorganic nutrients are consumed by seaweeds (Fig. 7.4). As

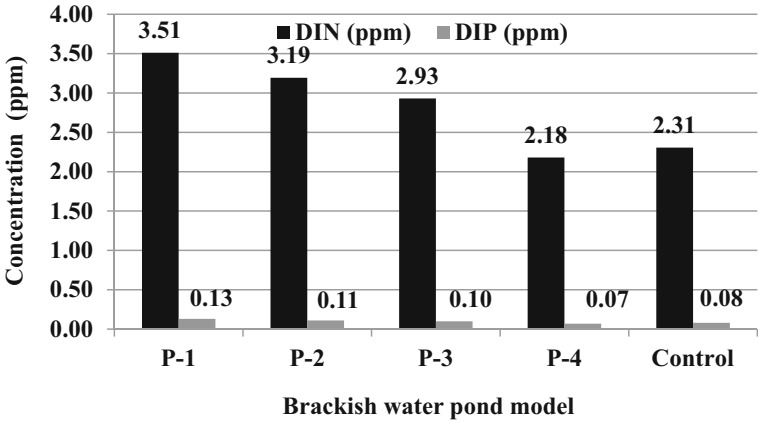

Fig. 7.3 Mean average of DIN (*dissolved inorganic nitrogen*) and DIP (*dissolved inorganic phosphorus*) of each brackish-water pond model (Sachoemar et al. 2014)

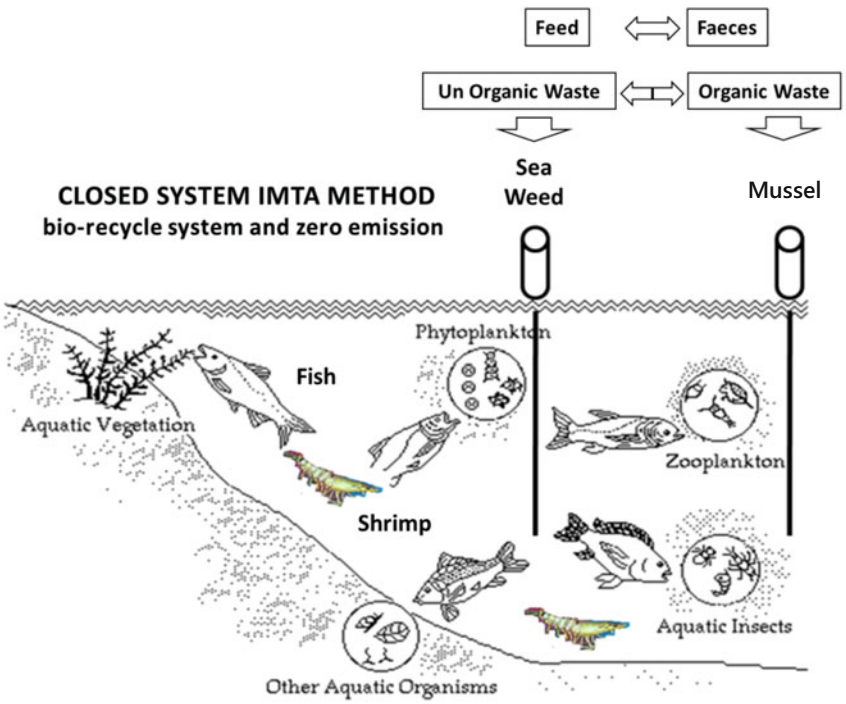

Fig. 7.4 Closed system IMTA method on the base of bio-recycle system and zero emission

a result, the ecosystem and water quality in P-4 are the most stable compared to other ponds. According to the results of the statistical analysis shown in Table 7.2, DIN concentration in P-4 is significantly different from other ponds, but not from the

Table 7.2 Statistical analysis of the ANOVA and mean of DIN, DIP, and DO of each brackish-water pond model (Sachoemar et al. 2014)

Parameters	Control	Brackish-water pond model			
		P-1	P-2	P-3	P-4
DIN (mg/L)	2.31 ± 0.33	3.51 ± 0.38*	3.19 ± 0.61*	2.93 ± 0.34*	2.18 ± 0.28
* Significantly different with control and P-4 ($P < 0.05$)					
DIP (mg/L)	0.08 ± 0.03	0.13 ± 0.10	0.11 ± 0.11	0.10 ± 0.08	0.07 ± 0.04
Not significantly different among treatments ($P > 0.05$)					
DO (mg/L)	6.65 ± 0.34	6.28 ± 0.22*	6.27 ± 0.12*	6.74 ± 0.34*	7.11 ± 0.57**
* Significantly different with control ($P < 0.05$)					
** Significantly different with control, P-1, P-2, and P-3 ($P < 0.05$)					

control pond. This indicates that IMTA in P-4 works significantly better than P-1, P-2, and P-3 in reducing DIN concentration. The dissolved inorganic phosphorus (DIP) concentrations in P-4 showed different results. In P-4, DIP concentration was the lowest, but not significantly different from P-1, P-2, P-3, and the control pond (Table 7.2).

Green technology in the field of aquaculture was developed to overcome the problem of environmental degradation. By developing a model of environmentally friendly aquaculture as an IMTA, the productivity of brackish-water ponds in the coastal area is expected to be increased, and the quality of the environment can be well maintained and sustained.

The experimental results of P-4 show that IMTA of seaweed, mussels, shrimps, and tilapia maintains good water quality in the aquaculture ponds. The organic and inorganic materials such as residual feed, feces of shrimp and tilapia, and their decomposition are recycled to seaweed and mussels. Additionally, the oxygen from the seaweed maintains a healthy environment for the cultured organisms.

7.3.2 Growth Rate

Among the growth rates of the four cases shown in Fig. 7.5, the growth rate of the shrimps of P-4 is the highest, and the growth rate of the seaweeds of P-4 is higher than that of P-3. The difference in growth rates between P-1, P-2, P-3, and P-4 indicates that IMTA including seaweeds and bivalves increases the growth rates of shrimp and fish in addition to the growth of seaweeds and bivalves, rather than mono- or bi-species aquaculture of shrimps and fish. This is an important experimental result that suggests that high biodiversity does not contradict high biological productivity as stated in the definition of Satoumi (Yanagi 2008).

Due to the good results of the CSIMTA experiment, as of 2017, the technology has been deployed in Banten Province in western Java, the eastern and central north coast of Java, Takalar District in southern Sulawesi, Lampung Province in southern Sumatra, Aceh Province in northern Sumatra, and Lombok Island. The maintenance

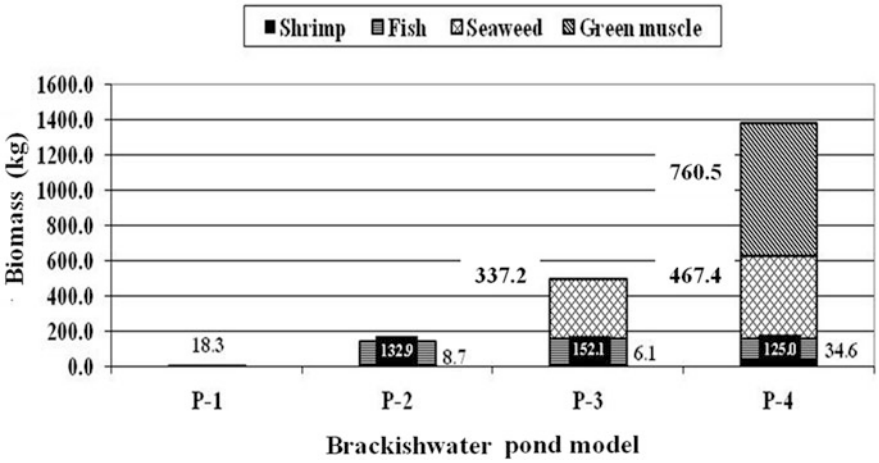

Fig. 7.5 Productivity profile of each brackish-water pond model (Sachoemar et al. 2014)

of healthy aquaculture pond environment and high growth rates of aquaculture organisms are directly related to the income of the fishers, so IMTA is expected to contribute greatly to the economic development of Indonesia.

7.3.3 Mangrove Planting

Local fishers have continued to plant mangroves around their culture ponds for protecting them from the wave erosion and maintaining their water quality. For this activity, they use the fund defrayed from a Japanese private company. The Japanese company, Nippon Shokubai Co., Ltd., is one of the companies that have special attention in the preservation of mangrove forests in Indonesia. The Nippon Shokubai Co. Ltd., together with the NGO (non-governmental organization) Bhumi Rekonvasi and community groups who are the members of the Pancer Coastal Youth Community Forum (FMPPP), planted mangroves in the Banten Bay area. In addition to planting and maintaining mangroves, the FMPPP also aims to use this mangrove forest for community-based tourism activities (Aswanto 2019).

Efforts to restore ecosystems by planting mangroves are active measures of Satoumi creation, which require direct human intervention (see Chap. 1). Mangrove forests have many functions and an important role in aquatic ecosystems. They also have social functions and other functions that are beneficial to the communities in the world, especially in anticipating global warming. From an economic point of view, mangrove forests produce several types of good-quality wood, as well as non-timber products, in the form of wood charcoal, tannins, coloring agents and cosmetics, food, and beverage. Also included are animals that are commonly caught such as mangrove crabs (*Scylla serrata*), mud shrimps (*Thalassina anomala*), mangrove snails

(*Telescopium telescopium*), and various types of fish. The more important benefits of mangrove forests are their ecological functions as coastal protection, habitat for various types of animals, and nursery ground for many types of marine fish (Aswanto 2019).

7.4 Open Sea Integrated Multi-trophic Aquaculture Model

We are now developing the open system integrated multi-trophic aquaculture (OSIMTA), which combines seaweed and fish aquaculture, to establish a sustainable aquaculture method in coastal waters by applying the CSIMTA technology. OSIMTA is also based on the concept of Satoumi, and OSIMTA experiments were being conducted off the coast of Bantaeng, South Sulawesi.

In this experiment, we aimed to maintain the health of the marine environment and improve the productivity of cultured organisms by combining fish culture using floating net cages and seaweed culture using ropes in the same marine area. It was expected that the organic excrement from fish cages would be decomposed into inorganic nutrients and used by seaweed, which would maintain the water quality and the health of the marine environment and increase the productivity of cultured fish and seaweed simultaneously.

In the eastern part of Indonesia, the cultivation of seaweed cottonii and spinosum using ropes and fishes of grouper, milkfish, barramundi, and saline tilapia using fish cages is operated. The main reason for trying CSIMTA in the western part of Indonesia and OSIMTA in the eastern part is the difference in water quality between the western and eastern coastal waters. In the western part of the country, there are many coastal areas where large rivers flow into, and the amount of suspended particles supplied by rivers is large in such coastal waters. Coastal waters are usually turbid and unsuitable for fish and seaweed culture, so aquaculture is conducted with the closed system in the ponds inland in the coastline. However, in the eastern part, where there are few large rivers, fish cage culture and seaweed rope culture are conducted in low turbid coastal waters.

7.4.1 Seaweed Culture

The seaweed cottonii cultivation (Fig. 7.6) is an alternative cultivation to increase the income of farmers/fishers and the use of the coastal areas. The simple technology, high market demand, and low production cost are advantageous factors in seaweed farming compared to other fisheries commodities. Important factors that determine the success of seaweed farming are as follows.

Fig. 7.6 Seaweed cottonii cultivation

1. Site selection

   A suitable site for seaweed cultivation is one that meets the following conditions: low wind and waves, sand and gravel for the seabed, water depth of 30–50 cm or more at the lowest tide, salinity of 28–34 psu with 32 psu being optimal, water temperature of 27–30 °C, transparency of at least 1.5 m, pH of 6–9 with 7.5–8.0 being optimal, current speed of 20–40 cm/s, and proximity to land-based workstations.
2. Sorting, storage, and transportation of seed algae.

   For seed algae, secure a sufficient quantity of fresh and appropriate breed. Seeds should be stored in nets before planting and kept wet during transport to the aquaculture site.
3. Cultivation methods

   There are two methods for cultivating cottonii: the surface method and the off-bottom method. The surface method uses rafts made of 2.5–5-m-long bamboo poles tied with ropes or the 30-m-long nylon ropes (longlines) with planted seed algae. In the off-bottom method, seed algae are planted on a rope, and both ends of the rope are fixed with bamboo poles inserted into the seabed.
4. Maintenance, harvest, and post-harvest

   During cultivation, clean the other algae attached to the facilities and repair the facilities. The algae are harvested when they have grown to 400–600 g or 30–45 days after the start of cultivation. The harvested seaweeds are dried in the sun for 2–3 days. After that, they are washed in seawater and dried again in the sun, taking care to avoid rain. After drying is completed, the seaweed is packed in bags for shipment.

7.4.2 Floating Cage Fish Farming

The following points should be taken into consideration for floating cage fish farming:

1. Site selection
   Coastal waters are used not only for aquaculture but also for shipping, leisure, and many other purposes, so the selection of sites requires consultation with other stakeholders. The Ministry of Agriculture has issued the Implementation Guidelines for the Development of Marine Aquaculture (Ministry of Agriculture 1994). Additionally, wind and wave effects, water depth, current velocity (20–40 cm/s), salinity (27–32 psu), water temperature (28–30 °C), marine pollution, and shipping routes should be considered in site selection.
2. Fish species
   Fish species that are commonly cultivated in Indonesia should be selected, such as groupers (*Epinephelus fuscoguttatus*, *E. altivelis*, *E. tauvina*), white snapper (*Lates calcarifer*), red snapper (*Lutjanus malabaricus*), marine tilapia, and milkfish (*Chanos chanos*).
3. Preparation of cultivation facilities
   Rafts made of bamboo, wood, or stainless steel should be prepared as frames for fixing fish nets. The shape and size of the raft depend on the nets to be used, but usually four nets are fixed to one raft. Buoys made of plastic, steel, or Styrofoam are necessary to float the rafts on the sea. The nets are usually made of polyethylene, cubic in shape, and 3 × 3 × 3 m in size. The rafts are anchored with concrete or steel anchors. Four anchors weighing 25–40 kg are usually required for each raft.
4. Harvesting
   It usually takes 6–8 months for the fish to grow to 600–800 g, with a survival rate of 80–90%. In some cases, the fish are harvested little by little depending on the size of the fish and the market demand, while in other cases, all the fish are harvested at one time.

7.4.3 Field Experiment

Seaweed and fish farming experiments were conducted in 2017 as shown in Fig. 7.7. Field investigations on the growth rates of the cultured organisms and water quality were conducted mainly in April 2017. The respective growth rates of seaweed and fish were 0.8–1.6 g/day for cottonii and 2.5 g/day for tilapia. The growth rate of cottonii was lower than that of India (2.0–6.1 g/day, Thirumaran 2009), and the growth rate of tilapia was similar to or slightly higher than that of Ghana (2.3–2.4 g/day, Mensah and Attipoe 2013).

The distribution of surface water quality is shown in Fig. 7.8. River water with high temperature, low salinity, high turbidity, and high DO is distributed near the

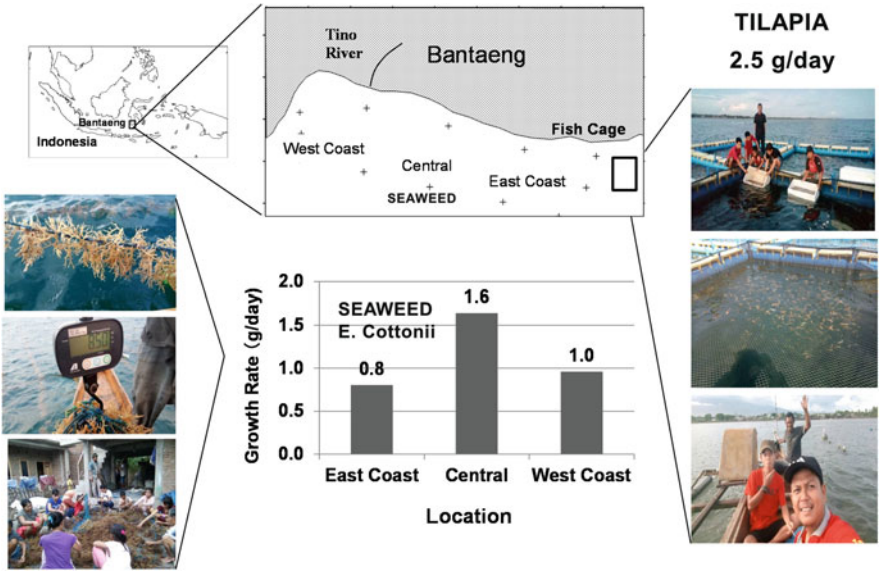

Fig. 7.7 Growth rates of cultured cottonii and tilapia

mouth of Tino River. The reason for the high DIN and DIP in the central to eastern part of the cottonii aquaculture area seems the influence of domestic and industrial wastewater from land. This may be the reason why the growth rate of cottonii is relatively high in the central area as shown in Fig. 7.7.

DIN/DIP mol ratio calculated from the average concentration in this area (Fig. 7.8) is 0.3, which is much smaller than the Redfield ratio of phytoplankton (16) and seaweed (5–50, Duarte 1992). This suggests that the limiting nutrient for the growth of the seaweed in this area is not DIP but DIN.

The DIN concentration required for the growth of cottonii is not known, but the limiting DIN concentration for the dis-colorization of seaweed in Japan is 0.028 mg/L (Makino 2014). The DIN distribution in Fig. 7.8 shows that the DIN is lower than 0.028 mg/L in most of the sea areas except for the inshore areas. In March and May 2017, similar DIN distributions were observed with April, suggesting that DIN in this area is depleted by cottonii farming. The low growth rate of the cottonii shown in Fig. 7.7 may be due to low DIN concentration in this area.

In response to this situation, we started experiments to confirm the changes in water quality and productivity through OSIMTA by arranging seaweed and fish aquaculture facilities, as shown in Fig. 7.9. Cottonii culture areas and tilapia culture areas were placed side by side, maintaining a healthy environment in fish culture areas and increasing the productivity of seaweed culture. To achieve this goal, we are continuing to develop technology for sustainable OSIMTA, such as clarifying the appropriate layout, spacing, and number of fish cages and seaweed culture ropes.

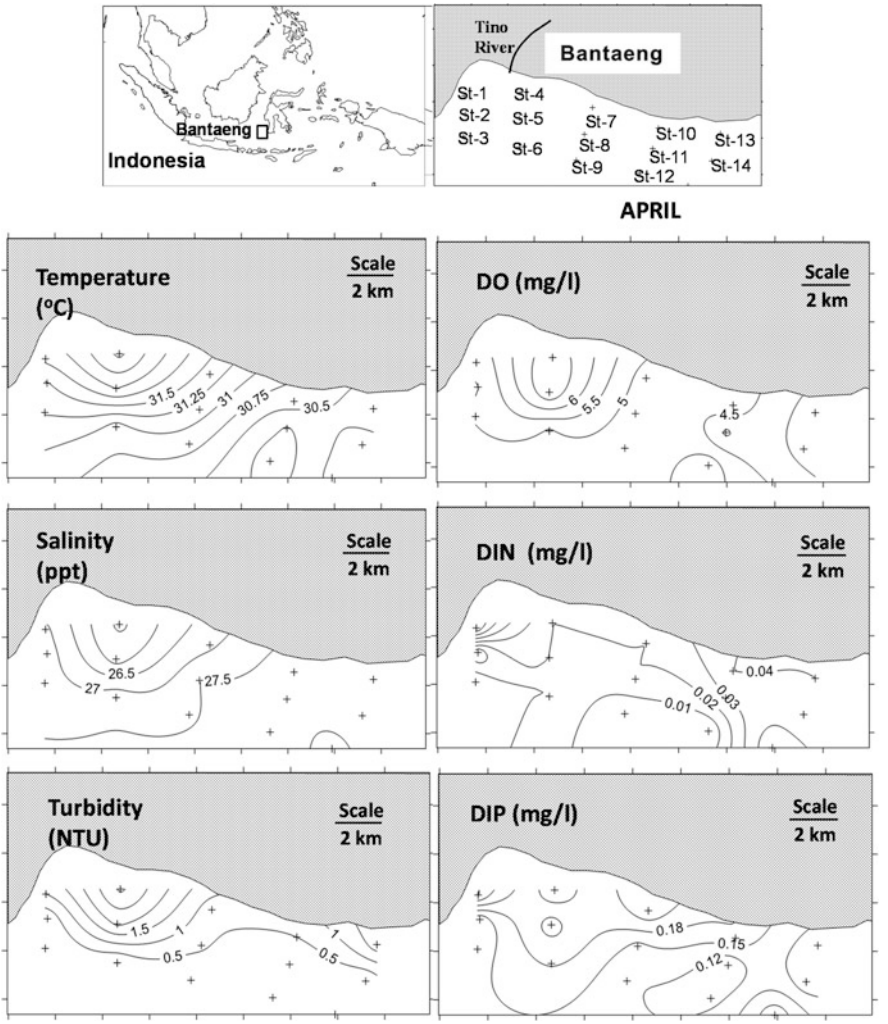

Fig. 7.8 Horizontal distributions in surface water temperature, salinity, turbidity, DO, DIN, and DIP in April 2017

7.5 Expansion of the Satoumi Concept in Indonesia

The involvement of Yanagi (one of the authors) in the Satoumi creation in Indonesia began when he visited the West Java Province in 2009 upon the request of Sachoemar to discuss with local fishers, fisheries researchers, and government officials about measures to restore abandoned shrimp ponds. After that, Yanagi often visited Indonesia to discuss Satoumi concept with local people in connection with some Japanese Satoumi-related projects.

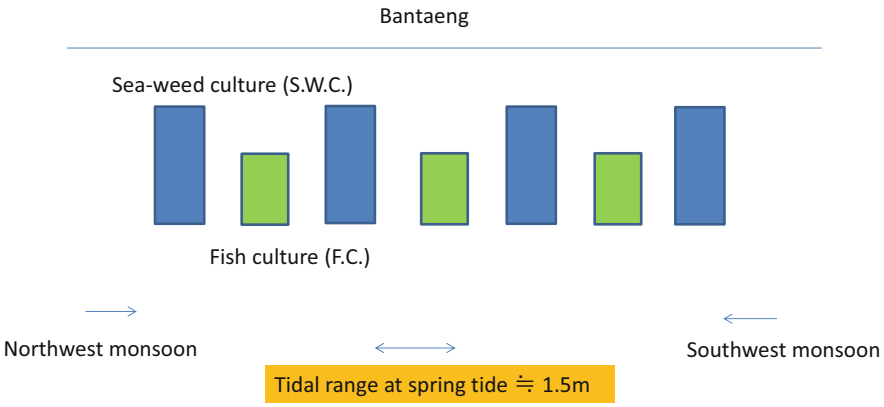

Fig. 7.9 Proposed distributions of cottonii culture and tilapia culture off Bantaeng

In Indonesia, apart from the International Satoumi Workshop held somewhere in the world every year since 2008, the Indonesia Satoumi International Workshop had been held in Jakarta in 2013, Pekalongan in 2014, and Jakarta in 2015 and 2017. In the workshops, the progress of the Satoumi concept and technology in the world and the status of Satoumi development in Indonesia, such as IMTA, were reported. It was confirmed that the Satoumi concept proposed in Japan is in harmony with the policy of "Sustainable Use of Fisheries and Ocean Resources for Society" proposed by the Agency for the Assessment and Application of Technology as a national policy of Indonesia and that it is meaningful to establish a "new relationship between nature and humankind" in the Indonesian economic zone to restore the degraded marine biodiversity and productivity.

In Indonesia, the President has called for establishing about 100 techno-parks across the country to promote regional industries. In two of them, Pekalongan in Central Java and Bantaeng in South Sulawesi, the name of the parks is Satoumi Technopark. Indonesia is probably the country in the world that has most actively incorporated the Satoumi concept into its policies, except for Japan.

7.6 Satoumi Creation Through IMTA in Indonesia

The closed system IMTA of shrimp, tilapia, seaweed, and mussel in brackish-water aquaculture ponds showed the lowest DIN concentration (i.e., favorable environment) and the highest growth rate, indicating that this technology is more sustainable and economically superior to mono-trophic aquaculture. This method increases the productivity of shrimp, fish, seaweed, and bivalves and improves the environment of the aquaculture ponds. The feces of the main aquaculture species are used by other aquaculture species to ensure smooth material circulation in the ponds. This is one of

the ways to create Satoumi, which increases productivity and improves the environment with human intervention (Yanagi 2008).

In the future, it will be important for sustainable aquaculture in coastal waters to develop an aquaculture model in which organic and inorganic materials, such as residual feed and feces, are successfully circulated in the ponds and the load on the outside of the ponds is reduced to zero. As proposed in the Satoumi concept, the participation of local people and their close involvement in the activities will greatly affect the success of the aquaculture model.

The open system IMTA had just started mainly in eastern Indonesia, but it is expected to be as successful as the closed system IMTA. Maintaining the sustainability of natural resources and the natural environment is not only a national challenge for Indonesia but also a global challenge. We should continue to do our utmost to maintain food, natural resources, and the natural environment for the sustainability of human beings.

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Part III
Managing and Enriching Coastal Resources

Chapter 8
Conserving Multiple Coral Reef Resources

Ippei Yanagida and Shinichiro Kakuma

Abstract In Okinawa City, located on the central east coast of Okinawa Island, a fishers' leader established a nonprofit organization (NPO), INO, to work on the Satoumi creation. INO conducted various activities, including research on traditional fishing methods, environmental education/research/conservation, and coral culture and planting.

This chapter discusses institutional issues of Satoumi, such as commons, local rules, fishery rights, and licenses. In Okinawa, coastal fishery resources are used by both customs and common fishery rights. The involvement of non-fishers in Satoumi creation and measures against increasing marine leisure such as diving are also important issues.

The activities of INO have been taken over by the Satoumi Council. The Satoumi Council established a vision for resource management and expanded and diversified the activities of INO, such as length limits for the most important species, establishment of a marine protected area, and resources and environmental surveys by fishers.

Keywords Fishery cooperative · INO · Coral farming · Coral planting · Fishery right · MPA

8.1 Environment and Fisheries in Okinawa City

Okinawa City is located in the center of Okinawa Island and faces Nakagusuku Bay, the largest bay in Okinawa, to the east (Fig. 8.1). Okinawa City is the second largest city in Okinawa after Naha City. Reclamation of the shallow sea area has progressed,

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Fig. 8.1 Location of Okinawa City

including a reclamation project currently underway in Awase area where many disputes have arisen. Okinawa City's Satoumi creation has become an example of Satoumi creation in urban areas.

The Okinawa City Fishery Cooperative consists of 49 full members and 42 associate members (as of 2017) and is engaged mainly in the Payao (fish aggregating device) fishery, Sodeika (*Thysanoteuthis rhombus*, a large pelagic squid) fishery, and diving fishery. The fishers' group operates a large-scale "Payao outlet store" next to the fishery cooperative office.

In the past, most of the fishers fished with diving fishing, hook and line fishing, bottom longline, and small nets to catch coastal fish. However, due to various reasons such as sedimentation caused by developments and overfishing, coastal fishery resources have decreased, and there has been a shift to offshore Payao and Sodeika fisheries.

8.2 NPO INO

8.2.1 What Is INO?

Okinawa has a coral reef area called Ino, which is different from mainland Japan. Ino is a shallow, calm lagoon between the outer coral reefs where waves break and shore (Fig. 8.2). In Okinawa, the Ino is the stage for the Satoumi creation.

The NPO INO was established in 2010 and consists mainly of diving fishers, marine consultants, academics, and photographers and is headed by Yanagida (one

Fig. 8.2 Ino of southern Ishigaki Island (© The Ministry of the Environment Japan)

Fig. 8.3 A grouper caught by Yanagida

of the co-authors). The NPO's operating funds are mainly provided by grants and subsidies from various organizations including Kaiho Bank, Bank of the Ryukyus, Okinawa Prefecture Coral Reef Conservation Council, and Okinawa City.

In 2017, it was 17 years since Yanagida, who was born in mainland Japan, started fishing in Okinawa. Learning from his predecessors, he had done a combination of various fishing and aquaculture. He had been mainly involved in Mozuku (seaweed) aquaculture for 9 years, diving fishing for 8 years (Fig. 8.3), and coral aquaculture for 8 years. He purchased a secondhand 8-ton fishing boat to go out to the offshore fishing grounds. Even in the 17 years, he had noticed a decrease in the size and

density of the target fish species. Giant clams and sea urchins had decreased drastically, and the fishing ground environment had deteriorated considerably due to landfill and red soil pollution. The sea is also turbid, which has a negative impact on diving fishing, coral farming, and Mozuku farming. When the turbidity is quite bad, it is impossible to see the tip of the speargun used in the diving fishery.

To overcome this situation, he decided to establish the NPO INO and aim to create Satoumi through environmental conservation and resource management. For resource management, INO tried to secure alternative income sources through works other than fisheries to give the sea a rest. Alternative income sources are important in resource management. Because in the early stages of resource management, fishers often have to have patience with decreased catch until the resource increases, and without alternative income to support family life, resource management activities cannot be sustained (Kakuma 2016). The following are summaries of INO activities.

8.2.2 Preservation and Application of Marine Culture

In 2010–2011, Yanagida interviewed senior fishers who had an average of more than 60 years of fishing experience. These fishers experienced navigation and fishing methods that are closer to nature, such as sailboats and skin diving fishing, which have now disappeared. By collecting their wisdom and experience, and by trying and learning them, he sought out hints that will lead to future fisheries and widely disseminated this information on the website so that many people can learn them. In addition, towels with designs of traditional fishing methods and the fishing boat Sabani (Fig. 8.4) were produced and sold as the alternative income sources.

Fig. 8.4 The Okinawa's fishing boat "Sabani"

8.2.3 Environmental Education, Research, and Conservation

As part of INO's activities, Yanagida provided children and young people, who will be the leaders of the future, with the opportunity to interact with the sea, prioritizing experience over classroom learning and feeling over thinking. In June 2010, he cooperated with three students from Koza Junior High School in Okinawa City to provide them with fishing experience, including a visit to a coral planting site. In March 2012, he gave a lecture on fisheries and coral culture at an environmental education event held by Okiden Corporation. And in November, he gave a lecture on the marine environment through fisheries and conducted fieldwork at the Awase tidal flat to students of Hibarigaoka Junior High School in Hyogo Prefecture.

In a sense, it is natural for fishers who know and have lived in the sea to participate in marine research in their working places. In addition, if this allows the sea to rest, it would lead to resource management. For this reason, he has been actively involved in surveys of the sea conducted by fishers themselves.

In February 2011, with the support of the "Kaigin Environmental Contribution Fund" of Kaiho Bank, Yanagida and fishers conducted a survey of the situation of drifting garbage and abandoned fishing lines in the sea at the breakwater off Awase. Grant money of 700,000 yen (about 6000 US$) from the Fund was received in March, and they cleaned the breakwater off Awase with the cooperation of the Okinawa City Fishery Cooperative. In September 2012, with a grant of one million yen from the same fund, they conducted the "Nakagusuku Bay Abandoned Mozuku Net Removal Project" in cooperation with the Cooperative and removed about four tons of abandoned Mozuku nets from the sea.

8.2.4 Coral Culture and Planting

In 2009 and 2010, INO received a special permit from the prefectural governor to conduct experimental aquaculture for 13 species of coral, including *Acropora*. INO succeeded to grow the corals and then shifted to full-scale aquaculture (Fig. 8.5).

In February 2012, INO sold the cultured corals to Okiden Corporation. The corals were used for environmental education and eventually planted in the sea. In March 2012, INO received a grant of 660,000 yen from the Bank of the Ryukyus' Grant Program to plant 72 colonies of coral cultured in Nakagusuku Bay in cooperation with the Okinawa City Fishery Cooperative. The activity was reported by Japanese public broadcast and Okinawa's newspaper. In December 2012, the INO coral planting project was selected for a grant from the Saudi Aramco Okinawa Coral Reef Conservation Activity Support Fund (800,000 yen), and 80 corals of 8–10 cm were planted in Nakagusuku Bay (Fig. 8.6).

INO's efforts have made it possible to provide sea-related jobs, such as coral planting, to older fishers who are not good at land-based work. Through the Fishery Cooperative, INO has provided the more than one million yen a year to the fishers as

Fig. 8.5 Cultured corals on an iron mesh table

Fig. 8.6 Planting segmented corals on the rocks

alternative income, including charter fees for boats and daily wages. By selling corals for planting, Yanagida personally could earn more than 1.5 million yen a year from coral farming. Coral planting activities are being carried out in various parts of Okinawa with the aim of restoring coral reefs. As a result, the demand for coral for planting is increasing, and the fishers' group is supplying the coral through aquaculture. Coral culture and planting techniques in Okinawa City, where conditions are not particularly favorable, can be used as a reference for similar activities in other parts of Okinawa. Although the scale of coral planting was still small, the activities of INO were frequently covered by the mass media and affected educating children about the environment and promoting the conservation of coral reefs throughout Okinawa.

8.2.5 *Fisheries Extension Officer*

Fisheries extension officers are government officers, and the main role of them is to go into fishing villages and provide fishers with technical guidance on fisheries, aquaculture, resource management, and fish distribution. The fisheries extension officers are potential bilateral knowledge translators (see Chap. 1). One direction of translation that they do is to organize information from research institutes and governments in an easy-to-understand manner and convey it to fishers. In the other direction, they translate the knowledge and experience of fishers into the language of science and administration and introduce them to the world of science and administration (Kakuma and Kitolelei 2018). Kakuma (one of the co-authors) supported the activities of INO when he was a fisheries extension officer in charge of south-central Okinawa Island.

8.3 Institutional Issues in Satoumi

In the Satoumi creation, where local people are closely involved, there are not only technical issues such as prevention of red soil pollution and coral restoration but also major institutional issues such as the arrangement between fishery rights and customs and the involvement of local residents and citizens to Satoumi. These issues relate to "commons" and "local rules."

Commons have many meanings such as common resources, common land, and common institutions (Ostrom 1990; Akimichi 2013). In the case of Satoumi, fishery resources shared by the local community are the typical commons. The "tragedy of the commons" (Hardin 1968) states that common resources are inevitably overutilized because each user strives to get as much as possible for his/her share. For this reason, the resource should be privately or publicly owned. However, subsequent studies have shown that overutilization occurs even under private and public ownership systems, and conversely, there are many cases where common resources are not necessarily overutilized (Feeny et al. 1998). We believe that the success or failure of resource management depends not on the ownership system of the resources but on ensuring exclusivity of the resource use and the existence of effective rules among users (Kakuma 2006a).

Local rules are "objective social rules that regulate our various social behaviors within a certain social group" apart from laws, and "some of these rules have a certain level of legal protection" (Satake 2006). In the process of Satoumi creation, it is important for many people who use the resources and sea surface to discuss and decide on various local rules concerning the use of them. When not only fishers but also various people are involved in the use of resources and sea surface in Satoumi, the local rules need to be fair, reasonable, and transparent (Hidaka 2016).

8.3.1 Type 1 Common Fishery Right and Governor Licensed Fisheries

When considering the commons of the sea, we should answer the question "Who owns the resources of the sea?" "Nature is essentially an ownerless entity that belongs to no one" (Akimichi 2013). Various types of fishery rights have been established in the seas of Japan. Although fishery rights are equivalent to real rights, they are not ownership rights of the sea or fish but "the right to operate a specific fishery in a specific water surface" (Fishery Cooperative Study Group 2008). In Japan, except for special cases, common fishery rights have been established almost everywhere in the shallow waters where the Satoumi creation is conducted. The common fishery rights are "the rights of fishers in a certain area to fish collectively in a certain area of water surface" (Fishery Cooperative Study Group 2008). There are Type 1 through Type 5 common fishery rights. Among them, the Type 1 common fishery right, which targets sedentary resources (marine resources such as seaweed, shellfish, and shrimp that live on the seabed), is closely related to Satoumi.

In the common fishery right system, a fishery cooperative receives the licenses, and individual fishers who are members of the cooperative operate the fisheries of the licenses. There is a local rule called the Common Fishery Right Exercise Rule, which is voted on at the general meeting of the fishery cooperative based on the consultation of the members. In 2013, Okinawa City Fishery Cooperative renewed a license for the next decade of the Type 1 common fishery right for fisheries of Mozuku, sea urchin, lobster, sea cucumber, octopus, and giant clam.

In addition to the fishery rights, there is the governor's license system for fisheries that have significant impacts on resources or pose risks of conflicts if not managed by the government. The diving fishery is a fishery licensed by the governor, and the diving fishery, especially using electric lights at night, is an important fishery of the Okinawa City Fishery Cooperative. The limits of the licenses for diving fishery should be set according to the size of the fishing grounds and the quantity of resources; otherwise, the tragedy of the commons may occur. However, so far, Okinawa Prefectural Government has not established such license limits.

8.3.2 Is It Possible to Restrict New Entrants?

Figure 8.7 shows the No. 9 Common Fishery Right Fishing Ground (hereafter No. 9 CFRF Ground) managed by the Okinawa City Fishery Cooperative and the Minamihara Fishery Cooperative located to the northeast. This fishing ground is smaller than those managed by other fishery cooperatives. The fishery resources targeted by diving fishery are typical commons, and if they are not managed well in this small fishing ground, it will soon lead to the tragedy of the commons, and resources will be reduced by overfishing.

Fig. 8.7 No. 9 Common Fishery Right Fishing Ground. White lines show the boundaries. The small square shows the MPA

Even though common fishery rights give us some exclusive rights, if the number of members of the Cooperatives with diving fishery licenses increases without a limit, it would decrease resources. For this reason, several discussions were held at the Okinawa City Fishery Cooperative, including officials from Okinawa Prefectural Government, to detect if it would be possible to restrict the entry of newcomers to the diving fishery by local rules. However, according to the Fishery Cooperative Law, members are "free to join or leave the fishery cooperative as long as they have addresses in the district of the fishery cooperative and fulfill the specified number of fishing days" (Fishery Cooperative Study Group 2008), and it was difficult to restrict new entrants to the diving fishery by local rules.

8.3.3 The Two Seas of Okinawa

The decrease in the number of fishers and the aging of the fishers have become major problems in Okinawa. For this reason, new fishery workers are desired, but some districts may not want more coastal fishers in their fishing communities. In 2012, as part of a survey of new workers in fishery cooperatives, Kakuma investigated the types of fisheries for which new workers were desired. The results of the survey showed that there were many requests for offshore fisheries and seaweed aquaculture than coastal fisheries and fish aquaculture (Kakuma 2014).

To provide information for fishery cooperatives considering new entry restrictions, Kakuma examined the situation of four remote island fishery cooperatives in three other prefectures in 2013 and 2014. The results showed that all of the fishery cooperatives used more exclusive resource use systems than Okinawa. Some cooperatives had internal regulations as local rules limiting the number of diving fishers, some prohibited the use of SCUBA gears, and one proposed the limit of diving

fishery licenses for their fishing grounds to the prefectural government (Kakuma 2014).

In Okinawa in the past, the offshore areas had been used by professional fishers, and the lagoon areas had been used by villagers as the commons in their half-farming, half-fishing lives (Tamanoi 1995). Even today, such commons use is still practiced, especially in remote islands. On the other hand, the members of the fishery cooperatives have the rights to harvest some sedentary resources in the lagoon because they are often subject to the Type 1 common fishery rights. For this reason, the relationship between customary practices and the fishery right system is complicated in the lagoon (Kakuma 2011). In Okinawa, there is a sense that the sea belongs to everyone, creating an ambiguity in which the sea is used by fishers based on their fishery rights and the sea is used by local residents based on their customary practices (Ueda 2006a). This ambiguity is a precondition for creating Okinawa's Satoumi, and it is necessary to coordinate the use of resources by fishers and local residents.

8.3.4 Involvement of Non-fishers in Satoumi

Of the two aspects of Satoumi creation, environmental conservation (aiming for clean seas) and resource management (aiming for rich seas), fishers should play a leading role in aiming for rich seas. On the other hand, the number of fishers in Japan continues to decrease, and they are aging. To create and maintain Satoumi, especially aiming for clean seas, the involvement of local residents and urban citizens other than fishers is becoming necessary.

The Fisheries Agency of Japan launched a project to promote the multifunctionality of fisheries in 2013. One of the pillars of this project is the conservation of seagrass and algal beds, tidal flats, coral reefs, and inland waters in which fishers play a central role. As of 2016, there were 850 organizations working on this project throughout Japan, and some of them include "Satoumi" in their organization names. The Fisheries Agency evaluated the activities of organizations, and one of the evaluation indicators was whether or not "members other than fishers participate in the activities," emphasizing the importance of the participation of local residents.

On the other hand, there are some cases in Okinawa where the ambiguity between the use of resources by fishers based on fishery rights and the customary use by non-fishers had negative impacts on resources. Three species of octopuses, which are the main targets of octopus fisheries in Okinawa, were not subject to common fishery rights in the past, but there were concerns about the decrease of the resources. For this reason, in most of the fishery cooperatives, they were added to the fishery rights when the common fishery rights were simultaneously renewed in 2013 with the aim of managing the resources by fishers. However, small octopus species were not subject to the fishery rights because they were not sold at fish markets and were widely recognized as customary catches by local residents. The sea cucumber was

also not subject to the fishery rights in most of the fishing grounds until then. However, due to intense demand from China, Okinawa's sea cucumber catches rapidly increased from around 2010, and overfishing was reported in many areas. To cope with this situation, many fishery cooperatives received the common fishery rights for sea cucumbers to promote resource management by fishers. However, the resources were already at a very low level at that time (Kakuma 2017a).

8.3.5 Response to the Increase of Marine Recreation

In the past, coastal areas were used by fishers based on their fishery rights in Japan. However, the increase of marine recreation has made it difficult to manage coastal areas under the rules of the fishers alone. There are two types of marine recreation: harvesting-type recreation, which uses marine resources, and non-harvesting-type recreation, which only uses the sea surface and underwater. In this section, how to deal with non-harvesting-type marine recreation, especially diving, is discussed.

The "diving incident" in Miyako Island is a representative example of the negative aspects of the use of the sea by fishers and non-fishers in Okinawa's Satoumi. A conflict arose between diving shops and a fishery cooperative over the use of the sea, and both sides sued each other several times (Ueda 2006b). The problem was settled by the payment of 500 yen per diver to the fishery cooperative as a contribution to environmental conservation.

Another problem is the overuse of the sea by divers. In Zamami Village, located in the west of Okinawa Island, overuse by diving, the main industry of the village, became a problem in the late 1990s. At popular dive sites, hundreds of divers use the dive sites in a day, and the impact of fin kicking and sand blowing up on the corals could not be ignored. For this reason, the diving shops in Zamami Village, in cooperation with the fishery cooperative, established MPAs (marine protected areas) in three areas where fishing and diving were prohibited for 3 years (Kakuma 2007).

In August 2017, Kakuma visited Maeda District in Onna Village to participate in a study meeting to discuss the problem of excessive divers. In Cape Maeda, after a diving shop advertised an underwater cave as the "Blue Cave," a huge number of divers began to visit. "The cave was believed to be a cave where gods and Buddha are enshrined, a mysterious and faithful cave for the residents of the district" (Onna Village Maeda District Community Association 2017). Divers of 380,000 a year visited the Blue Cave (Maeda District Mayor's personal communication). If you simply divide by 365 days, you get more than 1000 people per day. On the next day of the meeting, Kakuma visited the area and found that it was overflowing with boats, divers, and snorkelers even on a weekday (Fig. 8.8).

The parking lots, shower building, cafeteria, and tank-filling building at Cape Maeda are operated by "Maeda Corporation" whose shareholders are the residents of Maeda District. For the residents of Maeda, the problems caused by excessive divers

Fig. 8.8 Appearance in front of the Blue Cave

are probably of much greater concern than the income of the Maeda Corporation. The problems discussed at the meeting were more closely related to daily life, such as cars that could not park in the lots, diving shops' cars at high speed on village roads, and garbage dumping, rather than problems with the coral reef ecosystem as in Zamami. Although there are a number of major problems that need to be solved to create Satoumi there, the people who participated in the study meeting were positive and said that they wanted to set up a multipurpose use MPA for the waters around Cape Maeda in the future.

Tourism does not only have negative impacts on the Satoumi creation. The MPA set up by the Okinawa City Fishery Cooperative, which will be discussed later, has the primary objective of increasing fishery resources, but the fishers also have in mind the future use for tourism. MPAs set by local people based on local rules require a mechanism to cover the cost of maintaining them. In the Visayas region of the Philippines, many sustainable MPAs generate income by allowing divers to use the MPAs (Omori et al. 2010). In some villages in the Philippines that Kakuma visited to investigate the status of resource management, tourism had become a main source of livelihood rather than an alternative income source for marine resource management (Kakuma 2017b).

8.3.6 Toward the Solutions of Institutional Problems of Satoumi in Okinawa

In Okinawa, the relationship between fishery rights and customs has been historically complex, and it is difficult to clearly organize the right systems. However, this problem cannot be avoided when creating Satoumi in Okinawa. Our opinions on the direction to solve the institutional issues for the future development of Okinawa's Satoumi are the following. First, it is necessary for all parties concerned to fully understand that the relationship between fishery rights and customs is different from that of other prefectures and is ambiguous. Then, to protect the fishery resources of

the Satoumi, it is necessary to establish local rules that respect the exclusive right of fishers, the common fishery right, by referring to the examples of other prefectures. In response to the changes in sea use patterns caused by the rapid increase in marine recreation, it will be necessary to establish MPAs to control diving, as was done in Zamami Village, and to create rules that introduce the concept of environmental caring capacity to prevent adverse effects on ecosystems, resources, and the lives of local residents (Kakuma 2006b).

8.4 The Satoumi Council

8.4.1 Background of the Establishment of the Council

Okinawa Prefectural Government launched the "Okinawa Coastal Area Comprehensive Utilization Promotion Project" (hereafter referred to as "the Project") in 2012. The Project established a consultation system to work together with the fishery resource management councils of fishers established on Okinawa Island (Ohta et al. 2015).

The fishery resource management councils are located in four districts. Awase-Hamaya Satoumi Fishery Council (hereafter Satoumi Council) in Okinawa City and Minamihara district is one of them. The president is Yanagida. Most of the activities of the NPO INO have been transferred to the activities of the Satoumi Council.

The Satoumi Council has consisted of two to three members from the Okinawa City and the Minamihara Fishery Cooperatives, respectively, and one to three academic experts as advisors and observers. In addition, several members from Okinawa City, Okinawa Prefectural Government, and support organizations have participated in the meetings of the Council. Kakuma joined the Council as an observer when he was a fisheries extension officer. The discussions in the Satoumi Council meetings were diverse, and one of them was on the resource management vision.

8.4.2 Resource Management Vision

To promote resource management in the No. 9 CFRF Ground, the Satoumi Council took the lead in establishing a resource management vision to clarify the principles and actions to be taken. The first vision was established in December 2013 and has been revised every year since.

The vision consists of (1) measures to maintain and increase the resources, (2) measures to improve the fishing ground environment, (3) measures to add value of the fish caught, and (4) measures to effectively utilize the fishing grounds. The measures to maintain and increase the resources include the implementation and enforcement of length limits for important fish species such as the two high-class fish

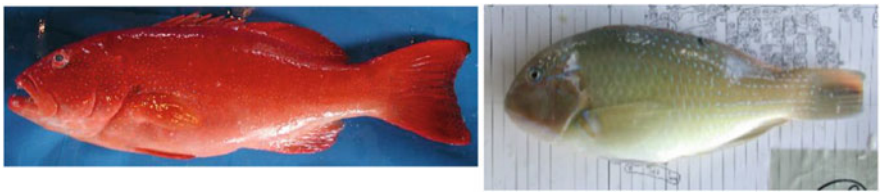

Fig. 8.9 Akajin (left) and Makubu (right)

in Okinawa, namely, coral trout (*Plectropomus leopardus*, Okinawa's local name, Akajin) and blackspot tuskfish (*Choerodon schoenleinii*, Okinawa's local name, Makubu) (Fig. 8.9), and the establishment and implementation of autonomous protection of spawning and nursery grounds. The measures to improve the fishing ground environment include monitoring surveys of redo soil sediment and water quality and requests to related organizations for environmental improvement measures based on the survey results. As for measures to add value of fish catches, measures to stabilize and increase the price of fish and branding strategies are mentioned. For effective utilization of the fishing grounds, publicity of the Council's activities and the creation of tourism fisheries are mentioned. The 10-year timeline and specific initiatives for each year are listed in a table. Most of the initiatives listed in the resource management vision were not only planned but were implemented.

To refer to the specific actions listed in the vision, the members of the Satoumi Council visited the Yoron Fishery Cooperative on Yoron Island in Kagoshima Prefecture in 2015, using the budget of the Project. The Yoron Fishery Cooperative prohibits the use of SCUBA gears too efficient for diving fishery. One of the purposes of the visit was to detect if this could be applied to the fishing grounds of the Okinawa City and the Minamihara Fishery Cooperatives.

8.4.3 Length Limits of Akajin and Makubu

Akajin and Makubu are the most important fishery resources in Okinawa because of their high prices, but there are concerns about the decline of these resources in many areas. In the fishing ground of Okinawa City and Minamihara Fishery Cooperatives, the resources are also decreasing. Since 2014, the fishers there had voluntarily set length limits of 35 cm and 30 cm for Akajin and Makubu, respectively, to protect small fish and raise them to spawning sizes. Akajin and Makubu of under length limits are not allowed to be sold in the fishery markets. Full-sized posters of the length limits were made and displayed at landing sites, markets, the Fishery Cooperative offices, and fishing tackle stores.

The Northern Area Resource Management Promotion Committee, consisting of six fishery cooperatives in the northern part of Okinawa Island, began imposing a weight limit on Akajin and Makubu in 2003 (1 kg for each). This rule was a self-imposed regulation, but it was a strict regulation because the Nago Fishery

Cooperative did not deal with undersized fish in its market (the biggest fish market there). The 1 kg limits for Akajin and Makubu are about 40 cm and 35 cm in length, respectively, which are larger than the 35 cm and 30 cm limits in the Okinawa City and Minamihara Fishery Cooperatives. The reason for limiting the weight instead of the length was that it was easier to sort the fish at the market.

The weight limits for Akajin and Makubu in the northern part of Okinawa Island became an instruction of the Okinawa Marine Area Fisheries Adjustment Commission (hereafter the Commission's instruction) in 2015 instead of a self-imposed regulation. In 2017, the remaining three fishery cooperatives in the northern Okinawa Island were added to the area subject to the Commission's instruction. In the Committee's instruction, the length limits (40 cm and 35 cm) were adopted instead of the weight limits, from the viewpoint of objectivity of judging violations. In addition to self-imposed regulation and the Commission's instruction, there is another rule for resource management, the Okinawa Prefecture Fisheries Adjustment Regulation (hereafter the OPFA Regulation). For example, for the smallest giant clam species (*Tridacna crocea*) which were restocked in Okinawa City, Shiraho, and Onna Village (three Satoumi sites in this book), the OPFA Regulation prohibits harvesting the giant clam from June to August during the spawning season and the giant clam below 8 cm in size when they are capable of spawning. There are penalties for violating the OPFA Regulation, and the Coast Guard and other agencies can enforce them. There is no penalty for violating the Commission's instruction, but the governor can issue an order with penalties for malicious violations. So, the Commission's instruction has a stronger legal basis than the self-imposed regulations (Kakuma 2009).

8.4.4 MPA

In 2013, a public forum entitled "The Concept and Practice of Satoumi: Integrating Science and Community in the Restoration, Monitoring, and Sustainable Use of Marine Resources" was held in Florida, USA. The venue was the Mote Marine Laboratory, where Michael Crosby, one of the authors of this book, is the director (see Chap. 13). Among the authors of this book, Crosby, Yanagi, Sato, and Yanagida participated in the forum. In spite of the fact that the title of the forum was "Satoumi," which must be an unfamiliar word to the local people, about 100 people attended the forum.

Yanagida had an opportunity to dive and observe a local MPA. The large groupers were not afraid of people and could be observed very closely. After returning to Okinawa, Yanagida proposed the establishment of an MPA in the No. 9 CFRF Ground with the cooperation of the Okinawa City and Minamihara Fishery Cooperatives as one of the activities of the Satoumi Council. It took some time to persuade fishers, but in 2015, a no-take MPA was established in an area as small as 100 m square (1 hectare) but rich in corals and fishes (Fig. 8.7).

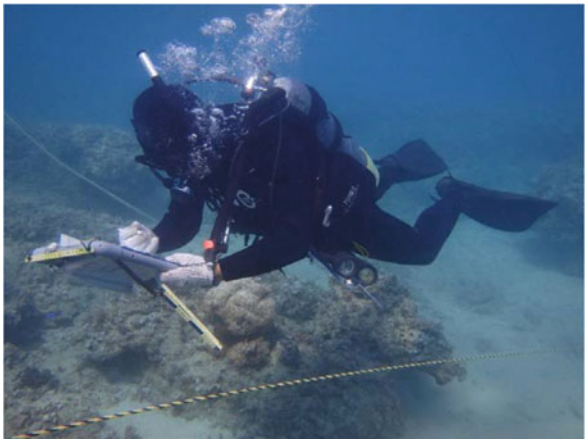

Fig. 8.10 The survey of the MPA by a fisher

Initially, the diving fishers of the Okinawa City Fishery Cooperative were asked to sign a petition with the name of the head of the Cooperative to support the establishment of the MPA. After receiving sufficient support, the MPA was established, including all fisheries and members of the Minamihara Fishery Cooperative. The Satoumi Council created posters of the MPA and displayed them at landing sites, markets, Fishery Cooperative offices, and fishing tackle stores. Buoys have been placed at the four corners of the MPA to clearly indicate the extent of the MPA. The MPA rules are self-imposed, so no penalties have been set. The increase in the number of fish around the MPA would produce visible results for fishers and lead to increased awareness of resource management among fishers.

The monitoring of fish and benthic organisms in the MPA was conducted periodically. Two methods of monitoring were selected, which are scientifically valid and feasible for the fishers to implement. One method is the line transect method to set five 100-m longlines at 25 m intervals in the MPA, and divers swim along the lines to measure the number and type of fish and other major organisms and live coral, seaweeds, and bottom sediment covers (percentage of the seafloor, Fig. 8.10). The other method is the quadrat method, in which 17 square frames of 2 m $\times$ 2 m are set up on the lines and the same items of line transect are measured and photographed.

8.4.5 Restocking of Giant Clam

In addition to coral planting in the MPA, the restocking of the giant clam *T. crocea* was carried out. The restocking of the giant clam was also carried out in Shiraho (the site of Chap. 5). In Shiraho, the purpose of the restocking was not to harvest the clam but to allow them to spawn and increase the resources of the surrounding waters, as

well as to show them to tourists through snorkeling tours. This tourism income is thought to be much larger than the income from harvesting.

In the 1980s, the giant clams were restocked throughout Okinawa. In addition to providing technical guidance on the restocking of the clam, Kakuma organized the knowledge and techniques of fishers in various areas as a fisheries extension officer and as a bilateral knowledge translator and prepared "The Guide to the Re-stocking of *T. crocea*" (Kakuma 1989a). For example, the young shellfish enter small holes in rocks and grow by scraping the rocks. Taking the advantage of this ecology, a fisher in the northern part of Okinawa Island devised a method to make holes for the young shells by using air-powered drills in the sea which are used in car repair shops. However, the young shellfish would sometimes escape from the holes or be eaten by fish. Fishers of a remote island came up with the idea of using a construction "tacker" (like a stapler) to block the holes where the young shells were embedded (Kakuma improved this method by using the tacker to staple small pieces of nets on the holes). Such ideas could not have come from researchers, and the richness of the ideas of the fishers is astonishing.

In the MPA of the No. 9 CFRF Ground, a trial of the restocking of the giant clam was conducted. First, 100 juvenile clams of 12 mm purchased from the Okinawa Prefectural Hatchery Center were released in 2015. However, due to several reasons, the survival rate was quite low at 4% after 2 months. Therefore, the fishers improved the method and released 100 juvenile clams of 18 mm in 2016, and the survival rate was significantly improved to 96% after 40 days.

8.4.6 Surveys by Fishers: Fishery Resources

In the Project, fishers themselves conducted recruitment surveys of important resources. The survey by fishers themselves has several advantages for resource management. First of all, the survey ability of the diving fishers is high. Diving fishers who always dive in the research area are familiar with the sea and can detect juveniles more efficiently than researchers if they are given the characteristics of the juveniles (juveniles often have different morphology and color from adults). In 2017, Kakuma conducted a survey of green snail (large snail that is an important local resource) in Vanuatu. While he could only identify one individual during an hour skin diving survey, a local fisher who joined the survey found more than a dozen individuals. Another advantage is that information useful for resource management can be obtained inexpensively. If the survey is continued for a long time, fishers will be able to confirm the effectiveness of resource management with their own eyes. It also fosters a sense of ownership that the resource belongs to them. This sense of ownership is an important condition for the sustainability of resource management (Kakuma 2016).

In the No. 9 CFRF Ground, the fishers (mainly the members of the Satoumi Council) conducted surveys on recruitment of Akajin and Makubu. The survey method was guided by researchers from the Okinawa Prefectural Fisheries and

Ocean Technology Center. At each survey point, three 50-m lines were set at depths of 5 m, 5–9 m, and 10 m or more. The number and length (nine classes of 5-cm interval) of Akajin and Makubu were recorded by divers swimming along the lines. The number of survey points varied from year to year, ranging from 12 to 36. In 2015, for example, 4 surveys at 24 survey points were conducted with 5–6 surveyors. As a result, only 1 Akajin was found, but 56 Makubu were found. Most of the found Makubu were 5–20 cm in length.

8.4.7 Surveys by Fishers: Red Soil Pollution

As described in Shiraho in Chap. 5 and Onna Village in Chap. 11, red soil pollution is one of the most serious environmental problems in Okinawa. Red soil pollution has a negative impact on coral reefs that sustain coral reef fisheries (Kakuma 2011), and it also has a direct impact on fisheries and aquaculture. When red soil adheres to cultured Mozuku, it becomes unsaleable. When set nets and gillnets become dirty with red soil, fishers must wash their nets frequently because fish cannot be caught with dirty nets. In addition, it is difficult for diving fishers to spear fish in the turbid waters of red soil.

Red soil pollution can be quantitatively measured by examining the sediment on the seafloor. The concentration of red soil in seawater is unstable, but SPSS (content of suspended particles in sea sediment) is relatively stable (Omija 2004). Kakuma prepared a guide so that SPSS can be easily measured by fishers and fishery cooperative staff (Kakuma 1989b).

In the No. 9 CFRF Ground, SPSS has been measured by fishers since 2013, and red soil concentration has been divided into nine ranks in SPSS. For example, in 2015, the area north of the MPA was ranked 5a: “Fine particles can be observed on the surface of bottom sediment by careful observation. This rank corresponds to the SPSS upper bound where lively coral reef ecosystem can be observed” (Omija 2004). The sea area in front of the Minamihara Fishery Cooperative had the highest rank of 8: “Feet get bogged in mud. Sands can rarely be observed. A massive-type corals which have strong sediment-resistance distribute” (Omija 2004).

8.4.8 Maintaining Freshness of the Fish

It takes time for resources to increase through resource management, and during this time, the catch may decrease slightly. To mitigate the resulting decrease in fishery income, measures are sometimes being implemented to increase fish prices such as maintaining the freshness of the fish. In 2014, Yanagida invited an expert to a workshop to learn the nerve-destroying technique to maintain the freshness of the fish. Based on the knowledge gained at the workshop, the fishers developed a method of underwater nerve-destroying technique that is unique to diving fishers.

This method has been introduced on the INO website and video distribution sites and has received a considerable number of hits. Although some restaurants have paid twice the usual price for Akajin and Makubu that have been kept fresh using this method, the effect of keeping fish freshness has not yet been recognized by the middlemen in the market, and the price of fish has not improved. Therefore, the fishers are conducting a needs survey of middlemen and retailers to find ways to improve fish prices.

8.4.9 Public Awareness Campaign

When cigarettes and sewage are discharged into the gutters of roads near the sea, they flow directly into the sea. In case of heavy rain, garbage on the road will also flow into the sea through the gutters. For this reason, the Satoumi Council created a stencil that says "The sea is ahead" and, with permission, installed it in 30–50 roadside gutters every year.

In addition, a short film on resource management activities was made to publicize the activities of the Satoumi Council. The activities have been introduced at various events such as the Okinawa City Industry Festival every year using panels and videos. Also, the activities are frequently featured in local newspapers and TV programs, which is useful in spreading awareness of resource management and environmental conservation.

8.5 Satoumi Creation in Okinawa City

The characteristics of Satoumi creation in Okinawa City are the establishment of the NPO INO by the fishers, the implementation of various activities related to Satoumi, and the establishment of the Satoumi Council to take over the activities of INO and greatly develop them. In this chapter, institutional issues of the Satoumi, such as the complicated relationship between fishery rights and customs and the participation of non-fishers in the Satoumi creation, are also discussed.

In addition to active measures such as coral culture and planting, and the restocking of giant clams, what is unique about the Satoumi creation in Okinawa City is that various passive measures by fishers have been implemented that cannot be seen in other Satoumi sites. In particular, with regard to the fishery resource management, various unique activities were developed, such as the setting of length limits for important fish species and the efforts of fishers themselves to conduct resource and environmental surveys. These activities of Satoumi creation in Okinawa City can be referred for the Satoumi creation in other Asia-Pacific Island countries also surrounded by coral reefs.

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Chapter 9
Villagers Managing Lake Fisheries Resources by Themselves: Mbenji Islands in Lake Malawi

Tetsu Sato and Dylo Pemba

Abstract The process of Satoumi, in which various human activities improve ecosystem functions and services in coastal waters and enrich the connection between people and the sea, has been accumulated mainly in developed countries such as Japan. However, Satoumi is functioning in many parts of the world, and the least developed countries in Africa are no exception. In addition to the oceans, we can find activities to manage and create the environment and resources of lakes and rivers along their coasts, which are closely related to human activities. In this chapter, as an example of the process of "Satoumi" in the least developed countries, we analyze the efforts of local people themselves to manage fisheries resources in a riparian community of Lake Malawi in East Africa, which have been practiced since the 1950s. We examine the mechanisms by which three generations of traditional authorities of the village (chiefs) and fishers have effectively managed the seasonal ban on fishing during the spawning season, which is rooted in local culture. This management system also incorporated government regulations into traditional management systems to achieve effective management of fisheries resources, which are a valuable source of animal protein. We will discuss the importance of bilateral knowledge translation by the villagers themselves and interactions with external actors in the Satoumi processes.

Keywords Developing countries · Social-ecological system · Innovation · Traditional authority · Byproduct · Knowledge translator

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9.1 Satoumi in Least Developed Countries

The process of Satoumi has emerged in many parts of the world, not to mention the examples presented in this book. The process by which various human activities maintain or create habitats for various aquatic and coastal organisms and enhance environmental diversity by preventing ecosystems from reaching their extremes can be considered universal (International Partnership for Satoyama Initiatives 2010). The background to this process is the formation of locally and culturally specific knowledge (integrated local environmental knowledge) as the basis for life and livelihoods by using various ecosystem services that have supported people's lives and the deepening of the relationship between people and nature (Sato 2014, 2016; Integrated Local Environmental Knowledge Project 2012). Knowledge producers (residential and visiting researchers) and bilateral knowledge translators who are deeply embedded in the local communities have played an important role in the formation of integrated local environmental knowledge related to the Satoumi (Sato 2008; Sato et al. 2018a, b). As long as these conditions are in place, the Satoumi process and the deep relationship between people and nature should be observable everywhere.

However, most of the documented examples of Satoumi processes have been obtained from within Japan (Berque and Matsuda 2013; United Nations University Institute of Advanced Studies Operating Unit Ishikawa/Kanazawa 2011; Yanagi 2012). Other reported cases are found in the developed countries including the United States introduced in this book and in Indonesia, which has been experiencing rapid economic development recently (see Chaps. 7 and 13 of this book). Even if the concept of "Satoumi" is not used, many cases where Satoumi-like processes are considered as underway are reported from developed countries and countries with rapid economic development (e.g., Macho et al. 2013). However, this does not necessarily mean that the process of Satoumi is unlikely to emerge in the least developed countries. People living in rural villages in the least developed countries are often dependent on coastal resources for their livelihoods through primary industries, living in close connection with ecosystem services and the natural environments supporting them. Under these conditions, it is not surprising that the process of Satoumi is rather easy to emerge. However, rural villages in the least developed countries are often under poverty conditions. For people under poverty conditions, the use of natural resources for their daily needs is an extremely important activity with the top priority. The vulnerable people in the least developed countries face various economic, political, social, and cultural constraints that prevent them from decision-making and action in implementing the process of Satoumi. For example, it is rather difficult to conduct the process of Satoumi due to the following reasons: activities to rehabilitate coastal resources cannot be conducted for economic reasons; resource management activities by women's groups are not encouraged in the social and cultural context; and they have little political voice and must follow government regulations reactively. It can be assumed that there are many cases where it is difficult for the rural people to mobilize the

process of Satoumi. Additionally, the social-ecological systems related to the Satoumi are extremely complex and have high uncertainty. The social-ecological systems of the least developed countries are dynamically and unpredictably changing due to factors such as economic growth, population increase, and climate change. Therefore, it is difficult to assess in advance whether the processes of the Satoumi will produce positive impacts on people or not, even if they are set in motion. In such a situation of great uncertainty, it is difficult for poor people to invest time, energy, and money in actions that may or may not be successful through the adaptive processes of trial and error.

What conditions are necessary for the revitalization of Satoumi processes under the strong constraints and uncertainties of decision-making and action in rural areas of the least developed countries? What types of actors are important in this process? In this chapter, among the few examples of the process of the Satoumi in the least developed countries, we take up the remarkable case of seasonal ban on fishing, which is practiced by the villagers and fishers in the riparian communities of Lake Malawi in East Africa, to reveal the conditions and actors for the emergence of the process of Satoumi in the least developed countries.

9.2 Seasonal Ban on Fishing in Lake Malawi and Mbenji Islands

9.2.1 Fishery in Lake Malawi

The Republic of Malawi is a small landlocked country surrounded by Tanzania, Zambia, and Mozambique in southern East Africa, with an area of about 118,000 km^2 and a population of about 18 million. Lake Malawi, an international lake, occupies one-fifth of the country's land area (Fig. 9.1). Lake Malawi is located about 500 m above sea level on the border with Tanzania and Mozambique. It is a long, narrow lake, 560 km from north to south and 75 km from east to west, with an area of about 3000 km^2. Although it is a freshwater lake without tides, it is truly an inland sea. Because the lake was formed in the East African Great Rift Valley, it has a maximum depth of 700 m. The warm climate throughout the year prevents cooling of the surface during the cold season, so there is no seasonal water convection. Therefore, fisheries resources are concentrated near the surface of the lake, and the coastal area is a particularly rich fishing ground. The Great Rift Valley is still slowly expanding, and Lake Malawi is an ancient lake that has remained unburied for two million years since its establishment. Lake Malawi is famous for the explosive speciation of cichlid fishes, and almost all among more than 800 cichlid species that inhabit the lake are endemic to Lake Malawi (Turner et al. 2001). This rapid speciation, which is rare among vertebrates, is a major characteristic of the Great Lakes of East Africa, including Lake Malawi, and the Cape Maclear area in the southern part of the lake, which is representative of this precious nature, was

Fig. 9.1 The Republic of Malawi and Lake Malawi. Districts and major sites mentioned in this chapter are indicated by dashed arrows and brown colors

designated as Lake Malawi National Park in 1980 and registered as a UNESCO World Natural Heritage site.

The people living in the communities along the shores of Lake Malawi depend mainly on fishing and subsistence agriculture for their livelihood. Although the coastal environment of Lake Malawi is rich in diverse ecosystem services such as fisheries, agricultural, forest, and tourism resources, a large portion of the people are living in poverty conditions who are engaged in small-scale fishing or small-scale trading of fisheries products. Ninety-nine percent of the fishers along the shores of Lake Malawi are small-scale fishers operating with dugout canoes or small wooden boats, and small-scale fishers produce more than 90% of the fisheries products (Fig. 9.2). They mainly use simple fishing methods such as gill nets and longlines, and their fishing grounds are generally within 10 km of the coast. The catches of

Fig. 9.2 Small-scale gillnet fishers in Lake Malawi using dugout canoes. Children are also a valuable source of labor

these small-scale fishers, who operate with little investment, provide inexpensive animal protein to the public and support the livelihoods of people living along the coast (Sato et al. 2018c). The fisheries industry in Malawi, which is dominated by small-scale fishers, accounts for 4% of the gross national product, and the fisheries and related industries generate employment for 14% (about 200,000 people) of Lake Malawi riparian population. The fisheries and related industries are easily accessible and provide an inexpensive source of protein such as Usipa (*Engraulicypris sardella*, Cyprinidae) and Utaka (*Copadichromis* spp., Cichlidae) throughout the year. The fisheries production in Malawi has been around 70,000 tons per year for the past decade until 2010, but stocks of some fish species are declining. It is estimated that post-harvest loss accounts for as much as 40% of the catch due to deterioration because of inadequate quality control systems for fisheries products in the distribution process (Government of Malawi 2012). In 1997, the Government of Malawi enacted the Fisheries Conservation and Management Act, which introduced measures such as mesh size regulation, fishing gear regulation, and a ban on fishing during the rainy season, the breeding season for major fish species. Beach Village Committees (BVCs) were institutionalized as community-based management systems of fisheries resources, which can enact and enforce their own regulations on fishing. However, according to a 1999 survey, illegal seine nets were commonly used, and the mesh size of 96% of gill nets was illegal (Government of Malawi 2002;

Sato 2008). The government lacks the power to enforce the rules and regulations due to lack of finances and human resources. It has attempted to transfer authority to local communities in the form of BVCs, but it did not work very well. The government mentioned the dysfunction of the BVCs, and the BVC leaders blamed the government for the lack of proper enforcement, resulting in a blame game. Because of the strong dependence of coastal residents on fisheries resources and the heavy load on resources and supporting ecosystems caused by their livelihood activities, there is a dire need for sustainable management of resources and coastal ecosystems through the process of Satoumi and the revitalization and strengthening of connections between people and nature through this process, which is expected to have a huge potential impact on the status of fisheries resources.

9.2.2 Structure of the Seasonal Fishing Ban in Mbenji Islands

In the communities along the shores of Lake Malawi, fisheries resources are ownerless properties that belong to no one, and fishing grounds are open to all fishers. The situation is prone to the tragedy of the commons, and it is not easy to prevent the depletion of fisheries resources. It is also true that top-down management, such as government regulation, has not worked well due to a combination of factors. In this context, a significant case of community-driven practices of fisheries resource management has been recognized. The seasonal ban (i.e., total bans on fishing within a defined lake area) on fishing of Utaka (a general term for mesopelagic plankton-eating cichlid fishes, Fig. 9.3) by coastal communities (mainly Nema Village) has been in place since the 1950s around a small island of about 9 km^2 in area called Mbenji Island, located about 10 km off the coast of Salima District on the eastern shore of central Lake Malawi (Figs. 9.1 and 9.4). A joint project between the German Agency for Technical Cooperation (GTZ) and the Department of Fisheries, Government of Malawi, has "rediscovered" this practice of seasonal fishing bans of Utaka, attracting considerable attention (Scholz and Chimatiro 2004). The fishing ban was initiated by the Traditional Authority (TA) of Salima, Chief Makanjira (then known as Chief Msosa), and a group of elders. The traditional chiefs (senior chiefs) in Malawi are the heads of traditional local governing bodies that govern the group village heads (GVHs) of ten or more villages through hereditary succession. They take the same surname as the place name of the region, and the population under their rule ranges from tens of thousands to hundreds of thousands (Kurita 2004). He is a high-ranking traditional leader of the community who is respected by the people and still plays a critical role in the administrative system of Malawi. This seasonal ban has continued uninterruptedly under the strong leadership of the current Chief Makanjira Mangwere M. Namputu, the third generation from the original Chief, and the Mbenji Island Management Committee (now also the BVC), which consists of the GVHs.

Fig. 9.3 An Utaka caught on Mbenji Islands. The species name of the fish in the photo is not known

What is most surprising is the start of the seasonal fishing ban in the 1950s (perhaps 1952 to be exact). At that time, it was generally believed that fisheries resources were inexhaustible and that it was possible to catch as much as one could. At that time, it was extremely innovative and advanced for a small African village to start practicing sustainable management of local fisheries resources on its own.

The closed season begins in December of each year, coinciding with the beginning of the rainy season, and ends in March/April of the following year, when the rainy season ends. This schedule corresponds to the agricultural season, which depends on the rainfed water. During the rainy season, people cultivate maize, their staple food, and harvest it for the rest of the year. Agriculture during the rainy season is a priority above all else, and the ban on fishing during this time is considered an acceptable mechanism for the people. Additionally, the knowledge that the rainy season is the breeding season of Utaka has been passed down to the fishers. This knowledge was probably derived from the breeding ecology of Utaka. Utaka are mouthbrooders that protect their eggs and hatchlings in their mouths, and eggs and hatchlings are found in the mouths of females caught during the rainy season. Solemn ceremonies including traditional songs and dances and speeches by the chief are held at the beginning and end of the closed season (Fig. 9.5). At the end of the closed season and the beginning of the fishing season, the management committees conduct a review of the year's fishing activities.

Fig. 9.4 Mbenji Island and a fishing boat heading to the island for fishing after the end of closed season of fishing in 2019

The closed lake area surrounds Mbenji Islands. The area around Mbenji Islands deepens rapidly as one moves away from the island and then becomes shallow again. The area of the lake bounded by a line about 100 m deep is closed to fishing. The color of the water is markedly different in deeper areas, so they use that as a marker to determine the area to be closed to fishing. In this way, the areas a few kilometers offshore from the village to Mbenji Islands are not closed to fishing because the water is less than 100 m deep. In addition to the advantage of being able to define a clear boundary based on the color of the water, defining the fishing ban areas by depth has significant implications for people's lives. Mbenji Island is widely known as an excellent fishing ground, attracting many professional fishers from all over Lake Malawi during the fishing season. The island is uninhabited, but during the fishing season, fishing camps are set up, and many fishers and brokers sleep on the island, making it active. The seasonal ban on fishing restricts these professional fishers from operating in the spawning grounds of Utaka, thereby maintaining the breeding environment and allowing for effective management of the Utaka stock. Alternatively, the shallow lakes near the village are used by the poorest villagers without fishing equipment and skills for their subsistence fishing. The system of avoiding fishing ban in shallow areas is said to be a consideration for the livelihood of these particularly vulnerable people. This system of resource management that incorporates a consideration for the vulnerable is an important feature of this

Fig. 9.5 Chief Makanjira declaring opening of fishing at the ending ceremony of closed season in 2019

seasonal fishing ban, which is led by village leaders who are familiar with people's lives and needs.

9.2.3 Relationships Between People and Lakes as Satoumi

On Mbenji Islands, the BVC consisting mainly of the Chief Makanjira and the group village heads (GVHs) has also introduced strict rules for the fishing season. First, the mesh size is restricted. At present, before the beginning of each fishing season, fishers operating around the Mbenji Islands submit all the nets they intend to use to the village BVC, which visually judges the mesh size, and only those nets with 2 inches or larger mesh sizes are allowed to be used around Mbenji Islands. The introduction of such a positive list system is also extremely advanced. A fishing method that uses lamps at night to catch fish that are attracted to the light has been banned. Lamp fishing is said to have been banned because of the large catches of plankton-eating fish that are attracted to the light. Alcohol, gambling, and the use of marijuana are prohibited on the island, and women are not allowed on the island because it is sacred. These regulations may have the function of preventing trouble among fishers, thereby maintaining discipline and order that facilitates compliance

with fishing regulations and eventually sustainable management of the lake environments. These regulations are widely known among the fishers, and violators are warned and fined (ten goats). In the case of serious violations, the fishing of violators is suspended for the following year. Violations of the fishing ban and these fishing regulations are said to bring the wrath of the spirits that control the lake and its fisheries, resulting in the loss of fish, encounters with snakes, the appearance of monkeys and white women in the water, and being struck by lightning. At the beginning of the fishing season, a goat is sacrificed to the spirits of the lake to pray for a good catch. The effectiveness of resource management is probably enhanced by the creation of a system that links such traditional cultures with animistic beliefs.

The authors have been visiting the village regularly since 2014 and have had a series of deep dialogues with Chief Makanjira and BVC members to build mutual trust to understand the details of the innovative resource management mechanism of the seasonal ban on fishing in Mbenji Islands. Because of this resource management by the villagers themselves, Chief Makanjira, the BVC members, and the villagers are very confident and proud to say that the Utaka resource around Mbenji Islands has not declined at all. They are convinced that their resource management practices are maintaining the good resource status of Utaka and supporting the livelihood of many fishers, and they are determined to continue their efforts. Based on their self-awareness as the responsible managers of the lake's fisheries resources, the villagers have developed a relationship with the lake and its environment through long-term resource management activities. The villagers have a strong attachment to and pride in the taste of Utaka caught in Mbenji Islands. The people say that Utaka of Mbenji Islands is special and distinctly different from those of other regions. Even when poached Mbenji Island Utaka is landed in other villages, this difference allows them to be easily identified and the poaching reported to BVC of the island. This discourse has not been confirmed scientifically. To the best of the author's knowledge, at least two species of Utaka (*Copadichromis* sp. 'virginalis kajose' and *C. quadrimaculatus*) have been identified from the area around Mbenji Island, which are distributed over a relatively wide area (Anseeuw et al. 2012), and other "species" are also distributed as being from Mbenji Island in ornamental fish trades. However, it is certain that Utaka of Mbenji Island is delicious. Utaka is usually sun-dried for storage and distribution, but the villagers say that it is best to cook it fresh. In fact, the fresh stewed Utaka in tomatoes that we ate in the village was truly delicious (Fig. 9.6). This recognition of the value of the lake's resources based on the food culture is another example of the relationship between people and the lake. With the recent construction of a road connecting this area with Lilongwe, the capital of Malawi, many traders now come from Lilongwe with iceboxes and ice and charter boats to go to Mbenji Island to buy fresh Utaka for distribution to the markets in the capital (Fig. 9.7). The cultural value of Utaka from Mbenji Islands, which has emerged among villagers through the process of Satoumi, is now widely shared by urban consumers through supply chains.

Fig. 9.6 Fresh Mbenji Islands Utaka in tomato stew, a common dish in the village

9.2.4 Resource Management as a Byproduct

In January 2015, after iterated dialogues and deliberations with Chief Makanjira, we could uncover the fundamental reasons why the villagers, often living in poverty, have recognized the value of their fisheries resources through food culture, become aware of and proud of their role in resource management, and engaged in dedicated resource management activities that require a great deal of time and energy. Our dialogues with Chief Makanjira have always been extremely wide-ranging. On that occasion, the topic was his grandfather, the leader of the fishery at the time the seasonal ban began, and the state of the fishery at that time. Chief Makanjira began telling us, as if it were a matter of course, that the seasonal ban on fishing of the Utaka was not initiated because of a sense of crisis over the resource, but the more important motive was to protect the safety of the fishers. It was a bolt from the blue for the authors. We, as scientists, had been strongly interested in seasonal fishing bans as a mechanism for managing fisheries resources and had naturally tried understanding the whole picture from the perspective of resource management. As a researcher investigating the relationship between people and lakes in the Satoumi processes, this was a natural approach to take. The safety of fishers was completely missing from our scopes. Here is the story of Chief Makanjira, according to our notes from that meeting. The Chief's grandfathers probably recognized that it was

Fig. 9.7 Ice box filled with fresh Utaka purchased on Mbenji Island

important not to interfere with the breeding of Utaka because of the small juveniles caught frequently during the rainy season. However, more pressing was the threat to fishers' lives posed by the frequent thunderstorms that occurred during the rainy season. Furthermore, Mbenji Island is a place where lightning frequently strikes, making it extremely dangerous. In fact, some fishers lost their lives. When we got to this point, one of the authors (Pemba) was struck by surprise. The anecdote that the rocks that make up Mbenji Islands are rich in iron returned to his mind. Perhaps Mbenji Islands really were a place with a high risk of lightning strikes, and the lightning striking the island was thought to be the anger of ancestral spirits governing the lake. It is no wonder that Mbenji Island, with its many lightning strikes, was considered a sacred place.

The Chief went on to say that the fishing ban around Mbenji Islands was put in place to protect the fishers from the thunderstorms of the rainy season. If they did not follow the rules, the island spirits would get angry, and the weather would be rough. To appease the spirits, it is necessary to offer a goat to the spirits and ask for their permission to fish on the island. Incidentally, thunderstorms in tropical regions such as Lake Malawi are different from the thunderstorms we imagine. The sky suddenly becomes cloudy, and in no time at all, violent winds and rains hit, huge waves rise, and thunder rumbles. It is not something that the small boats of small-scale fishers can compete with. To protect the fishers from the dangers of the thunderstorms, the area around Mbenji Islands, which is the most dangerous (and the most likely to

suffer the wrath of the spirits), should be closed to fishing during the dangerous (rainy) season. The closure would reduce the catch of juvenile Utaka, resulting in lowered disturbance of their breeding. In this way, people can protect the fish resources as a byproduct. This was the reason for the introduction of the seasonal fishing ban.

Let us recapitulate the whole story in the language of science. The seasonal ban on Utaka fishing is not urgent for the people of the village, even though it prevents the deterioration of the stock status by maintaining the breeding environment. However, fishing around Mbenji Islands during the rainy season is dangerous due to the frequent occurrence of thunderstorms (the wrath of the spirits), and protecting the lives of the fishers is an urgent issue. To ensure the safety of fishers from thunderstorms, which have been regarded as the wrath of the spirits, the decision to ban fishing around Mbenji Islands only during the rainy season makes sense. Keeping up with the various rituals to appease the spirits would mean reiterating the meaning of the fishing ban to the villagers and fishers. As a byproduct of the ban, the breeding habitat of the Utaka can be maintained, which makes the ban even more significant. The rainy season is also the busy farming season, and it is easier for the people to accept the interruption of fishing. Since the fishing ban is limited to the lake areas around Mbenji Islands, it will not prevent the most vulnerable people from gathering food in shallow coastal areas.

In other words, the sophisticated resource management system of the seasonal ban on fishing of Utaka around Mbenji Islands was a byproduct of measures to address a more pressing issue for villagers and fishers (ensuring the safety of fishers). In retrospect, it might have been obvious that the Satoumi process was not always built with the sustainability of resources or ecosystem functions clearly in mind. The processes of Satoumi in Japan described in this book, such as the use of stone tidal wears introduced in Chap. 5, represent that various mechanisms created for the needs of life and livelihood of people resulted in habitat diversifications and enhancements of the function of Satoumi. The greatest factor that has encouraged the emergence of Satoumi processes in the difficult circumstances of the least developed countries is that they were designed as a byproduct of addressing urgent and compelling issues for people. Even if it is unintentional, the start of the process of Satoumi in this way deepens the relationship between people and the lake and creates pride and attachment to local resources, which in turn sustain dedicated activities. In the case of Mbenji Islands, the sophisticated fisheries resource management led by the villagers and fishers was so remarkable that, before long, the Chief Makanjira himself began emphasizing only the resource management aspect. The important aspect of resource management and the Satoumi process as a byproduct of different intentions has been hidden in the background. Through repeated deep dialogues based on mutual trust with the Chief Makanjira, we could shed new light on the hidden process of Satoumi creation.

9.3 Bilateral Translation of Knowledge

9.3.1 Incorporate and Take Advantage of Government Regulations

An important turning point in the long history of the seasonal ban on fishing of Utaka on Mbenji Islands was the enactment of the Fisheries Conservation and Management Act in 1997. This law clarified the authority of the Beach Village Committee (BVC) and strengthened the legitimacy, both within and outside the community, of the village-led resource management practices developed in the community. Various local mechanisms on seasonal fishing ban became widely binding as the rules of the BVC. However, the Chief Makanjira and village elders did not passively accept the BVC system. Rather, they seem to have translated these new systems and rules to suit their local conditions, incorporated them into the integrated local environmental knowledge related to the process of Satoumi, and actively used them. For example, the mesh size limit was initiated internally by the village long before the Fisheries Conservation and Management Act, and the law followed to confirm it. The Chief Makanjira assesses that the mesh size restriction by the Fisheries Department is reasonable from their perspective. They have continued to enforce mesh size regulations in a manner consistent with what they consider reasonable based on their own knowledge. Alternatively, the prohibition of lamp fishing at night is an original rule of the village and is not included in the regulations of the government. On a broader scale, with the decline of Utaka stocks, lamp fishing using the same nets (scoop nets called chilimila) at night has become popular in all lake areas, putting great pressure on the plankton-eating fish stocks (Utaka and Usipa). Here, based on their own knowledge of the magnitude of the lamp-fishing catch (integrated local environmental knowledge), the villagers have established their own rules that are not regulated by the government. Chief Makanjira and the BVC are responsible for translating and applying new regulations of the Department of Fisheries considering in light of local conditions while using their concepts, basic ideas, and underlying mechanisms. From within the villagers, the function of bilateral knowledge translators is emerging to incorporate foreign knowledge into integrated local environmental knowledge.

With the enactment of the Fisheries Conservation and Management Act, collaboration with the Fisheries Department on resource management in Mbenji Islands has evolved through the translation of knowledge by the villagers themselves. The Department of Fisheries has positioned the case of Mbenji Islands as a model for community-driven fisheries resource management and has strengthened its support for Chief Makanjira and his BVC. They have provided a boat with an outboard engine (now out of order) to enhance patrols on the lake during the closed season and have improved the facilities at the landing site. Despite this support, Chief Makanjira and the BVC view the seasonal ban on fishing and management of the Utaka stock in Mbenji Islands as their own initiative. They have developed a strong sense of ownership of the resource management system that they have created and are making work on their own, with or without the rules and cooperation of the

Department of Fisheries. The Chief and BVC also play the role of local gatekeepers to the influx of external knowledge through the selection of foreign knowledge, such as that of the government (Russell and Dobson 2011). Such knowledge translators from within the villagers have contributed greatly to the long-term sustainability of the Satoumi process despite changing conditions outside the village and interactions with new institutions and knowledge.

9.3.2 Communicate the Value of Local Practices

The abovementioned project of the German Agency for Technical Cooperation (GTZ) and the Department of Fisheries of the Government of Malawi has functioned as a knowledge translator to disseminate the significance and value of seasonal fishing bans and resource management practices during the fishing season by local people themselves. In an effort to realize the co-management of fisheries resources by incorporating local community initiatives by the BVCs into Malawi's fisheries policy, GTZ and the Department of Fisheries have been disseminating the value of practices in the Mbenji Islands to the wider community through various channels. Chief Makanjira's radio appearances have been used to disseminate the Satoumi process of Mbenji Islands throughout Malawi, and chiefs from fishing villages throughout Malawi have been invited to the opening and closing ceremonies of the seasonal fishing ban to experience the practices of Mbenji Islands. The work of these bottom-up knowledge translators has led to a movement to apply the lessons learned from the resource management mechanisms of Mbenji Islands to other villages, led by traditional chiefs in various parts of Malawi. The best-known case is the total ban on surface seine netting implemented by Chief Nkokwe in 1999 in a small lake called Lake Chiuta, located southwest of Lake Malawi on the border with Mozambique (Scholz and Chimatiro 2004). The ban was implemented to protect native fisheries in response to declining stocks caused by surface seine netting conducted mainly by fishers from outside the region. However, surface seine continued across the border in Mozambique, causing cross-border conflicts between the fishers of the two countries, and the confusion has not yet been resolved as of 2017 (Njaya 2017).

In the innovative Satoumi process of the seasonal ban on Utaka in Mbenji Islands, Chief Makanjira and BVC acted as "bilateral translators of knowledge" among the villagers, translating government regulations to suit local conditions and encouraging their use. He has disseminated the process of the Satoumi in the region to a wide area through the media such as radio. The Malawi Department of Fisheries and GTZ have served as bottom-up translators to disseminate the significance and value of local practices throughout Malawi and internationally. More recently, visiting researchers such as ourselves have joined them to act as bilateral knowledge translators, translating the value of Mbenji Islands seasonal fishing ban into the language of academia for international audiences, as we attempt to do in this chapter, while bringing to the village various scientific knowledge at the same time that may be

meaningful to local practice. The local knowledge translators such as the Chief, who are closest to the villagers, promote the use of wide-ranging knowledge, policies, and regulations and transmit the value of their own practices, while government agencies and other actors support local practices from the standpoint of national or broader scale policies and make their significance visible. From the standpoint of researchers involved in Satoumi, we are trying to translate the value of local practices as Satoumi into academic language and share it with others. In this way, various translators with different spatial scales and governance levels overlap, and the bilateral translation of multilayered knowledge from their respective standpoints can be considered one of the important factors for the revitalization of the process of Satoumi (Sato et al. 2018a, b). The case of Mbenji Islands is characterized by the effective functioning of the knowledge translators embedded in the local community. This case suggests that local translators will play a decisive role in linking people to the sea (lake), strengthening ownership of local resources, deepening pride and attachment, and mobilizing the process of Satoumi in the difficult circumstances of least developed countries.

9.4 Dynamism of the Satoumi Process

9.4.1 Enforcement Mechanism

Seasonal fishing bans and resource management by local people themselves, which have emerged around Mbenji Islands, have achieved excellent results as a process of autonomous resource management and Satoumi in the least developed countries. However, there are still many challenges to be solved. As mentioned above, Mbenji Island is an excellent fishing ground for Utaka, and many fishers come to fish from a wide area of Lake Malawi, especially from the northern part of the lake where the fishery is active. Unlike the people of the neighboring fishing villages that are under the direct control of Chief Makanjira, it is difficult to thoroughly explain the meaning of the seasonal ban and the details of the regulations to the fishers who come from faraway to operate, making it more likely for them to poach during the closed season and violate the fishing regulations during the fishing season.

Of course, Chief Makanjira is not sitting on their hands and letting this happen. The annual opening and closing ceremonies of the closed season attract influential traditional chiefs from all over the Lake Malawi coast. The ceremonies are an important opportunity to inform remote fishers about the implications of resource management in Mbenji Islands. More than passing on knowledge of fishing regulations, Chief Makanjira is actively negotiating with other traditional chiefs on these occasions to reduce fishing pressure and rule violations. In the central part of Lake Malawi, there are two islands in Mozambican waters, Likoma and Chizumulu, which are enclaves of the Malawian territory (Fig. 9.1). These islands are one of the largest fishing bases in Lake Malawi, and the inhabitants of the islands have no other means of livelihood but fishing, operating all over Lake Malawi and landing

their catch in various places. On the occasion of the opening ceremony of the closed season in December 2015, negotiations between Chief Makanjira and the Chief of Likoma Island were made, and it was agreed to limit the number of fishers coming from Likoma Island to 60. By limiting the number of fishers, the initiative aims to reduce pressure on Utaka stock and, simultaneously, instill in the fishers the meaning and value of the seasonal ban and fishing regulations in the process of selecting fishers who will be allowed to operate. Through his networks among traditional chiefs as local leaders, the process of the Mbenji Islands Satoumi has been shared with fishers in remote areas, dynamically transforming the way fisheries resources are managed throughout Lake Malawi in a bottom-up manner.

9.4.2 Incentives for the Process of Satoumi

Another and perhaps more fundamental challenge that is frequently mentioned is that the villagers are not always clear about the implications for themselves of the resource management that they put so much energy, time, and effort into as complete volunteers. It is true that the Utaka resource is in good condition, but the time and energy they put into it is not being fully rewarded. People seemed to expect more tangible benefits from their efforts. In other words, the challenge of inadequate incentives for resource management has become clear. According to the Vice-Chairman of the Board of Management of Mbenji Island BVC and the head of the group village that oversees Chikonda Beach (Fig. 9.8), a major landing site for Utaka, patrolling the lake during the closed season and maintaining a positive mesh size list system is very labor-intensive. During the fishing season, he monitors the mesh size and the size of the fish landed on Mbenji Islands. He says that the sense of ownership in managing local resources and the fact that this initiative has been well received throughout Malawi have been a great incentive for them. However, many of the young fishers who spend a great deal of time and energy on the ground in resource management expect to see some tangible benefits.

This is a serious challenge that is not straightforward to solve. The lack of incentives for resource management may threaten the future sustainability of resource management efforts around Mbenji Islands. Perhaps interaction with visiting researchers as bilateral translators of knowledge, such as the authors, makes sense for such challenges. In the two consecutive international transdisciplinary research projects (JST-RISTEX Future Earth Promotion Program "Transdisciplinary Study of Natural Resource Management under Poverty Conditions Collaborating with Vulnerable Sectors," 2017–2019, and JST-JICA SATREPS Program "Establishment of a Sustainable Community Development Model based on Integrated Natural Resource Management Systems in Lake Malawi National Park," 2020–2025), we have conducted a broad survey of riparian communities of Lake Malawi and found that local people have developed creative systems for value-added distribution of marine products (Sato et al. 2018c). For example, in Chia Lagoon area (Fig. 9.1), located in the north of Salima District, small-scale local traders of fisheries

Fig. 9.8 Chikonda Beach, a major landing site for Utaka from Mbenji Islands

products have established a system to sell high-quality smoked fishes using traditional smoking techniques with added value through their personal customer networks. In the village of Chembe in the Lake Malawi National Park in the southern part of the lake, there is a person who is practicing an innovative system of value-added supply of fresh fish according to customer orders based on personal connections with customers in large cities. Such a value-added supply system already practiced in riparian communities of Lake Malawi, if translated to fit to local conditions, probably applies to Utaka from Mbenji Islands. Sharing such knowledge with important actors of the village, including Chief Makanjira, BVC, local fishers, and traders of fisheries products, and collaborating with them in a transdisciplinary process to develop a system for branding and adding value to the Mbenji Islands Utaka may provide a solution to the serious problem of the lack of incentives for resource management. Through the interaction with knowledge translators such as ourselves who bring various knowledge from outside the village, the processes of the Mbenji Islands Satoumi are expected to develop more dynamically.

9.4.3 *Parallelism with Indonesian Sasi Systems*

The community-driven resource management systems in Mbenji Island represent a remarkable parallelism with a traditional resource management system in the eastern part of Indonesia called sasi. Sasi is a Satoumi-type traditional natural resource management system practiced by local communities since the sixteenth century, which covers marine, land, and riverine resources (Harkes and Novaczek 2002; McLeod et al. 2009). Sasi includes management measures of open/closed areas and seasons of harvesting, community tenure rights, limiting access, controlled harvest, equitable distribution of benefits, and regulations and enforcement by communities. These measures are perceived as effective and culturally relevant by local residents (Soselisa 2019). The system is still practiced in many villages with different degree of success.

Although Mbenji Island system had emerged in an independent background and processes from sasi system in terms of histories, geographical locations, and cultures, these two systems show marked similarities in various aspects of management measures and institutional arrangements. The decision-making systems in communities comprised of traditional authorities and institutions play a central role in implementations of resource management practices in both systems. Cultural and spiritual aspects are essential to maintain relationships between people and coastal environments (McLeod et al. 2009). Local rules and regulations are developed and enforced by legitimate local institutions centering on the strong and influential leaderships of traditional leaders (Harkes and Novaczek 2002). Diverse types of local knowledge constituting integrated local environmental knowledge are effectively used for development and practice of resource management systems in both cases. And both are going through dynamic processes of adaptive transformations to cope with changes of social-ecological systems, demonstrating positive impacts on marine and lacustrine fisheries resources. This parallelism between two independent Satoumi-type systems developed in the global south indicates widespread opportunities of Satoumi co-creations in the world regions where poverty is still prevalent.

On the contrary, Mbenji system is markedly different from sasi in the following three aspects. First, the original intention of seasonal ban of fishing in Mbenji Island was not directly targeting resource management, but a byproduct of measures targeting a more direct and imminent challenges of the community. Second, the traditional leader in Mbenji, Chief Makanjira, has broad linkages with chiefs of other regions over the lake, creating a network of leaders to influence other communities. He also produced impacts on national fisheries policies through the media and collaborations with Department of Fisheries. Finally, various external actors, including government agencies, NGOs, and scientists, are involved in the dynamic development processes of the system as bilateral knowledge translators to mobilize adaptive processes of transformations. We assume that these three aspects characterizing Mbenji systems are fundamental to provide solutions of remaining challenges and produce tangible impacts on social-ecological systems to secure long-term sustainability of management practices.

9.5 Mechanisms to Drive Satoumi in Least Developed Countries

In this chapter, we have made a detailed analysis of the fisheries resource management with the seasonal fishing ban developed around Mbenji Islands in Lake Malawi, East Africa, and the process of the Satoumi that is embedded in it. Finally, based on the analysis so far, we discuss the mechanism by which the process of the Satoumi, which deepens the relationship between people and the lake, emerges in the extremely difficult situation of the vicious cycle of poverty and the degradation of natural resources in the least developed countries. We further discuss the way forward to promote the improvement of human well-being and the sustainable management of natural resources. The following are four suggestions for creating the Satoumi that were obtained from the case study of Mbenji Islands, in order of importance.

First, it would be more important than anything else to have a system in which public benefits, such as resource management and the creation of the Satoumi, can be obtained as a byproduct of addressing the high-priority issues of people's safety and livelihood needs. In the complex social-ecological systems of the least developed countries, it is extremely difficult to promote public activities that are not directly related to people's own interests from the bottom up, and top-down coercion and regulation can cause various conflicts. To overcome this universal problem, a process in which the public values of resource management and the creation of the Satoumi are realized as a byproduct of resolving issues urgent to people is meaningful. In contrast, an approach that emphasizes various tangible benefits to people as byproducts of efforts to realize public values is adopted in diverse cases (Helgeson 2018). Regardless of which approach is taken, it is important to identify the issues that should be prioritized for people and to visualize and take advantages of the value of the various byproducts of the initiatives to bring solutions to prioritized challenges.

Second, the BVC must be led by actors with a guaranteed legitimacy that is consistent with traditional local decision-making systems. The BVC, which consists of the Chief Makanjira, a traditional chief who is respected by the local people, and the chiefs of the villages under his control, is a mechanism that completely overlaps with traditional decision-making systems, creating a climate of respect for the decisions of the BVC. The animistic discourse of appeasing the anger of the spirits and the establishment of no-fishing zones that do not prevent the most vulnerable people in the community from subsistence fishing, as well as other considerations that only a legitimate decision-maker with a thorough knowledge of the community can make, have encouraged people to accept the various rules. The ceremonies at the beginning and end of the closed season are not mere festivities, but function as a place to reaffirm the legitimacy of the BVC. The legal background of the Fisheries Conservation and Management Act has been added to further ensure the legitimacy and long-term stability and continuity of the process of the Mbenji Islands Satoumi.

It is also important to note that this network of legitimate actors both within and outside the region strengthens local practices and at the same time creates broader impacts. The direct and indirect linkages between Chief Makanjira and other influential chiefs in the country have been strengthened through the practice in Mbenji Islands, which has prompted adaptive approaches to various challenges surrounding resource management, creating a ripple effect over a wide area. The chiefs in each local area of the network, including Chief Makanjira, are important knowledge producers (residential researchers) in their respective regions and are expected to play significant roles in producing multifaceted knowledge (integrated local environmental knowledge) that can lead to solutions. Simultaneously, as bilateral knowledge translators among villagers, they will visualize the value of local practices and translate and use various external knowledge, technologies, and social systems to suit local conditions. Such a network of locally embedded knowledge producers and translators will be the key to the emergence of Satoumi processes in various regions by activating exchanges and interactions across different communities.

Finally, actors from outside the region, especially various knowledge translators, must be involved in the local Satoumi process in various ways so that mutual learning can occur. In addition to visualizing the multifaceted value of the resource management and Satoumi processes that have been mobilized around Mbenji Islands, visiting researchers (knowledge producers) from outside the village, such as ourselves, have functioned as bilateral knowledge translators to bring new knowledge and mechanisms to the village. The multilayered knowledge translation, including knowledge translators in the local communities, has dynamically transformed and will continue to transform the process of Satoumi in this village.

It is not easy to sustain the process of Satoumi over a long time, as the dynamic transformation of the social-ecological systems is inevitable. Deepening the connection between people and the sea (lake); strengthening ownership, pride, and attachment to local resources; and enhancing the sustainability of resources and ecosystem functions are the fundamental factors securing the sustainability of the Satoumi process. In the case of Mbenji Islands, an outstanding leader like Chief Makanjira is an asset to the community. Fortunately, his rightful successor, who will be at the center of future efforts, has already earned the trust of the community and is beginning to fulfill his role. The process of Satoumi in this village will surely continue and take new developments in the future. It is our sincere hope that this chapter's attempt to learn from the case of Mbenji Islands will help people drive the process of Satoumi by themselves under the diverse cultural and societal conditions in various parts of the world, including local communities in the least developed countries.

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Chapter 10
Protecting Fisheries Resources Through Marine Protected Area Networks: Fiji

Jokim Kitolelei and Shinichiro Kakuma

Abstract Marine protected areas (MPAs), which are attracting international attention as resource management tools, have rapidly increased to more than 400 and have been building a network called FLMMA in Fiji. In one village, villagers' traditional knowledge and perceptions of the environment and ecosystem were transformed, leading to collective actions to protect resources and ecosystems. The villagers have connected with outside stakeholders through bilateral knowledge translators. Various types of MPAs exist in Fiji, including those that do not change the location and area, those that rotate the locations, and those shared by multiple villages. The types, locations, and area of the MPAs were decided according to the area of the fishing grounds, the target organisms, and the distances from the villages. The tourism use of the MPAs to meet the cost of MPA operation was observed in some villages. This chapter discusses how to balance the ecosystem conservation and resource use, for example, how to balance ecosystem conservation and fisheries, tourism and fisheries, and how to decide the area size of MPAs.

Keywords MPA network · USP · FLMMA · Tabu · TEK · ILEK

10.1 Background and Importance of MPAs

The Convention on Biological Diversity (CBD), enacted in 1993, is an important legal framework for Satoumi creation. Article 8 of the CBD encourages the establishment and appropriate management of MPAs to conserve biodiversity. The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, mention the importance of MPAs in Goal 14.5: "By 2020, conserve at least 10 per

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cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information."

MPAs have often proven to be an effective resource management tool that is widely used in the co-management of coastal resources by fishers and various stakeholders. In co-managed MPAs, the active involvement of local people is essential for the success of MPA management. Small island developing states (SIDS), such as Fiji, have been at the forefront of the MPA management in improving coastal fisheries resource management. And there are various MPA networks around the world that have increased MPAs and awareness of their effectiveness from local to global levels.

MPAs are popular, but not always successful, means of protecting marine areas. One study examined the success rate of 1306 MPAs worldwide and found that only 33% of MPAs achieved their objectives and only 24% was well managed (Kelleher et al. 1995). In Southeast Asia, only 14% of MPAs was reported to be effectively managed (Burke et al. 2002). Another study in the Philippines found that less than 20% of 1100 MPAs was effectively managed (Lowry et al. 2009). Although the global success rate of MPAs is thus low, MPAs have been widely adopted as a management tool in Pacific Island countries. In Fiji, the number of MPAs is increasing and a network is being formed.

While many factors contribute to the success of MPAs and their networks, it is important that various stakeholders with interests in the target community, such as fishers, government, non-governmental organizations (NGOs), international organizations, and research institutions, work together effectively. In the case of Fiji, the Fisheries Department in the government and the University of the South Pacific (USP) have played a particularly important role in establishing effective MPAs and expanding the network.

10.2 FLMMA for Community-Based Coastal Resource Management

10.2.1 What Is FLMMA?

Fiji is located in the South Pacific (Fig. 10.1) and has a population of about 880,000, which is the largest among Pacific Island countries except Papua New Guinea. The majority of people live on the coast. Islands in the Pacific can be roughly divided into islands with high mountains (high islands) and atoll islands. The high islands are richer in resources such as freshwater and crops than the atoll islands. There are 322 islands in Fiji, and 2 main islands, Viti Levu and Vanua Levu, are large high islands. The main industries are tourism, sugarcane, mining, and forestry. More than 800 communities depend on coastal resources and have been using the resources for generations (Kakuma and Kitolelei 2018).

In Fiji's coastal waters, there are 410 management areas called *qoliqoli*, similar to Japan's common fishery right grounds (see Chap. 8), where villages along the coast conduct community-based resource management led by chiefs (Kakuma 2005). In

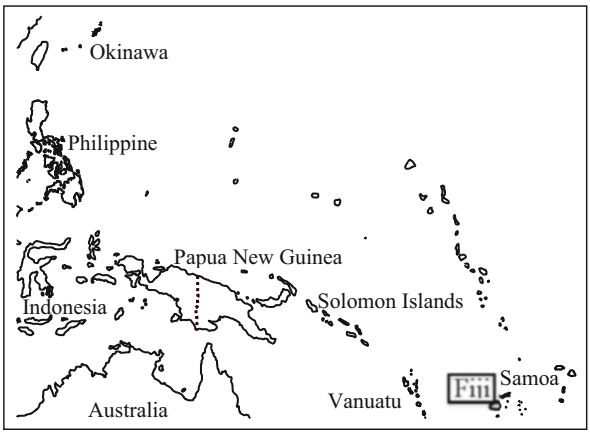

Fig. 10.1 Location of Fiji

the *qoliqoli*, fishing pressure is increasing, and villages are facing various issues related to resource management.

In the Asia-Pacific region, a network-type resource management activity called LMMA (locally managed marine area) is spreading. This activity started in 1997 in the village of Ucunivanua on the east coast of Viti Levu Island. At that time, the LMMA had not yet formally begun. The community-driven activities in Ucunivanua were incorporated into a new international framework of LMMA, which spread throughout Fiji and to other Asia-Pacific countries such as Solomon Islands, Papua New Guinea, Indonesia, and the Philippines (Kakuma and Kitolelei 2018).

The Fijian government formally adopted FLMMA (Fiji's LMMA) in coastal resource management policy in 2004. In 2003, there were 27 FLMMA sites, but by 2013, more than 400 communities were involved in FLMMA across Fiji, and 466 MPAs were established (FLMMA Network n.d.).

10.2.2 MPAs of FLMMA

In Fiji, activities progressed to increase the effectiveness of MPAs, one of the goals of the LMMA. Various types of MPAs exist in Fiji, with two main types: legally established MPAs and MPAs established through the traditional *tabu* system.

Legal MPAs are legally established by the government and are officially recognized. Temporary *tabu* MPAs are often established and managed by local communities in collaboration with governments, universities, NGOs, etc. Although *tabu* MPAs are not legally recognized, many studies have shown that these collaboratively managed MPAs are effective (Bohnsack 1998; McClanahan and Mangi 2000).

In 2000, the government, USP, NGOs, and others who worked with communities formally launched the FLMMA network. Traditionally, Fiji has had a *tabu* system where a certain area of the sea is closed to fishing for 100 days after the death of the village chief. This is mainly to ensure that there is enough fish for the ceremony

100 days later. The knowledge that fishing bans increase fisheries resources has also been passed down. FLMMA introduced a new concept, "MPA," but the concept and effects of the no-fishing zone were already well understood and easily accepted by the communities (Kakuma and Kitolelei 2018).

The success of FLMMA has not been limited to Fiji but has also spread to other Pacific Island countries, Southeast Asia, and the Indian Ocean countries (Govan et al. 2009). FLMMA was also introduced at the Ocean Conference in New York in 2017 and has gained recognition in the international arena.

10.3 Coastal Resource Management in Kumi Village: Knowledge, Perception, and Collective Action

In this section, we focus on integrated local environmental knowledge (ILEK; see Chap. 1), perceptions of the knowledge, and collective actions and analyze how ILEK is produced and distributed in a village, how it influences people's perceptions and leads to collective actions, and how bilateral knowledge translators function in this process.

The authors studied Kumi Village, Verata District, located on the east coast of Viti Levu, in 2013–2014 (Figs. 10.2 and 10.3). The population of Kumi was 273 people and 84 households in 2014, and agriculture and fishing were the main industries. Agriculture is not based on a single crop but on various crops cultivated according to the seasons, benefiting from traditional knowledge of terrestrial ecosystems.

In front of the village is a vast expanse of mudflats and mangroves, with coral reefs off the coast. The villagers harvest various marine products from these ecosystems. There were six boats with engines, two without engines, and eight bamboo rafts in 2014. The fishing methods include hand fishing, gill netting, non-diving spearfishing, and harvesting shellfish and sea cucumbers in the mudflats. The *qoliqoli* area used by the Kumi community is shared by six villages in Verata

Fig. 10.2 Study sites in Viti Levu Island

Fig. 10.3 Location of Kumi Village

District. Most of the fish caught are for their own consumption, but some are sold at markets far from the villages. The bivalve *Kaikoso* (*Anadara* spp.) is important, and mainly women harvest it. Half of the households that harvest *Kaikoso* also sell the shellfish, making it an important source of cash income (Kakuma and Kitolelei 2018).

10.3.1 Tabu, Solesolevaki, *and Totem*

In Kumi Village, ILEK related to *tabu*, which prohibits certain types of fishing activities; *solesolevaki*, which is a concept of collaborative work; and totem, which is a symbol of the clan, greatly influenced the decision-making system of the community (Fig. 10.4). The recognition of the importance of these traditions was linked to collective actions based on consent and collaboration among community members.

It is known that *tabu* in the *qoliqoli* of Kumi has been practiced for quite long time (Tawake et al. 2001). Interviews in Kumi revealed that knowledge of traditional *tabu* was widely held among the Kumi people and that recognition of its importance was the basis for collective actions such as fisheries resource management (MPA, sea cucumber stock enhancement, etc.).

The tradition of *solesolevaki* was also passed down among the Kumi villagers, and collective actions were regularly carried out. The *solesolevaki* was the basis for integrating the individual actions of different sexes and age groups, distributing responsibilities, and collaborating in various labor-intensive community activities. All the Kumi people interviewed said that collective actions were the results of customary practices passed down in the village. The connection among the villagers performing *solesolevaki* provided the basis for a mutual support system among the groups and prevented potential conflicts among the participants.

Traditional knowledge of the ecosystem associated with *Kaikoso* as a clan totem influenced the perception of the importance of protecting the habitat of this resource.

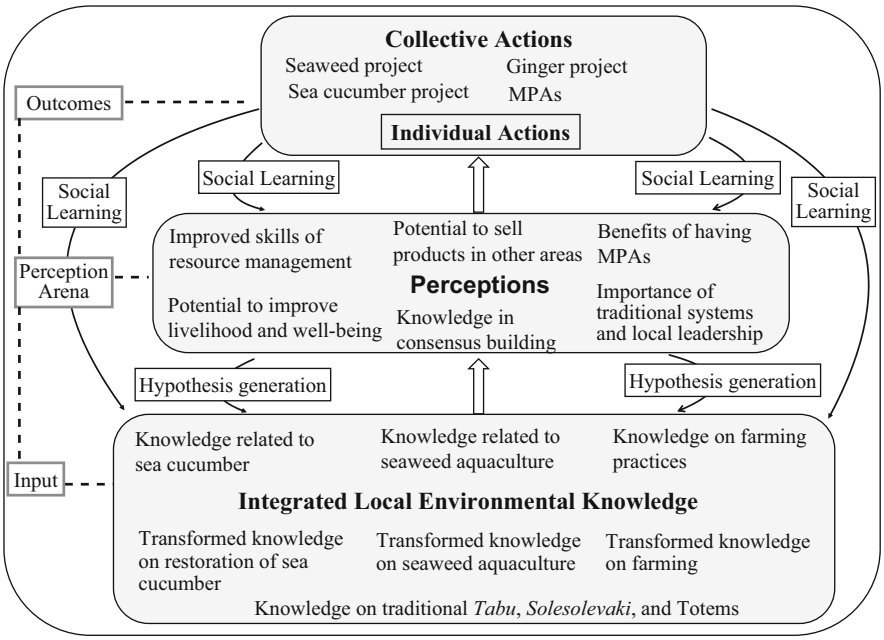

Fig. 10.4 Components of integrated local environmental knowledge and perceptions of people leading to relevant collective actions

This perception deeply rooted in traditional culture then became the basis for collective actions such as MPA, seaweed farming in tidal flats, and improvement of the bivalve habitat.

Traditional rules and decision-making systems in Kumi are considered to function well in preventing rule violations and conflicts. Rules and procedures for action were discussed and agreed upon by local stakeholders, and external stakeholders respected them and drew lessons from them.

Traditional organizations, rules, and decision-making systems were critical for collective actions to help sustainably manage the various coastal resources. These collective actions were valued by external stakeholders and led to the transformation and reinforcement of the perception that the traditional systems of the community had global value.

All of the traditional institutions and rules described so far were supported by village traditional chiefs, sub-clan chiefs, elders, religion leaders, and others in key positions who made decisions about community activities. These various traditional and chief-clan institutions were formed much earlier than the institutions brought into the community by the colonial and current governments and are the oldest and longest lasting institutions in Fiji. These old institutions are still functioning well in Kumi, facilitating the distribution of responsibilities and collaboration among the villagers.

10.3.2 Bilateral Knowledge Translators

The ILEK and dynamic transformation of its perceptions among the villagers of Kumi impacted external stakeholders. Officials from the government's Fisheries Department frequently visited Kumi to monitor the results of sea cucumber stock enhancement and seaweed aquaculture. They collected data on the growth and quality of the products and communicated them to other villages along with the stock enhancement and aquaculture techniques that had been developed in Kumi. At the same time, they shared their knowledge of new technological developments in other villages with the people of Kumi.

In the case of FLMMA, researchers from USP (including Kitolelei, one of the co-authors) played a role similar to that of the Fisheries Department officials. They helped circulate the knowledge of FLMMA among the villagers and to initiate collective action to establish and manage MPAs. They also shared the success of FLMMA in Kumi with other villages.

Government fisheries officials and researchers of USP can be regarded as "bilateral knowledge translators" (Crosby 1997; Sato et al. 2018, see Chap. 1). They activated bilateral circulation of knowledge by making visible new implications of locally developed knowledge so that the local government, scientists, and other communities could share it.

10.3.3 Turaga-ni-koro

In Fijian villages, there is a key person called the *Turaga-ni-koro*, who is elected by the villagers and authorized by the provincial government. In Kumi, the *Turaga-ni-koro* played an important role in connecting the community with external stakeholders (Biturogoiwasa 2001). He advised the traditional hereditary chief and other decision-makers in the village on interference from outside the village. At the same time, he advised stakeholders from outside the village, such as government officials, NGOs, and university researchers, in the situation and needs of the village, especially with regard to resource management. He is the bilateral knowledge translator.

Village chief, elders, sub-clan chiefs, and religion leaders also often acted as the translators at meetings held outside the village or by visiting other communities. By observing and learning resource management in other areas, they could share their knowledge with people in their own communities and influence their perceptions. In addition, external stakeholders such as governments, NGOs, and USP researchers also shared their scientific knowledge with the communities.

In all of these processes, the *Turaga-ni-koro* played a pivotal role as the "gatekeeper" of the community. He controlled the different knowledge and perceptions of the various stakeholders inside and outside the village and facilitated their interaction. When external stakeholders visited the village, he held a "kava ceremony" in his house to facilitate knowledge exchange with village leaders and decision-makers.

The kava ceremony is a ritual in which people take turns drinking kava (the roots of a family of ginger are ground into a powder, which is then mixed with water and squeezed to kava). He also took these people inside the village and allowed them to interact with other members of the community. Through these "gatekeeping" activities, the *Turaga-ni-koro* seems to have translated knowledge from both sides through the filter of his own perception, blended external and local knowledge, and transformed them into ILEK.

10.4 Types of Community-Based MPAs

In Fiji, community people and diverse stakeholders have set up MPAs as a result of the decline in coastal resources, and the number of MPAs in the *qoliqoli* areas has increased significantly. The FLMMA Strategic Plan 2014–2018 (FLMMA Network n.d.) identifies three types of FLMMA MPAs: (1) permanent MPAs, (2) MPAs occasionally open to fisheries, and (3) MPAs that rotate locations. In our study, we compared three types of MPAs: (1) fixed location/area MPAs, (2) rotational MPAs, and (3) multiple villages shared MPAs in four *qoliqoli* and communities. The four communities are Veivatuloa, Kumi, Nakawakawa, and Nakorokula. Data on MPA types were collected from communities through qualitative interviews, field observations, etc. The type and size of the MPAs were determined by the size of the *qoliqoli*, the types of resources that are valuable to the community, the duration of the MPAs, and the opinions of all relevant stakeholders (e.g., communities, governments, NGOs, and third parties).

10.4.1 Fixed Location/Area MPAs

Fixed location/area MPAs are set at fixed locations in the *qoliqoli*, without changing the area size or moving the location. In some cases, the MPAs are permanent, but in most cases, they are set for a fixed period. A fixed location/area MPA is often the first type of MPA that a community joins FLMMA. And they are usually set in small *qoliqoli*. The area of the MPA does not expand because the fishing grounds are small and there is not enough space.

An example of fixed location/area MPAs is in Veivatuloa (Fig. 10.5). The community decided on the location of the MPA because the site provides a good habitat for various marine lives and is rich in resources. In addition, the location is close to the village, making it easier to watch. The Veivatuloa MPA was established in 2006 with the support of the NGO Seaecology Foundation. Since the establishment of the MPA, community members have followed the rules of the no-take MPA, and the MPA was perceived to be successful according to the results of the interviews.

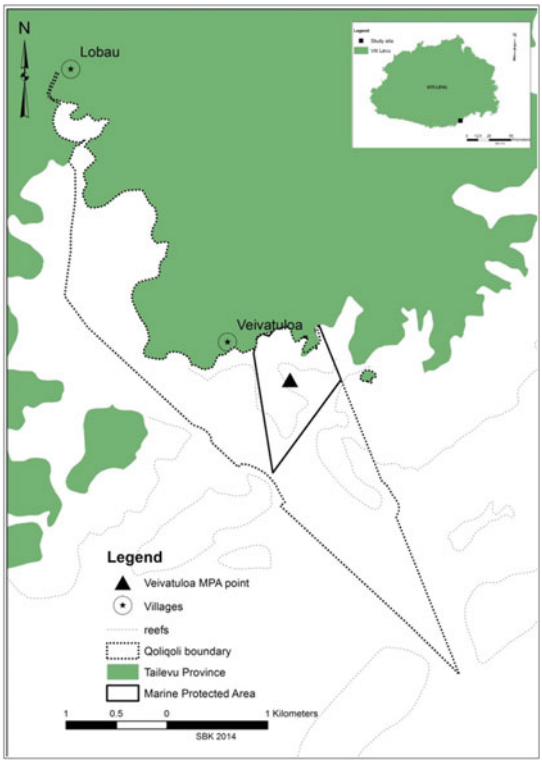

Fig. 10.5 Location of the MPA of Veivatuloa

10.4.2 Rotational MPAs

For rotational MPAs, a number of locations are selected in the *qoliqoli*, and only one location is set as the MPA for a certain period, and that position rotates. How many years for a given position is usually decided by the community in consultation with the FLMMA secretariat.

The main purpose of establishing this type of MPA is to restore the resources of the target species economically important to the community and to increase the community's income. The reason for the rotation of locations seems to be a matter of balancing the effects of resource recovery with the restrictions on fishing grounds. This type of MPA is usually established in a large *qoliqoli*, and each location of the MPA is often close to the community to facilitate watching.

The MPA established in Kumi is of this type (Fig. 10.6). When the FLMMA secretariat proposed MPA, the villagers were aware of the decreasing resources of the bivalve *Kaikoso*, an important source of income, and thus the MPA was initiated.

Since 2007, the MPA changed its location twice and was rotated among the three locations (2007–2009, 2009–2011, 2011–?). According to the results of the interviews, the community recognized that the resources in the MPA had increased and

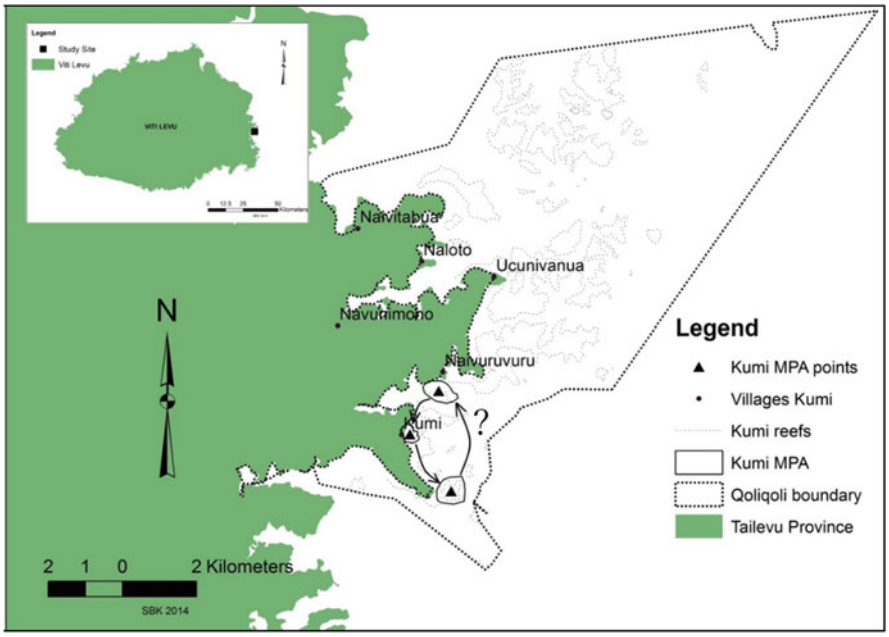

Fig. 10.6 Locations of the MPA of Kumi

that the resources in surrounding waters of the MPA had also increased due to spillover effect (i.e., the target organisms in the MPA spill over outside the MPA and increase there).

10.4.3 Multiple Villages Shared MPAs

Multiple villages shared MPAs are set up in the *qoliqoli* shared by several villages, and these MPAs are also shared. Not all MPAs in shared *qoliqoli* are multiple villages shared MPAs. The *qoliqoli* of Kumi village is shared by six villages, one of which is Ucunivanua, the village where FLMMA began. The MPAs in Kumi and Ucunivanua are not shared but their own MPAs.

Multiple villages shared MPAs are mainly set in large *qoliqoli* and usually cover multiple ecosystems such as mangroves, mudflats, and coral reefs. Multiple villages shared MPAs are established when multiple communities that share the same *qoliqoli* can agree to establish shared MPAs.

The Nakawakawa MPAs are of this type (Fig. 10.7). The four MPAs are Duanuku (160 hectares, hereafter ha), Cakau Yakale (80 ha), Cakau Nukuse (30 ha), and Cakau Caniqe (340 ha). These MPAs were initiated in 2012, and several communities have agreed to continue the no-take MPAs for 10 years.

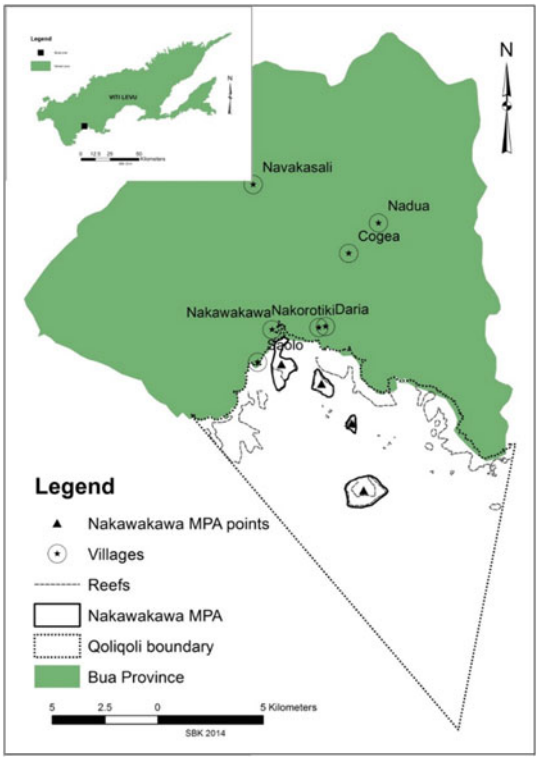

Fig. 10.7 Locations of the MPAs of Nakawakawa

10.4.4 Terminated Multiple Villages Shared MPAs

In Nakorokula, multiple villages shared MPAs could not be continued because some communities did not want to reclose the MPAs after they were temporarily opened. This means that multiple communities sharing the same *qoliqoli* and MPAs could not agree to reclose the MPAs. Once MPAs are terminated in such a case, it becomes difficult to resume the activities of FLMMA.

The terminated MPAs were located in Tuvereki, Vatukadiri Passage, Namotumotu, Qwanakoto, and Lomawai (Fig. 10.8). The reasons for the failure of the MPAs to continue were the antipathy of the community's fishers to the restriction of their access to important resources for their livelihood, lack of leadership within the community, and weakened watch and enforcement of the MPAs.

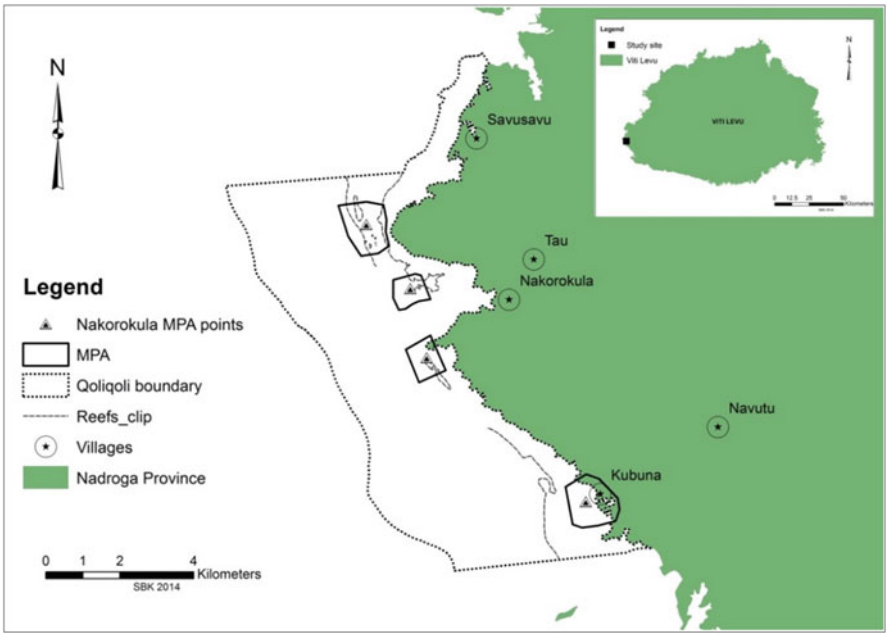

Fig. 10.8 Locations of the MPAs of Nakorokula

10.4.5 Comparison of the Four Cases and Challenges

In Fiji, declining resources are serious issues in the coastal zone (Balmford et al. 2005), and the increasing number of MPAs indicates that people are aware of the decline of their resources and want to protect and sustainably use the remaining resources. The interviews to the communities showed that the objective of the MPAs was to manage and restore the fisheries resources.

In all four cases, 54% of the respondents answered that management activities were sufficient to protect their resources. On the other hand, despite the establishment of MPAs, 64% of the respondents felt that fishing pressure was increasing. This difference of opinion indicates that the MPAs are both supported and criticized by the community members.

The degree of deterioration of the resources differed among the four cases, and a larger proportion of the area in the narrower *qoliqoli* was not allowed fishing with the establishment of MPAs compared to the larger *qoliqoli*. These factors influenced why each community choses the type, location, and area of the MPAs. Some MPAs in the case studies were successful in managing fisheries resources and others were not. The success cases can serve as guides on how to properly manage MPAs in other parts of Fiji.

There are many challenges to the application of MPAs, such as poaching. And some small-scale fishers do not know the community rules and do not participate

much in community activities. In addition, community rules are not official (not documented), and villagers sometimes do not follow them. This is also due to the fact that the governments do not legally enforce autonomous MPAs, and violations of MPA rules are often overlooked. The Nakorokula case study shows that this had led to the failure of MPAs.

Another problem identified in the four case studies is that the boundaries of the MPAs are not clearly marked and there is no clear map showing the exact locations. The community members had difficulty to pinpoint the exact location of MPAs. Usually, the boundaries of MPAs are marked by wooden poles poked into the seafloor, but these sticks are often lost due to strong winds and currents. In some cases, MPAs were established with the intention of continuing for many years but were terminated after a short period, and the MPAs were established at different locations from the original ones.

In the four case studies, the duration of MPA establishment varied greatly, from 1 to 10 years. The areas of the MPAs were relatively small, averaging about 100 ha. Some of the MPAs lacked scientific knowledge about resources, habitats, and environments. In the future, it may be necessary to gather this knowledge from external stakeholders and increase the areas for resource recovery. In addition, in the four case study sites, there were few boats provided to the communities for daily watch by the supporting agencies, and insufficient watch and enforcement of the MPAs was also a problem.

10.5 Tourism Use of MPAs

Community-based MPAs usually involve costs to maintain, such as boundary buoys and watch, and require a funding mechanism to cover the costs if they are to be sustained. It would be good if the MPAs could increase the amount of fish caught to cover these costs, but this is not easy. It takes time for the resources to recover, and the increase in the catch due to spillover effects is difficult to see as a direct effect of the MPAs (Kakuma 2017a). For this reason, many of the community-based MPAs sustained in the Philippines use diving fees to cover their costs (Omori et al. 2010).

In Fiji, there are many examples of MPAs being used for tourism. In this section, we introduce the cases of Cuvu and Navutulevu on the south coast of Viti Levu and Soso in Yasawa Islands located northwest of Viti Levu.

10.5.1 Cuvu

In 2003, Kakuma (one of the co-authors) interviewed the hotel manager at the Shangri-La Resort, which is adjacent to the village of Cuvu in the southwestern coast of Viti Levu. The entire small island was a resort, with 436 rooms on a 44 ha site and 700 employees. Most of the employees were employed from the local

communities. The annual income of the resort was about 20 million Fijian dollars (about 12 million US dollars at the time of the survey). Five such big resorts existed in the southern part of Viti Levu. Since Fiji's coastal fisheries annual output was 20–30 million Fijian dollars, we can see how tourism is a big part of the Fiji's economy.

Across the narrow channel is the Cuvu Village, and the sea in front of the resort is inside the village's *qoliqoli*. Cuvu community had established an MPA here in cooperation with the resort. For the benefit of the resort, the guests can swim in the sea right in front of the resort and see many fish and beautiful corals. In addition to employment, the community benefits from the resort's funding for various village events. Ten MPA watches were appointed from Cuvu, whose wages were funded by the resort to a community fund. The resort hired local people and trained them as guides to conduct snorkeling tours in the MPA. A part of the tour fees was also given to this fund.

The MPA was located on the south side of the island, and almost the same area as the island was designated as a no-take zone. The MPA was opened to the Cuvu community for 1 or 2 days once a year. The chief determined the timing in conjunction with the ceremony.

Concrete structures called the Fish House were installed in the MPA by the resort's ecologist. The structure was about 30–40 cm in length, width, and height and had a void inside. When 5–6 cm sand was removed from the seabed, bedrock was revealed, and cement was used to fix it in place. Small corals were planted in the Fish Houses, and when they grew up, the complex structure became a hiding place for small fish. The scale of the activity was still small to increase biological diversity, but it is deemed a tourist attraction. Efforts to restore ecosystems by planting coral, such as installing the Fish House, can be considered an active measure of Satoumi creation, which requires direct human intervention (see Chap. 1).

The Shangri-La Resort had its own sewage treatment facility. In the past, when the Shangri-La was a different hotel, it had trouble with the Cuvu village over wastewater, which led to the construction of the sewage treatment facility. The sewage was finally separated into water and organic sludge. The water was pumped to the golf course pond inside the facility and then used for irrigation. The sludge was dried and used as organic fertilizer to grow flowers and other plants in the facility.

10.5.2 Navutulevu

In 2003, Kakuma visited Navutulevu Village in the southern coast of Viti Levu. The village is located in an area called the Coral Coast, where several resort hotels are located. At that time, Navutulevu had a population of 250–300 people and 54 households. There were no fishing boats with engines and no licensed fishers. The lagoon in the Navutulevu area is narrow, only about 1 km from the beach to the outer reef. The *qoliqoli* is also narrow, and for this reason, the villagers said they did not need fishing boats for fishing.

The traditional MPA by *tabu* was established in 2003 for a period of 5 years. The *tabu* rules are also valid for neighboring villages. This MPA occupied about a half of the small *qoliqoli* (about 100 ha). It seems too big, but the villagers including the chief believed it would increase their catch.

There was a major resort called Warwick about 10 km west of Navutulevu. The villagers were hoping that they would be able to earn money through ecotourism using the MPA by the guests of Warwick. The villagers said that one of the reasons for setting the MPA was to secure marine food and the other was to attract tourists from Warwick. In Navutulevu, there was still a traditional fishing method called Yavirau (yavi means pull and rau means leaf). It is a kind of drive-in net, where fish are driven into the center of the net by attaching scare leaves to long ropes. In the end, the fish are caught by spear or by grabbing them by hands. The Navutulevu Village had a close relationship with Warwick, because the Yavirau was shown to tourists from Warwick on the village foreshore.

In Navutulevu, the chief said that there had been an unprecedented increase of sargasso. Because seaweed and corals compete for light, excess seaweed would disrupt coral reef ecosystems. According to researchers of USP, as of 2005, there was a definite increase in sargasso in the southern coastal waters of Viti Levu, and the cause was thought to be increased nutrient loading from the land (piggeries near the coast and human households).

10.5.3 Soso in Yasawa Islands

Soso village in the Yasawa Islands are located to the northwest of Viti Levu. In 2017, the authors visited Soso. The sea area in front of Soso was registered in FLMMA, and a no-take MPA was established. A resort facility exists on a small island about 1 km south of Soso, and the resort had established its own MPA to protect tourism resources in the waters in front of the facility. The ecologist managing the facility was a residential researcher (Sato et al. 2018, and see Chaps. 1 and 12), and he had a plan to protect the ecosystem and tourism resources by establishing a marine park in a large area of the sea including the MPA of Soso. There are eight such resorts in the vicinity of Soso (28 in the entire Yasawa Islands). At the time of the survey, the villagers of Soso were not considering tourism use of the MPA as the purpose of their MPA was to increase fisheries resources. However, since many tourists visit the beautiful beaches of Soso, tourism use of the MPA has potential to sustain the MPA.

10.6 Resource Management of Sea Cucumber

10.6.1 Sea Cucumber Fishery and the MPA in Kiuva

In 2003, Kakuma visited the village of Kiuva, located at the southeastern tip of Viti Levu, about 20 km east of Suva, the capital of Fiji. At that time, Kiuva had a population of 280 people and 54 households. There were 12 licensed fishers in the village, but most of the villagers were harvesting marine resources in some way. There were 26 fishing boats with engines of about 5–7 m in length, manned by 3–4 people including unlicensed fishers. The lagoon in the Kiuva area is vast, and the *qoliqoli* shared by five villages in Bau District is also large. Sea cucumbers were important resources for Kiuva. From the beach in front of the village to the outer reef, there is a vast shallow area of sand and coral reefs, and fishers use outboard engines and wooden sticks to steer their boats to harvest sandfish (sea cucumber, *Holothuria scabra*, Fig. 10.9). The Fisheries Department's landing logbooks showed that most of the catch were sea cucumbers, with a small amount of fish caught by gill nets and handlines. When several fishers were asked about the status of the resources, they said that catch of finfish had decreased compared to 5 years ago but that there was no change in sea cucumber catch (Kakuma 2005).

The MPA of Kiuva had been set at the south side of *qoliqoli* as a traditional chief's *tabu* area, which was set in 2001 and planned to continue for 5 years. At that time, Kiuva was not registered in FLMMA, but the government's Fisheries Department was planning to legislate Kiuva as a FLMMA site and was considering to prescribe the MPA legally. One of the advantages of the legal legislation is that enforcement and penalties can be applied to outside rule violators of Kiuva (Kakuma 2005).

Fig. 10.9 Sea cucumbers in Kiuva. Lower: sandfish

10.6.2 Management of Sea Cucumber Resources

Sea cucumbers are valuable coastal fisheries resources throughout the Pacific. The sea cucumbers are used as food sources for local residents, but most of them are dried and exported mainly to China as a source of cash income. The status of sea cucumbers as a source of cash income is high, and because they are easy to catch, they had been repeatedly overfished until they were depleted in shallow waters when demand became high (Akamine 2010). In 2003, the need for resource management was increasing in Fiji due to the introduction of diving equipment, which led to the collection of sea cucumbers in deep waters and the expansion of the target to many species. In the late 1990s, a 2-year ban on sea cucumber fishing was considered in Fiji, but there was intense opposition from many chiefs gathered to protest, and the ban was canceled (Kakuma 2005).

Sea cucumbers are the second largest foreign currency earning resources after tuna in the Pacific, but the resources are overexploited in most of the Pacific Island countries due to intense Chinese demand. The same is true for Okinawa, where the resource is at a very low level (see Chap. 8). According to a report in 2014 by the Secretariat of the Pacific Community (SPC), an international organization for the Pacific region, of the 17 countries and territories that fished sea cucumbers, only French Polynesia and New Caledonia could manage them well, while eight countries, including Papua New Guinea and Solomon Islands, which had been the top 2 producing countries until then, had banned the fisheries entirely (Kakuma 2017a). Fiji permitted the sea cucumber fisheries at that time; however, it has banned the export of sea cucumbers since 2017.

10.7 Release of Giant Clams

At Kiuva, the largest species of giant clams (*Tridacna gigas*) were released. The large ones had grown to more than 60 cm in shell length. Efforts to release giant clams can be considered active measures in Satoumi creation. Giant clams are important fishery target organisms that make up the coral reef ecosystem. However, due to their sedentary and easily detectable ecology, their stocks have been declining in many Pacific Island countries. In some islands, large species such as *T. gigas* and *T. derasa* have become extinct at the local level. For this reason, many projects of giant clam seedling production to restore the resources are underway in various parts of the Pacific (Kakuma 2006a). In all Asia-Pacific Island countries where Kakuma visited, such as the Philippines, Indonesia, Malaysia, Fiji (Fig. 10.10), Samoa, Tonga, Solomon Islands, Palau, Federated States of Micronesia, and Vanuatu, seedling production and release of giant clams in MPAs or other areas had been conducted by the governments and the universities. The objectives of the release were often to increase resources outside the MPAs through spillover effects as well

Fig. 10.10 Released giant clams in Fiji

as harvesting or tourism use (Kakuma 2017b). In Okinawa, the smallest species of giant clams, *T. crocea*, has been released (see Chap. 8).

10.8 Balance Between Ecosystem Conservation and Resource Use

10.8.1 Balance Between Coral Reef Ecosystem Conservation and Fisheries

Many factors disturb coral reef ecosystems, such as massive coral bleaching caused by climate change, the inflow of soil and excess nutrients from the land, and the predating damage by crown-of-thorns starfish. On the other hand, there is a view that the fishery is a serious disturbing factor to coral reef ecosystems. In addition to the direct destruction of corals by dynamite and cyanide (poison) fishing, the catch of herbivorous fishes increases algae that compete with corals. In Western countries, there has been a historical tendency to try preserving pristine nature by eliminating human influences (see Chap. 3). "Fishery has long been a major factor in the deterioration of coral reef ecosystems and should be strictly regulated" (Pandolfi et al. 2003). One of the challenges in Satoumi creation is to achieve a balance between ecosystem conservation and resource use. Since coral reef fisheries are supported by coral reef ecosystems, the industry cannot be sustained without protecting the ecosystems. Rather than viewing fisheries and ecosystem conservation as opposites, considering that protecting the ecosystem to increase fisheries resources, and that managing herbivorous fish resources to protect the ecosystem (Kakuma 2016).

10.8.2 Balance Between Tourism and Fisheries

In Navutulevu, almost a half of the *qoliqoli* was set as the MPA. If a large resort is built near a village with a small *qoliqoli* like Navutulevu, and with the coordination of the resort and the village community, a large part of the *qoliqoli* may be set as no-take MPAs for tourism use. In this case, many villagers would be employed by the resort, and other tourism-related income would increase.

On the other hand, since the catch of marine products from the *qoliqoli* would be reduced, villagers would buy canned foods or meat as a source of protein. This will affect the food culture of the Pacific Islanders, who, like the Japanese, are highly dependent on fish diet. When establishing MPAs for tourism use that are large compare to the remaining fishing grounds, not only the income but also the impact on the culture should be considered (Kakuma 2006a). It is also necessary to pay attention to the health of villagers. In Tonga, there is a report of an increase in lifestyle-related diseases such as heart disease in the villagers as a result of a change in eating habits to imported frozen mutton with high fat content instead of fish (Hamaguchi 2002).

10.8.3 Area Size of MPA

With regard to the area size of MPA, the balance between conservation and resource use is also an issue. The larger the area of the MPA, the better for ecosystem conservation, and also the better for spillover effects. However, a larger MPA means a smaller area for fishers to fish.

In Samoa, there is a system of MPAs with a large, loosely regulated buffer zone surrounding small no-take MPAs in several fishing villages (Kakuma 2006b). In such a system, overly efficient fishing methods, such as bottom trawling, large drive-in net, and diving fishing, are prohibited in the buffer zone, and only traditional fishing methods such as handlining, daytime spearfishing, and basket trap fishing are often allowed. This system is a so-called zoning-type MPA and one of the potential methods to achieve the balance between conservation and resource use.

The most famous zoning-type MPA in coral reef areas is the Great Barrier Reef Marine Park in Australia. It is an excellent system for managing a vast coral reef area by establishing various zones with different levels of regulations. However, the Great Barrier Reef is several tens to a hundred kilometers offshore from the Australian continent and is not subject to much human influences on land. In areas such as Southeast Asia and the Pacific, where so many people live along the coast and are closely involved with coral reefs, such MPA systems may not function well (Kakuma 2006a). Rather, we should develop a Satoumi-type MPA system in which people are closely involved and coexist with coral reefs.

What is the appropriate area size of an MPA? This will vary depending on the situation in the sites, and various conditions should be considered, such as the

ecology of the target species, the size of the fishing grounds, and the degree of catch reduction due to the establishment of MPAs. In the FLMMA, the area sizes of MPAs were not decided by the governments, universities, or NGOs, but rather by the local communities. The local knowledge translators translated the scientific information provided by external stakeholders and communicated it to the communities. And then the communities decided the area sizes of the MPAs.

10.9 Future of FLMMA Network

10.9.1 Why FLMMA Had Expanded So Rapidly?

Compared to other countries that have LMMA activities, FLMMA had developed much faster. This can be attributed to the fact that the Fijian government had formally incorporated FLMMA into its policies and that the researchers of USP had contributed as bilateral knowledge translators. In addition, the MPAs, which are the cores of the resource management tools, were actually effective, and many communities had realized that.

It is difficult to evaluate the effects of MPAs quantitatively. Like other Pacific Island countries, Fiji has national catch statistics, but not village catch statistics. Therefore, it is impossible to judge the effectiveness of MPAs by catch statistics. In Ucunivanua, researchers of USP conducted a study and found that the *Kaikoso* stock in the MPA increased fourfold and the stock outside the MPA doubled due to spillover effects (Tawake et al. 2001). However, this is a special case, and such a quantitative study had not been conducted in most sites.

Even if there are catch statistics for each village, it is not always possible to evaluate the effectiveness of MPAs based on them. The amount of resources and catches inside and outside the MPAs are intensively influenced by external factors other than community activities (e.g., climate change), and resources may decrease no matter how hard the community works. In addition, it usually takes many years for the effects of MPAs to show up in fish catches. For this reason, in the Philippines, efforts are being made to evaluate the effectiveness of MPAs based on the activities of the community, not on the amount of resources or how the ecosystem has changed (Kakuma 2016).

In Fiji, however, the effects of the MPAs must have been visible to the communities. Otherwise, it is unlikely that the FLMMA, which started in 2000, would have continued for more than 20 years and expanded so much. Some sites, like Nakarokula, have stopped MPAs, but many more sites had joined FLMMA and started MPAs.

10.9.2 Challenges of FLMMA

Although the FLMMA has expanded greatly, it has also had some negative effects. The first is that it is becoming more difficult to maintain consistency in activities. In FLMMA, there are organizations called "partners" that provide financial and technical support to the communities. In 2003, there were 6 partners, mainly USP and the Fisheries Department of the government, but in 2013, the number had increased to 23 (FLMMA Network n.d.). Since each organization has its own activity policy, it is difficult to maintain consistency of activities when the number of partners increased so much.

The other is that there is a critical shortage of human resources to support the more than 400 communities involved. For this reason, some officers were trained and organized to YMSTs (*Yaubula* Management Support Teams) in several provinces. *Yaubula* means resources and environment. And instead of sending people from Suva, those officers would support FLMMA activities in those provinces (FLMMA Network n.d.).

The community members were well aware of the importance of managing their own marine resources. Further development of FLMMA will require proper watch and monitoring of MPAs, scientific information on ecosystems and resources, and training and capacity building of the young people who make up the YMSTs. In addition, it is important that local people who have the rights to use the resources are directly involved in the coastal resource management and Satoumi creation, and it will be necessary to further strengthen collaborative management between communities and supporting organizations.

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Part IV
Building Broader Connections Between People and the Sea

Chapter 11
Connecting Local Regions and Cities Through Mozuku Seaweed Farming and Coral Reef Restoration: Onna Village, Okinawa

Yoshimi Higa, Amane Takeuchi, and Shigeru Yanaka

Abstract At Onna Village in Okinawa, "the Cultivation Activities of Coral Reefs" are being implemented by many organizations including Onna Village Fisheries Cooperative, consumers' cooperatives in various areas, Igeta Takeuchi, Co., Ltd. which is a fishery processing and marketing company, and Onna Municipality. While the aquaculture of Mozuku and other seaweeds enhances biodiversity by itself, the organizations are applying the aquaculture techniques to develop aquaculture and planting techniques for corals to restore and protect coral reef ecosystems. Their activities are supported by the Mozuku Foundation, which is funded by accumulating part of the profits from sales of Mozuku products. A wide variety of people related to the blessing of coral reefs are participating in the Foundation, each playing a different role, to co-create the common value of the Satoumi. Through the distribution of Mozuku cultivated in coral reefs, the Foundation is generated to support coral reef restoration and conservation activities, which in turn stimulate the production of Mozuku, thus creating a cycle around the Satoumi. The activities being conducted through the Foundation are further developed to the conservation activities of fishing grounds, such as the prevention of red soil runoff and eradication of crown-of-thorns starfish (COTS), which have been implemented so far by Onna Village Fisheries Cooperative based on the belief that fishery activities are part of the ecosystems.

Keywords Onna Village · Mozuku Foundation · Coral aquaculture · Seaweed aquaculture · Fisheries cooperative · Consumers' cooperative

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11.1 Overview of Onna Village and Its Fisheries

Onna Village is located on the west coast of northern Okinawa Island and has a population of approximately 11,000 people. It has a long and narrow shape that stretches from northeast to southwest, with a boarder of mountains including Mt. Onna to the east and the East China Sea to the west. Along the coast, coral reefs stretch over a linear distance of approximately 27.5 km, with the length of the coastline of approximately 46 km and the reef area down to depths of around 50 m amounting to 3000 ha. The sea floor quickly drops down to 350 m outside the coral reefs, which causes diverse fishing grounds. All of the coastal area is designated as the Okinawa Coast Semi-National Park and has become one of the best marine resort areas in Japan.

Onna Village Fisheries Cooperative (OVFC) solely manages the No. 6 common-fishery-right area. In 2017, the number of the Cooperative members was 255, of which 114 were regular members who were mainly engaged in seaweed aquaculture and coastal fisheries. In 2016, the Cooperative's yield was 631 tons with the monetary value of the yield being 387.26 million yen (about 3.5 million US$), and Mozuku aquaculture accounted for approximately 80% of the yield and 40% of the monetary value. In extensive lagoons, they perform the aquaculture of three types of Mozuku: Okinawa Mozuku *Cladosiphon okamuranus* (commonly known as "Futo-Mozuku" or thick Mozuku), Mozuku *Nemacystus decipiens* (commonly known as "Ito-Mozuku" or yarn Mozuku), and Onna No. 1, which was registered as a variety in 2007 (commonly known as "Onna Mozuku"). They are also performing the aquaculture of Hitoegusa seaweed *Monostroma nitidum* in tidal flats called Yakata-katabaru, as well as the aquaculture of Kubirezuta seaweed *Caulerpa lentillifera* (the so-called sea grapes) in onshore facilities at each fishing port. The Cooperative succeeded in Hitoegusa seaweed stick and net culture in 1976 and subsequently expanded the work to Okinawa Mozuku stick and net culture in 1977, onshore aquaculture of sea grapes in 1994, and coral stick culture in 1998. OVFC was the first fisheries cooperative in Okinawa to perform the aquaculture of all of these seaweed species. For the aquaculture of sea grapes, the Cooperative's sea grapes production even won the emperor's award for excellent achievement in agriculture, forestry, and fisheries in 2011. Moreover, Onna Mozuku was the first variety of brown algae to be registered in Japan.

Since the Okinawa Islands are located near the southern limit of Ito-Mozuku distribution, its production is limited to winter only and tends to be easily affected by high water temperatures due to the geographical conditions. In 1998, high water temperatures in the summer caused extensive damage to coral reefs around the Okinawa Islands. The seawater temperature was also high during the preceding and subsequent winters and hindered the growth of Ito-Mozuku, which prefers lower water temperature. In particular, during coral bleaching (the loss of symbiotic algae of corals due to high water temperatures) caused by high water temperatures in the summer of 2001, the remaining coral reefs received extensive damage. In Onna Village, the production of Ito-Mozuku remained stagnant for the following 4 years

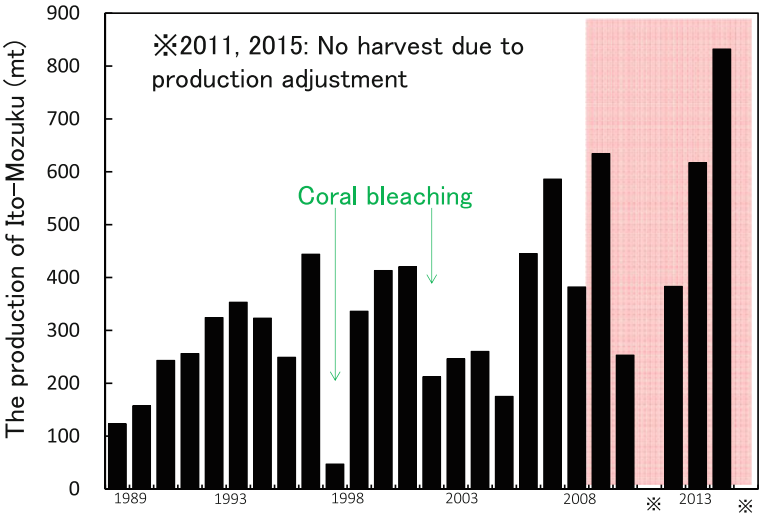

Fig. 11.1 The relation between the production of Ito-Mozuku and coral bleaching

despite the fact the water temperature during winter was sufficiently low. The production of Ito-Mozuku recovered once the corals of Onna Village recovered in 2006. In other words, the primary production of the sea increased in response to an increase in corals (Fig. 11.1).

11.2 Creation of Satoumi: Seaweed Farming, Coral Planting, and Biodiversity

In accordance with the belt zone distribution of lagoon organisms, OVFC arranges various fishing grounds in a zonal fashion from the coast toward the open ocean: Hitoegusa aquaculture grounds on tidal flats, which are closest to the coast; Mozuku nursery beds in eelgrass beds; and Mozuku aquaculture grounds, giant clam *Tridacna* spp. aquaculture grounds, and coral aquaculture grounds in the lagoon. Since Mozuku aquaculture requires the cleanliness of seawater and sediments, the Cooperative has been making efforts in water quality protection and red soil runoff prevention from land-based activities. It has also been engaged in the eradication of crown-of-thorns starfish (COTS) for protecting corals since the production of Mozuku tends to stabilize in healthy waters where corals propagate (Higa et al. 2017).

In this fashion, the Cooperative has been managing its fishing grounds based on the idea that fishery activities are part of the ecosystems (Fig. 11.2). Simultaneously increasing the primary production of the sea, it also implements the aquaculture and planting of corals. As active protection of coral reefs, it has been performing “the

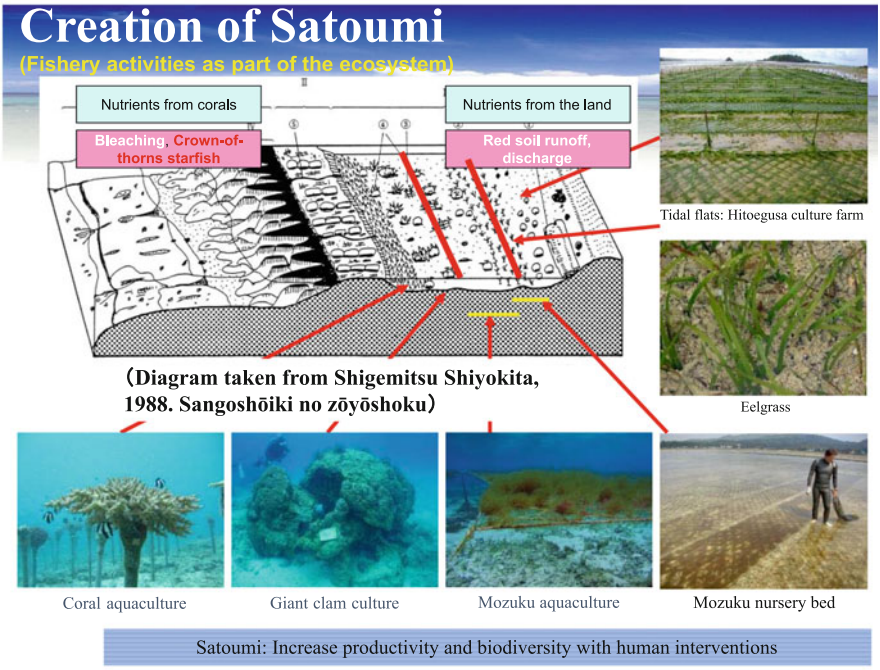

Fig. 11.2 Creation of Satoumi: fishery activities as part of the ecosystem

Cultivation Activities of Coral Reefs," in which breeding corals are grown through coral aquaculture and planted so that the breeding corals can spawn and thereby assist the restoration of natural coral reefs since 1998. These activities combine two methods, one being coral planting in which segments are taken from cultured growing corals and planted on the sea floor and another being coral stick culture (Higa and Omori 2014), in which corals are grown on iron bars or shelves installed into the sand and gravel bottom. Coral stick culture was inspired by frequent observations of large numbers of coral larvae that settled and grew healthily on iron bars used in Mozuku aquaculture (Higa et al. 2017) (Fig. 11.3).

Satoumi is defined as "the coastal sea with high biodiversity and productivity with human intervention" (Yanagi 2007, 2016). In Mozuku aquaculture where nets are set on the sand and gravel bottom in the sea, the biodiversity of the sea becomes higher. It is because small organisms such as shrimp settle in Mozuku and because many species of fish that eat seaweed, such as rabbitfish, gather in the area. Moreover, when portions of tidal flats are sectioned off by placing sandbags and rocks to maintain water level so that they can be used as intermediate nursery beds for Mozuku, seagrass beds become formed in these areas and result in the higher biodiversity compared to the rest of the tidal flats. In this manner, Mozuku aquaculture can be said to create Satoumi by itself, where biodiversity is improved through human interventions. Activities that are performed using even a more

Coral species in the farms in Onna Village, Okinawa, Japan

	Family	Number of genus	Number of species
1	Pocilloporidae	2	5
2	Acroporidae	2	35
3	Poritidae	1	3
4	Agariciidae	1	1
5	Fungiidae	1	1
6	Euphyllidae	1	2
7	Lobophylliidae	1	1
8	Merulinidae	4	4
9	Dendrophylliidae	1	1
10	Milleporidae	1	1
	Total	15	54

Fig. 11.3 The coral stick culture method: culturing 54 species of 10 families of corals

proactive intention to create Satoumi are the aquaculture and planting of corals. With coral stick culture in which iron bars are installed into a sandy sediment, small fish species gather once corals grow, which improves biodiversity.

The first coral planting in Onna Village was the experimental planting of corals by the youth group of the Cooperative in 1989. The second OVFC Fisheries Revitalization Plan, which was established in 1994, determined that coral planting shall be implemented as the Cooperative activity to ensure a more active protection of fishing grounds. Then, since 1998, as the Cooperative movement for the creation of Satoumi, they have performed "the Cultivation Activities of Coral Reefs" by which they implement the aquaculture of the corals that inhabit the sea of Onna Village so that the conservation of species and restoration of nature through spawning can be achieved. In 2009, they established the Onna Village Coop Coral Forest Liaison Committee (n.d.) with the Japanese Consumers' Co-operative Union who came in support of the OVFC activities, and together, they have implemented the aquaculture of approximately 24,000 corals (in the end of March 2017).

In response to a proposal for the introduction of coral planting tours by an NPO organization called the Okinawa Tourism Industry Study Group in 2002, the Agriculture, Forestry and Fisheries Section of Onna Village, the Chamber of Commerce of the village, Manza Beach Hotel, and OVFC held a conference and agreed to engage in coral planting actively. The Cooperative independently established facilities for coral seedlings in 2003 and accepted coral planting tours in the spring and

fall of that year. Subsequently in 2004, to restore the coral reefs of Onna Village, Team Chura (chura means beautiful in Okinawa's dialect) Sango (coral) was formed among 17 businesses inside and outside Okinawa Prefecture including All Nippon Airways and the Okinawa Electric Power Company and has since continued their activities (Sato 2016). Coral planting has also been performed since 2009 as a project for fisheries multi-functionality funded by the Fisheries Agency of Japan (and implemented as the activities of the Onna Village Chura-Umi (beautiful sea) Creation Sub-group formed among the members of the fisheries cooperative). Since 2013 as a coral reef restoration project funded by the Okinawa Prefectural Government, by 2016, the project alone has planted approximately 120,000 corals over 3 ha areas. It was the first coral planting implemented on such a large scale.

11.3 Aquaculture and Planting of Corals

11.3.1 Zonal Structure of Coral Reefs and Zonal Distribution of Corals

Each of the Okinawa Islands is surrounded by fringing-type coral reefs. Fringing reefs have a belt zone distribution of coast, lagoon, reef flat, and reef slope from the coast outward. The lagoon, reef flat, and reef slopes differ from each other in environmental conditions, such as the flow of seawater, water temperature, and effects of freshwater. In particular, inland water affects coastal areas greatly, leaving sections of reef flats with channels.

Many reef-building corals grow by adhering to bedrocks. However, this does not mean that corals can grow anywhere as long as there are bedrocks. The types of corals that can grow depend on the environment. For example, many members of the family Poritidae are seen in the central part of lagoons, while many branching corals grow in the back reef portion of reef flats, tabular corals in the upper crest, and many Pocilloporidae corals in sections of reef slope with fast water flow. In this manner, the dominant types of coral species change in a zonal fashion from the coast outward. For aquaculture and planting of corals, this zonal distribution of corals must be taken into consideration, and the types of corals suitable for the location must be selected. It is also necessary to check the past and current coral inhabitation on adjacent rocks and to take the effects of inland water into account.

11.3.2 Coral Aquaculture in Sand and Gravel Bottom

Coral stick culture is suitable for sand and gravel bottom sections between the area immediately outside the Poritidae coral zone of lagoons and the back reef portion of reef flats, where corals do not normally grow. Sticks are installed in the sand and

gravel bottoms of lagoons, and corals are grown at a height of approximately 50 cm from the sea floor. This exposes corals to fast water flow and enables the growth of corals that prefer sections of reef slope with fast water flow, such as Pocilloporidae corals. Furthermore, faster water flow makes bleaching less likely to occur even when the water temperature is high. Natural branching stony corals such as *Acropora muricata*, polyps (soft bodies of coral) in coral base die once the colonies grow large. However, with this type of aquaculture, sufficient sunlight reflected off the sea floor reaches the bottom part of corals and allows firm adherence and survival of polyps in coral base even after the colonies grow large. Since corals also grow toward the sea floor, they become spherical in shape.

OVFC is currently implementing the aquaculture of 54 species from 10 families and believes that many adherent corals can be grown in aquaculture. The eggs and sperm of clone corals taken from the same coral colony (a large coral, which grew from a small cell by cell division) are incapable of fertilization. The test results obtained by the Okinawa Institute of Science and Technology Graduate University on the genetic information of aquacultured corals being grown by the Cooperative revealed that many of the corals of each species were genetically diverse rather than genetic clones. In other words, the eggs and sperm of the corals that the Cooperative have grown through aquaculture and planted to mature are capable of fertilization, which means they are supplying larvae to the surrounding waters.

11.3.3 Development of Aquaculture and Planting Techniques for Corals

The seaweed aquaculture techniques, including those for Mozuku stick and net culture, that OVFC has independently developed and accumulated are applied well in the Cooperative's aquaculture and planting techniques for corals. Their keen, observant eyes on marine organisms as fishery operators and the will and pride to challenge a new field greatly support their activities (Yanaka 2019). Each aspect of the techniques is described below.

1. **Characteristics of planting base for coral seedlings**

   In Okinawa Prefecture, it is required that corals be affixed to an artificial object at the time of coral planting. Although corals were affixed to metallic screws early on, from 2005 on, the base material was switched to plate-type bases cut out from natural stones (fossilized Poritidae corals). Okinawa Cement Industry Corp. had developed artificial bases for giant clams using Mag-white, which is an environmentally friendly soil hardening agent extracted from seawater. Therefore, we asked the company to make plate-type bases in 2009, cylindrical stick-type bases in 2012, and prism stick-type bases in 2015. While corals easily adhere to bases made of Mag-white, they have differing characteristics depending on the shape of the base (Fig. 11.4).

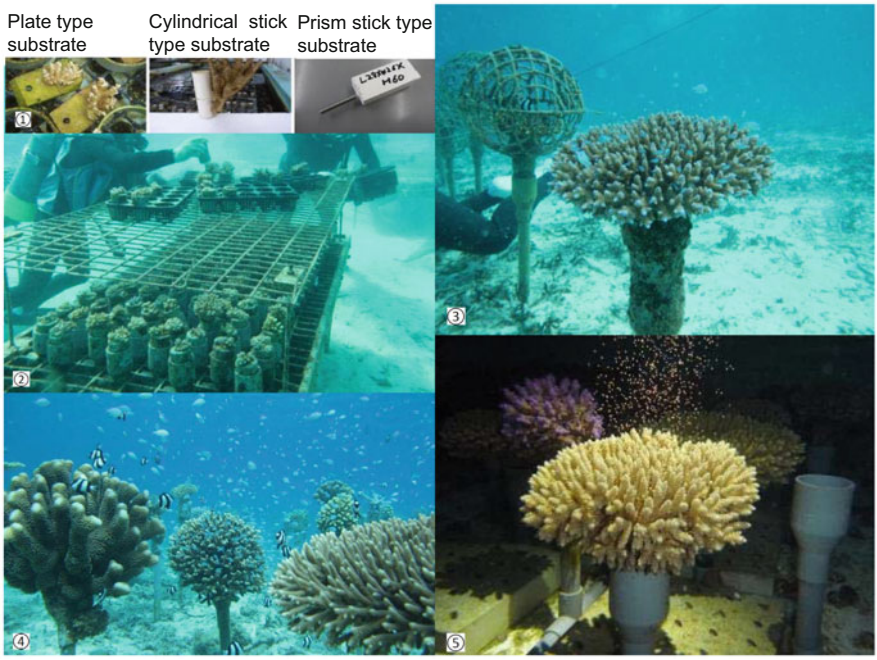

Fig. 11.4 The process of aquaculture and planting of corals. (1) Artificial substrate, (2) middle stage nurturing, (3) protective cage, (4) coral stick culture, (5) spawning

Although plate-type bases are convenient in terms of portability due to their compact size that measures 3 cm width × 6 cm length × 0.9 cm height, placing corals horizontally on the bases caused problems whenever the intermediate nursery period was long, since corals would grow too large and block the holes for installation. Moreover, because plate-type bases are limited when it comes to growing large-sized seedlings, corals exhibited higher mortality in early stages, which remained at around 50% in 2–3 years. Therefore, the use of these bases also required the installation of protective baskets to prevent initial mortality caused by fish.

Stick-type bases are intended to enable the faster growth of large-sized seedlings. By taking advantage of the characteristics of corals that they easily adhere onto Mag-white, we expected the corals to cover the surface of the bases, thereby making it work as an imitation skeleton. What we conceptualized was that the amount of energy the corals must exert for the skeleton formation can be reduced by the volume of the base, and the amount of energy unused can be used for coral growth instead. The cylindrical stick-type bases were designed to have a height of 8 cm to fit the root portion of tabular coral *Acropora hyacinthus*. However, because of the cylindrical shape, these bases would spin around if they were hit by strong waves in the early stage following the installation, and this prevented corals from adhering to the bases for a long time. As a countermeasure,

the bases were modified into a prism shape to suppress the spinning, and simultaneously, the height was changed to 6 cm to fit the corymbose tipped *A. tenuis*.

2. **Intermediate breeding**

   Before planting corals, they are nurtured in shelves set up on intermediate breeding area. The distance among the corals on the shelves needs to be sufficient by considering the amount of coral growth during the nursery period (Fig. 11.4). This method of "intermediate breeding" was inspired by our experience in Mozuku aquaculture. In Mozuku aquaculture, nets seeded in onshore water tanks are temporarily kept in a nursery set up directly on the sea floor in eelgrass beds to promote sprouting after seeding. Once Mozuku grows up to 10–15 cm long, they are moved to their permanent beds further away from the coast.

3. **Attachment of seedlings onto bases and planting**

   When attaching corals to bases, the coral fragments must be positioned as close to the bottom of the bases as possible so that the corals can adhere to the bedrock as fast as possible. Although seedlings often adhere onto the shelf surface during the intermediate breeding period, they can be easily peeled off the shelf surface. When planting the seedlings, it must be ensured that the bottom surface of the bases is in contact with the bedrock. Planting is done by boring a hole in the bedrock and fastening a screw attached to the bottom of the base into the hole. If boring is done by a skilled operator, even tourists can participate in the planting activities.

4. **Species and density of corals to be planted**

   The types of corals to be planted should be selected from the species that inhabit the area adjacent or similar to the area to be planted. When planting corals in an area for the first time, a few species should be selected to discover which species best match the area. If corals are being planted improving the underwater scape promptly, you would probably hope to plant many species at high densities. However, when corals get close to each other, they start competing for space, which tends to slow down their growth. At the time of planting corals, sufficient space needs to be secured among them by taking their growth into account. In cases where spawning of corals is the objective, corals that are of the same species but are not identical clones should be planted in close proximity to each other while taking the number of breeding corals into account.

5. **Management after planting**

   When corals are planted in areas where there are no corals in proximity, they occasionally suffer from predation by fish species that feed on corals. Although protective baskets can be used as a countermeasure in cases of small-sized seedlings, the baskets cannot be used for large-sized seedlings. In such cases, the damage to each colony can be reduced by planting a larger number of seedlings. Moreover, if damselfishes start dwelling in corals, they protect corals by attacking other fish such as parrotfish. Furthermore, because COTS and *Drupella* snails tend to gather on planted corals, eradication activities need to be implemented periodically.

6. **Coral planting by sexual reproduction method**

   Coral planting methods can be roughly divided into asexual and sexual reproduction methods. Coral fragments broken off by waves propagate asexually and form new colonies. The asexual reproduction method uses this ecology, by planting coral fragments taken from parent colonies into the sea floor. With the sexual reproduction method, the larvae of corals produced by sexual reproduction are adhered on bases and planted in the sea. This method can be implemented in the sea by adhering to naturally occurring larvae on bases or in onshore water tanks where corals are spawned and the resulting larvae are adhered on bases.

OVFC has been engaged in coral planting using the asexual reproduction method since the cultivation of coral seedlings is more efficient with this method. From 2013, it has also been engaged in the sexual reproduction of corals. Through the following processes by 2016, approximately 15,000 corals have been planted under the Prefectural Government project: (1) Breeding corals taken from the coastal area in Onna Village are transported to the Aka Island or Kume Island where onshore hatchery facilities are located. (2) The corals are spawned on one of the islands, and larvae attached to bases are transported back to Onna Village. (3) The corals are grown in the intermediate breeding for approximately 2 years in the sea of Onna Village. (4) The corals are planted in the area of the sea, which is suitable for the specific species. With the sexual reproduction method, larvae are adhered on plate-type bases made of Mag-white. These bases are then bound to stick-type bases and put in the nursery and then planted. Through these processes, the same nursery and planting methods as the asexual reproduction method can be employed for the sexual reproduction method.

11.4 Nurturing of Coral Reefs

11.4.1 Chura-Umi Plans

In 1994, OVFC established the Chura-Umi plan which was a comprehensive plan to promote activities of OVFC and members of OVFC. In 2000 and 2007, OVFC revised the plan to Chura-Umi plan Part 2 and Chura-Umi plan Part 3. The objectives of the Chura-Umi plan Part 3 were the development of human resources who can achieve their roles and village planning that is friendly to the people, the society, and the environment. Additionally, as the philosophy, it clearly writes that the Cooperative members shall perform fisheries friendly to the environment and ecosystems and perform the "Satoumi Creation Campaign" whereby they receive the rich blessings from the sea and at the same time also protect and nurture the beautiful sea using the blessings (OVFC 2008).

To implement the Chura-Umi plan Part 3, we needed not only vital activities of the members of OVFC but also collaborations with a variety of organizations and people. We should ask for cooperation from people who are linked to OVFC through the keywords "the sea," "people," "Mozuku," and "life" and ask them to help out in

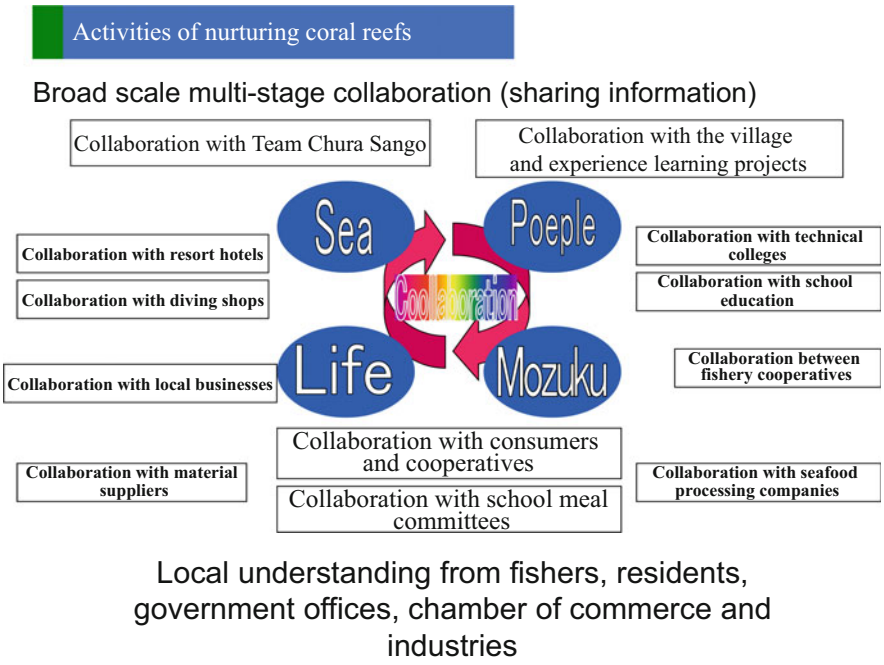

Fig. 11.5 Satoumi creation involving diverse stakeholders

their area of specialty (Fig. 11.5). The keyword "the sea" encompasses the planting of corals in cooperation with Team Chura Sango and resort hotels in the village, while "people" includes the nurturing of seedlings in cooperation with the project for experience and learning, "Mozuku" includes the Onna Village Coop Coral Forest creation activities (coral aquaculture) performed in cooperation with the consumer cooperative, and finally the keyword "life" encompasses the development of coral-related materials in cooperation with local companies. Although each activity is one fragment, as a whole, they function at a great scale.

11.4.2 To Prevent the Runoff of Red Soil

It was after the handover of Okinawa to Japan in 1972 that the problem of red soil runoff emerged in Onna Village. A large amount of red soil ran off into the coastal waters because of resort development and the bypass and expansion constructions for National Route 58, which were done in a rush to be in time for the Okinawa International Ocean Exposition of 1975. In accordance with the Special Measures Law for Development of Okinawa (to be referred to as "the Okinawa Development Law" for short) was enacted in 1972 as a law of specified duration for 10 years. It was extended in 1982 and 1992. The agricultural land improvement projects started

and made the problem of red soil runoff worse. The extent of red soil runoff around this time period was so ferocious that mud would build up on tidal flats after heavy rain, and they became just like rice paddies. Virtually everywhere in Onna Village was contaminated with red soil back in 1974, and Higa (one of the co-authors) remembers being in a fierce rage as a child, seeing the pure white sandy beach get contaminated with red mud in a short time. The sea floor Higa saw from a glass-bottom boat in 1983 was always turbid near the coast, and he witnessed a large school of *Diadema* (sea urchin) species, which inhabit areas with high turbidity. The scenery is not even imaginable today.

While Mozuku aquaculture was performed successfully for the first time in 1977 in Onna Village, in the following year, 1978, red soil runoff caused damage to Mozuku and Hitoegusa seaweed. Although the fishers at the time strongly protested to persons in charge, given the Okinawa Development Law was a law of specified duration with 10 years of validity, the social trend was all for development. Thus, fishers protesting about red soil runoff generated a sense of alienation as if they were an obstacle to developing Okinawa.

By around 1989, red soil runoff became a public concern. The wider public began to think what they had lost in exchange for developing Okinawa and whether the tertiary Okinawa Development Law should be left unchanged. In 1998, led by the Okinawa Fisheries Foundation, several fisheries cooperatives and Prefectural Government officials held a meeting, and the Red Soil Runoff Prevention Council initiated its activities. As a representative from OVFC, Higa joined the Council and could obtain much knowledge and action guidelines. At the Council, the state of red soil runoff at various locations in the prefecture was surveyed, and at the same time, guidelines for countermeasures were talked about. These activities developed into a movement to demand the Prefectural Government to establish a red soil runoff prevention ordinance.

In 1989, the OVFC Fisheries Revitalization Plan was devised, and it says that OVFC would engage in the prevention of red soil runoff. It also established the basis that red soil runoff is not a natural disaster, but rather a type of pollution. As long as it is pollution, it must have a cause and a polluter. Therefore, we decided to demand the polluters to take measures to prevent runoff. Every time we had a heavy rainfall early on, we would go running out in a raincoat and rain boots to try identifying the source of pollution. However, with this method, we would find ourselves running behind.

For this reason, we decided to persuade those in charge of private resort development in Onna Village that the reason they are developing in our village is that the sea off the coast of Onna Village is attractive as a resort area and that the sea, which is a fortune belonging to us all, should not be polluted by their company's act of development. Upon prescribing the size of the sedimentation basin needed in "the agreement of prevention of fishing rights violations for No. 6 common-fishery-right area," we developed a system of preliminary arrangements for persuasion, whereby the consultation is held regarding pollution prevention measures and a facility for pollution prevention is prepared and checked before the start of the actual development (Yanaka 2000). Furthermore, we requested the village municipality and local districts to sign a similar agreement, and together, we agreed that all the parties are to

attend the consultation for pollution prevention with the developers. By establishing that each party will be responsible for paying for its own expenditure for this process, the autonomy of each party is respected, preventing them from being restricted by the budget. In agreement with the prevention of violation, we made a provision that states "If the developer receives from OVFC a request to improve the cases of red soil runoff but does not obey, OVFC will set up a sign that states 'It is a construction site, which polluted the public coastal waters.' at the construction site. The developer shall not object." However, we have never had to set up such a sign so far.

In the second Onna Region Fishery Activities Plan established in 1990, the basic stance on the prevention of red soil runoff is described. Among the citizens of Okinawa, those who receive direct damage from red soil runoff are the fishers, and the parties who cause the red soil runoff are only a portion of the population. Since most of the citizens of the prefecture would have third-party positions in these cases, we decided to adopt measures to bring many citizens on our side.

First, OVFC and fishers have a social responsibility to protect the sea and contribute to the community. We should obtain an understanding of the residents of Onna Village for preventing red soil runoff. The members of the Cooperative shall conduct promotion activities so that "each member persuades one person" at the least. Regarding measures to be taken in cases of red soil runoff, the source of runoff and state of pollution must be examined in addition to conducting research of damage on fisheries. An examination of the source of runoff is particularly important. Even if there are many polluters, only one needs to be identified. To the polluter who has been identified, we request improvement and ask for specific measures. Furthermore, based on the belief that damage should be prevented rather than treated, preliminary consultation and preliminary checks shall be conducted. For these, we will sign the agreement of prevention of damage with the developers. Regarding the prevention of damage, we exercise our right to claim damages or losses in the civil law, rather than the fishing right. If any damage is caused, we will publish the details of the damage in the newspaper and on TV. There is no need to fear harmful rumors for fisheries products. We will explain the conditions of Mozuku that received damage and explain that it will not be put in the market. Essentially, all members of the Cooperative shall participate in these. All members serve as a watch of fishing grounds and report to the Cooperative if they find a site of red soil runoff or a site where runoff is likely to occur. The ground rule is that we must protect our own sea. Moreover, for the preventative measures against red soil runoff, the activities conducted in Hokkaido for many years greatly helped us and encouraged us (Nemuro District Fisheries Cooperative Directors Council 1992).

As with private constructions, the Red Soil Runoff Prevention Council of Onna Village has been adopted for municipal agricultural land improvement projects in the village. The preventative measures against red soil runoff conducted in Onna Village in 1994 prevented approximately 97% of spillage compared to no measures. Although Onna Village experienced red soil runoff from a US base in 1992 and from the construction site of a national route in 1995 when the damage on fisheries was caused by the construction of coastal revetment in Yakata-katabaru tidal flats, no incident has happened since 1996. In the Yakata-katabaru tidal flats, where many red

soil runoff prevention measures have been taken, the yield of Hitoegusa seaweed has been increasing from approximately 11 tons in 1991, which was the worst year, to around 60 tons in 2002. The effectiveness of prevention measures is obvious. If red soil runoff can be improved further, the basic yield is estimated to increase to approximately 70 tons per year based on the area and basic productivity of the tidal flats (OVFC 1995).

11.4.3 Eradication of COTS

The eradication of COTS is also one of the active measures for the creation of Satoumi, where direct human interventions are implemented to protect biodiversity. A major objective in the eradication of COTS is to prevent their outbreak, which occurs periodically. To do this, the pattern of outbreaks and the movement of organisms must be grasped, and measures that suppress the COTS reproduction should be taken.

In the sea of Onna Village, the process to outbreaks and the annual movement of COTS show certain patterns. Since the first large-scale outbreak at the southernmost part of Onna Village in 1969, there have been three major COTS outbreaks on a 12- to 13-year cycle, occurring in 1971, 1984, and 1996. Their occurrence has been chronic even in other years. In the second year of life, COTS grow up to approximately 20 cm in length and are capable of spawning. They grow about 10 cm in length per year, becoming as large as 80 cm in length. Around Okinawa Island, their spawning period starts in July or later when the water temperature reaches 28 °C. COTS arises from deeper sections of the sea to the reefs in spring and fall.

Figure 11.6 indicates the number of COTS removed and the number of participants of eradication from 1983 on. Although removal activities were conducted

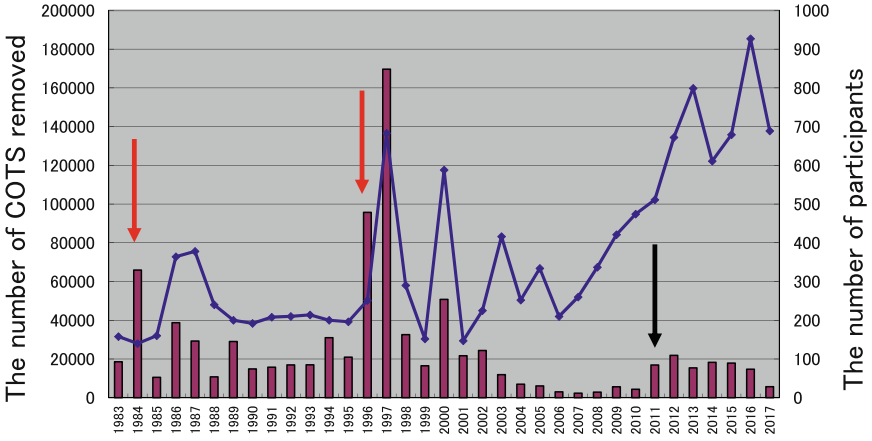

Fig. 11.6 The number of COTS removed and the number of participants

consistently every year, the outbreaks occurred in 1984 and 1996. However, after the outbreak in 1996, removal activities were conducted monthly, with the numbers of total participants and COTS removed in 2 years being 992 people and approximately 270,000 COTS, respectively. Early in 1998, we had estimated that we protected corals in approximately 700 ha, yet many corals died during mass coral bleaching that occurred in the summer of 1998. Although we could not protect corals in the end, it gave us the confidence that corals can be protected through human interventions. Accordingly, from 2002 on, we set it as a goal to prevent the fourth outbreak.

An outbreak of COTS is estimated to occur when these four factors are present at the same time: (1) increase in the number of adult COTS (increase in the number of larvae), (2) increase in the arrival rate of COTS larvae, (3) increase in the number of calcareous algae which young starfish feed on, and (4) increase in the amount of corals in the deeper sections of the sea. Since factors 1 through 3 are present in the sea off Onna Village, it is most likely that COTS outbreaks are occurring concurrently with the recovery cycle of factor 4, corals in the deeper sections of the sea. Therefore, regarding the direction of COTS countermeasures, we believed the best measure was to remove adult COTS effectively in all sections of the sea off Onna Village and decided to remove COTS of spawning size before the spawning season.

At the time of COTS removal, we divide the sea area off the coast of Onna Village into five sections and determine where to work on that day to ensure complete removal. The removal operation is conducted by groups of three to six fishers per fishing ship. While tagging a small boat of approximately 2 m in length and using a harpoon or hook, each of them catches COTS by free diving. With this method, the fishers can check broad ranges of the sea down to depths of around 5 m.

For each fishing ship, every COTS removed is recorded in terms of the date, time, and location of removal and length in 5 cm increments. The measurement results are used to create a table of length frequency by day and by location, which are provided to the fishers as the removal results by the following day. As removal activities are conducted repeatedly, the removal data demonstrate the decreasing density and size of the individuals which were removed. As well, the size-composition graphs reveal the order of priority for the sections to be worked on, or in other words, the graphs visualize those sections that they have missed, thereby motivating the fishers. On a long-term basis, the spawning season of COTS is believed to be from around July to October in the sea off Onna Village. By reducing the density during the spawning season, we expect to successfully suppress their occurrences in 2 years later. Although the number of COTS removed has been on the rise since 2011 in the sea off Onna Village, the fourth outbreak has been successfully avoided by recruiting more than 500 people every year for removal.

11.5 Co-creation of Satoumi

11.5.1 The Relationships Between Igeta Takeuchi and the Area of Mozuku Production

Igeta Takeuchi, Co., Ltd. is a fishery processing company based in Sakaiminato City of Tottori Prefecture, Japan. It was the first company that merchandised seasoned Mozuku in consumer packs. Because the sea off the coast of Okinoshima Island in their prefecture produced a large amount of natural, high-quality Mozuku, they used it as the material for their products. Although they developed the products, it was difficult to secure a section at supermarkets since the seasoned Mozuku was barely known to consumers at that time. Although the sales of products increased due to the growing awareness of health among consumers, the yield of natural Mozuku kept decreasing nationwide in inverse proportion. As with the rest of the country, the yield of Mozuku raw material from the waters off Okinoshima Island became unstable as the years go by. Thus, the company needed to procure new materials.

It was in September 1984 that Amane Takeuchi (one of the co-authors) of Igeta Takeuchi, Co., Ltd. visited OVFC for the first time. Takeuchi started buying materials from multiple areas of production in Okinawa since 1985 on. As he continued doing business with them, he grew strong beliefs that, to make good products, he should have a producer whom he can sincerely consult regarding the quality of the materials, which requires the producer to be independent. More than anything, he also strongly believed that good products cannot be made unless both parties trusted each other. After he began his business with OVFC in 1986, he found the producers of OVFC to be fully independent and trustworthy. He then started to do business exclusively with OVFC in 1992, thereby starting to make a brand new relationship.

Although focusing his material procurement only on one cooperative increased his business risk, this was a big decision he made to develop trust. This was the beginning of their relationship as partners of value creation, rather than just a seller and a buyer. The businesses of producers and manufacturers can only be viable when they can contribute to the society. For this, it is important to improve the quality of the role each party plays. In other words, the producer and manufacturer should make up for to complete each other and build a better relationship in which they co-create value. Based on the above concept, they have been abiding by the following three fundamentals: (1) establishment of quality standards, (2) purchase by manufacturer done in ways that comply with the production plan of the producer, and (3) feedback of the needs of the product users or consumers.

While No. 1 fundamental should be in place naturally, most importantly, the quality standards must be based on mutual understanding between the producer and manufacturer. No. 2 is in place so that the efforts made by the producer can be rewarded economically. What No. 3 encompasses is the provision of feedback from the manufacturer to the producer on behalf of the product users regarding the evaluation of the products grown by the producer, including the challenges and

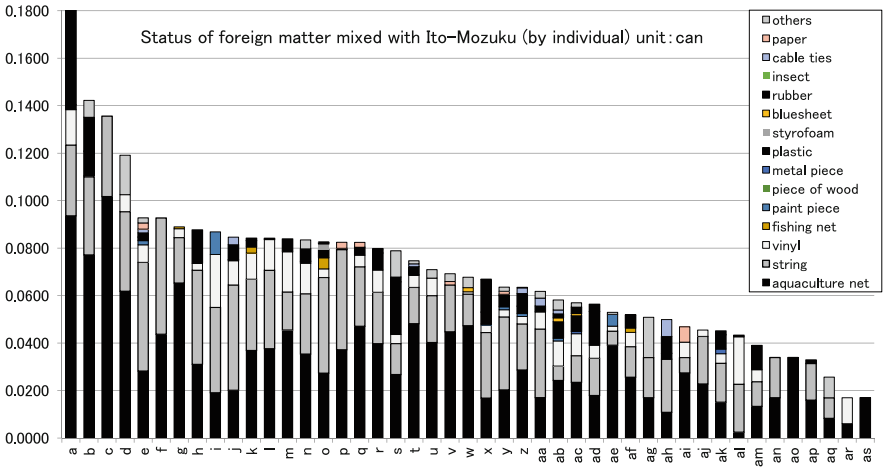

Fig. 11.7 Efforts to reduce foreign matter mixed with Ito-Mozuku

complaints. What is important here is that the manufacturer does not give specific instruction or demand to the producer but rather provides facts and voices from the product users so that the manufacturer can help the producer devise measures to improve and take action on their own. For this purpose, in 2000, they arranged it so that the quality of Mozuku can be clarified from data on producer identification, the day harvested, and location of Mozuku aquaculture based on traceability. Igeta Takeuchi published these data on quality during the producer meeting held annually prior to the Mozuku harvest season to improve material quality. The quality evaluation for each individual was shown to all producers, and the producers who exceled were given awards. In this fashion, by visualizing the efforts of producers, traceability data are also utilized as evaluation items to recognize those who worked hard (Fig. 11.7).

When Takeuchi first started visiting Okinawa, there was a big distance between producers and product users. Producers were isolated without being able to obtain the necessary information. With regard to the process where producers get connected to the society through their products, the manufacturers are closer to the product users. Therefore, if the manufacturers can provide the producers with the information about what product users require, this becomes added value for the manufacturers, at the same time as being attractive to the product users. Such co-creation relations based on trust greatly contribute to the management of the sales of the products and lives of the producers. As a result, the income of the producers has become stable, and approximately 40% of members of OVFC is the successors of their family business that are 40 years old or younger. This reflects that the co-creation relationship between producers and manufacturers has started to bring great value to both parties, and rich Satoumi is essential as the source of the value (Omoto 2017).

11.5.2 The Concept of "Mozuku Foundation"

OVFC has been engaged in Satoumi activities including coral reef conservation such as red soil runoff countermeasures and eradication of COTS and has made great achievements. However, global coral bleaching occurred due to El Nino in 1998, and this also caused extensive damage to corals, which played a central role in Satoumi of Onna Village. The bleaching was so serious it drastically changed the view under the sea, and producers including Mr. Munekazu Mekaru, who was an OVFC member, began their attempt to restore corals. They started working on the aquaculture of corals in 1998 and devised the stick culture method for corals by applying techniques for Mozuku (Yanaka 2019). Though this method of aquaculture, which was originally unique to OVFC, enjoyed a reputation as a superior method effective for coral restoration, they could not receive financial support from the government as it was an independent project of a fisheries cooperative.

Simultaneously the market for Mozuku products experienced large changes in 1998. Just as corals underwent bleaching due to high water temperature, the yield of Mozuku was severely affected that year. However, the size of the market for Mozuku products greatly increased as the health benefits of Mozuku were repeatedly featured by health information programs on TV. Yet, this enlarged market size caused many companies to enter the market, which caused them to be bombarded with competition for lower prices led by large-scale stores (large supermarkets) from 2005 on. Okinawa did not have a price making mechanism for Mozuku raw material, and the demands of the buyers were easily reflected in the purchase conditions that the producers were given. Thus, price competition at the stores drastically reduced the purchase price of the products, and as a result, many of the producers abandoned Mozuku aquaculture. The producers were cornered so badly and they even organized a protest in 2009. In response to these situations at the places of production, some attempts were made to survive in the market for Mozuku products by reducing the quality to be able to match the lowered prices. They were on the verge of losing the trust of the consumers.

Whereas the producers and manufacturers had the shared aspiration of making good Mozuku products that consumers would rejoice, the strong trend toward lower prices made it necessary that we make a new answer to the question "what are good Mozuku products that consumers would rejoice?" The source with which the producers and manufacturers create value as businesses is in the Satoumi of Onna Village, and corals play the central part in Satoumi. From early on, the producers belonging to OVFC were engaged in activities to protect Satoumi including the prevention of red soil runoff and eradication of COTS, and they had already gained the trust of the municipality and community in the village. To recover the richness of Satoumi as it once was, the producers of OVFC were continuously trying to increase the coral population. Thus, once the aquaculture techniques for corals were starting to be solidified in 2007, we decided to implement the concept of the "Mozuku Foundation," which we had been contemplating for some time.

Table 11.1 Used Mozuku products for the Mozuku Foundation and the number of cultured corals

The number of used Mozuku products for the Mozuku Foundation (unit, pack)						
Coop	Pal system	Tokai Coop	CS-NET	Total		
Before 2012	856,952	553,708	859,045	2,269,705		
2012	1,117,448	678,250	986,238	2,781,936		
2013	953,890	735,055	872,116	2,561,061		
2014	924,484	750,983	923,868	2,599,335		
2015	1,118,302	782,068	955,040	2,855,410		
Total	4,971,076	3,500,064	955,040	13,067,447		
The number of cultured corals						
Coop	**Onna Village Fisheries Cooperative**	**Pal system**	**Tokai coop**	**CS-NET**	**Others**	**Total**
Before 2012	2254	3300	552	127	117	6350
2012	450	1000	208	780	143	2581
2013	2076	1008	247	806	169	4306
2014	1193	1000	260	680	286	3419
2015	265	1000	260	715	247	2487
Total	6238	7308	1527	3108	962	19,143

Only with rich Satoumi, we can harvest high-quality Mozuku. Mozuku is the blessing of Satoumi of Onna Village. It is not just the producers and manufacturers that are receiving the blessing of Satoumi, but the people in cities who eat Mozuku are also receiving the blessing without realizing it. For this reason, we thought we may be able to get the product users to participate in our coral restoration activities if we could notify them of how Mozuku is grown in Satoumi and, as the background of the products, that the producers have been trying to restore corals. Based on these ideas, we determined to (1) notify product users of the details of activities performed by producers and (2) define "the participation" of the product users in these activities as their support provided in the form of coral restoration fund, which is part of the product price (1–2 yen per pack) (Table 11.1). Although we were not sure whether a concept like this could be accepted, we were feeling gradual changes and diversification in people's sense of values from 2000 onward. Thus, we decided to take chances to gain understanding and empathy for these activities, which are to be handed down to future generations.

The stick culture method for corals devised by OVFC is a highly original, effective method. However, coral restoration requires activities that take an overwhelmingly long time. Hence, it cannot be achieved merely by the good will of the locality but rather requires an independent and continuous framework. What Mozuku Foundation was aimed at were to get many people to participate, though they may be far from Satoumi nevertheless connected to it through the purchase of the products, and to construct a system to create a shared value of coral restoration through the cooperation of many people involved in the blessing of Satoumi,

including producers, manufacturers, and users of Mozuku products (Yanaka 2012, 2014; Sato 2016).

Although we had chosen to sell products with donations at the time, we wanted to make this Foundation a system whereby we create Satoumi with people who are using our products. Therefore, we determined to engage in the Mozuku Foundation with consumers' cooperatives with whom our message can be delivered to specific masses properly. From 2007 on, we proposed this plan to consumer cooperatives we had business with, and we received much approval. In 2008, the first fund was founded in Co-op Shimane, and the Onna Village Coop Coral Forest Liaison Committee (n.d.) was founded by consumers' cooperatives in various areas, OVFC, Igeta Takeuchi, and Onna Municipality. In 2015, the relating organizations had spread to consumers' cooperatives in Tokyo and 28 prefectures, with the number of co-op members covered being approximately 6.7 million. OVFC was given the award of Minister of Environment for its activities at the 16th National Convention for Developing Abundantly Productive Sea. Based on these movements, the declaration of "the Village of Coral" is defined as an important measure in the 5th Comprehensive Master Plan of Onna Village (latter period, 2017–2021), which demonstrates that co-creation of village planning has already started.

11.5.3 Establishment of the Shared Value of Satoumi and Roles of Each Stakeholder

The reason we have chosen specific, not unspecific, masses who purchased the products as targets for participation in the Mozuku Foundation was that we believed interactive relations through the products were important. It is important to notify the product users of the thoughts and efforts of the producers behind the products so that they would realize that the products are filled with the blessing of Satoumi. Simultaneously, it is also important to notify those who participated in the activities through product usage the actual results achieved by the usage. Igeta Takeuchi holds study sessions for consumers' cooperatives, whereas the producers belonging to OVFC visit consumers' cooperatives all over Japan to hold seminars and exchange meetings. It also helps greatly that they provide an explanation for the Mozuku Foundation on their shopping catalog, which is the most major line of business of the consumers' cooperatives. We also make opportunities for members of consumers' cooperatives to visit Satoumi of Onna Village so that they can understand the thoughts of the producers and feel engaged in Satoumi activities by checking the state of coral restoration for themselves and experiencing the actual operations of coral aquaculture. In particular, "the visit to producing place by parents and children" tours held during the spring and summer vacations are also important in terms of the purpose of these activities to hand down to the future generations (Fig. 11.8).

Fig. 11.8 The visit to producing place by parents and children of consumer cooperatives

Also, while these activities are conducted mostly by young producers, the fact that they get to meet the product users, exchange opinions, and see for themselves that their work is needed provides excellent learning opportunities. By getting to know each other through Mozuku, consumers find new appeals, while the producers gain new motivations. In other words, these sessions provide both parties with opportunities to find new values and sustainability for the future.

The most important target of coral aquaculture and planting is for the eggs being spawned from the breeding corals that were aquacultured and planted to assist in the natural restoration of corals. Through the Mozuku Foundation, approximately 24,000 colonies of breeding corals were grown in aquaculture fields from July 2009 up to the end of March 2017, and we have come to see approximately 5.7 billion eggs being spawned every year. The co-creation relations that have lasted for more than 30 years between the producers of OVFC and manufacturers have generated many values for both the parties. From this experience, we have come to realize that the power of co-creation is necessary for these activities to restore corals in Satoumi through the efforts of the producers, manufacturers, and product users.

The product users are receiving the blessing of Satoumi without realizing it, in their daily life far from Satoumi. By notifying this fact, they will find a new value in the products. By learning the background of products, mere purchase of a product turns into an opportunity to preserve rich Satoumi for future generations. For this

purpose, important things are clarity, so that anyone can understand, and objectiveness to describe the status and results of the activities accurately. You should not be too optimistic about facts, but not pessimistic about them, either. Most importantly, do not skew facts for commercial purposes to promote the products. These activities are not temporary, and they would not work out without continuity. We cannot continue forward unless we provide all participants involved with the accurate facts and use the knowledge that everyone has, with the trust and cooperation from every participant. Through the efforts made so far, we have realized that trust is the most important.

The co-creation relations centered around Satoumi are based on mutual benefits. Continued usage is only possible with valuable products. The producers and manufacturers should produce appealing materials and products in the first place. The product users can support the creation of Satoumi through using products that they need. In other words, the basis of these activities is to learn what other parties need and to want to help each other. The activities to create Satoumi cannot be completed only by producers and the people in the community. The more attractive the Satoumi, the more hidden values it has. However, the values of Satoumi stay buried for many people. One way to solve this problem is to widely announce the values and appeals of Satoumi through co-creation relations to gain support for creating Satoumi from the wider public.

Our society works out based on the provision of necessary products by people of various occupations. For the co-creation of the value of Satoumi, the addition of people of various positions complements the relationships among them and generates synergistic effects. As the richness of Satoumi requires biodiversity, people involved in the activities also need to be diverse. Most consumers do not think that their product use can change anything. However, even in cases of small-scale product use, people can have the power to change if they get connected with sincerity. Just as corals have been growing over a long time, continuous activities by connected parties will have a great power over Satoumi creation.

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Chapter 12
Divers and Fishermen Working Together to Create Satoumi

Masaru Kanda and Mayuko Shimizu

Abstract The sea of Kashiwajima Island, located in the southwestern tip of Kochi Prefecture, is a miraculous Satoumi that is home to many living creatures and provides abundant blessings to humans. This chapter traces the history of the creation of the Kashiwajima Satoumi from the perspective of Masaru Kanda, who founded the Kuroshio Zikkan (feeling) Center and has developed activities to protect the island's nature and lifestyle culture. In particular, the activities to set up artificial spawning beds for the bigfin reef squid [*Sepioteuthis lessoniana*], which have been undertaken together by divers and fishermen who use the sea as a place of livelihood, represent the Satoumi as an activity in which people cultivate and enrich the sea. We consider the activities of the Kuroshio Zikkan Center as "residential research," which is research and practice to solve local problems. This paper discusses the role of the Kuroshio Zikkan Center and Kanda himself as a "residential research institute/researcher" who uses a variety of knowledge and designs practical activities in the Kashiwajima Model of Satoumi creation that expands and deepens the ties among people and between people and nature.

Keywords Satoumi · Environmental education · Field museum · Residential researcher · *Sepioteuthis lessoniana* · Spawning bed

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12.1 Original Scenery of Satoumi

12.1.1 Sea of Miracles

Kashiwajima is an island where fish spring up. It is a small island with a circumference of 3.9 km and a population of about 400, located in the southwestern tip of Kochi Prefecture, a little north of Cape Ashizuri (Fig. 12.1). In the past, a set net fishing called "Tuna Oshiki" was conducted. At its peak, a single set net in a small bay was said to hold 2400 yellowfin tuna *[Thunnus albacares]* over 1 m in length. The small island is surrounded by a magnificent natural environment.

The author (Kanda, hereafter) first visited Kashiwajima in 1987, when he was a first-year university student studying fish ecology. He still remembers the shock of diving in the sea of Kashiwajima for the first time, accompanied by a SCUBA diving friend. There were no diving shops on Kashiwajima at the time, so they drove from Kochi and entered the sea from the beach on the north side of the island, and as soon as I put my face in the water, I was struck by the sight of corals spreading out all

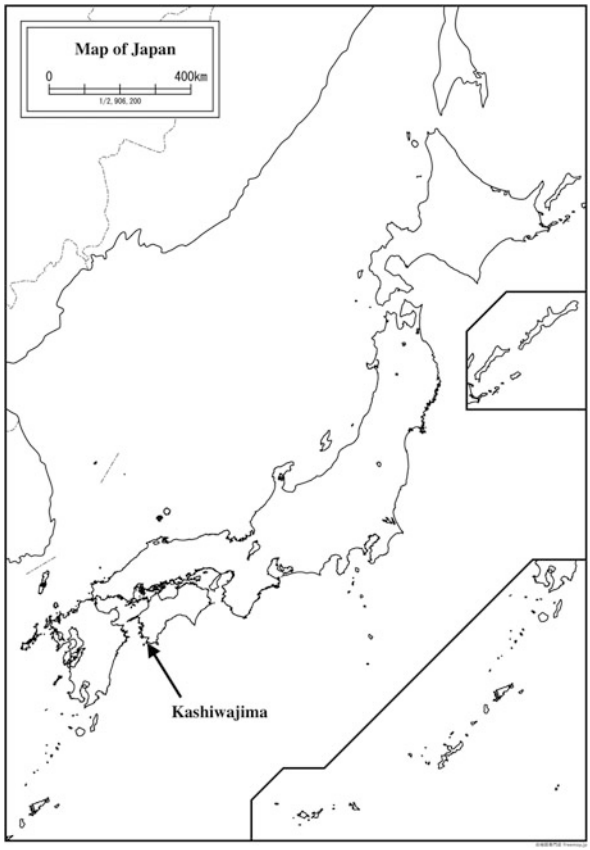

Fig. 12.1 Location of Kashiwajima

Fig. 12.2 The sea of Kashiwajima crowded with coral reefs, soft corals, and subtropical fish

around, schools of small fish blocking my view, and countless colorful fish. Despite being in a temperate zone, the clarity of the water was so high that it was almost subtropical. Even when we approached, the fish did not run away and were not afraid of us. The fact that so many fish can be found right in front of a human settlement on an island where fishing is the main activity must be due to the good relationship between people and the sea. I thought it was a true "Sato's (village's) sea." This is the original landscape of "Satoumi" for me.

According to the "Fish Fauna of Kashiwajima, Kochi Prefecture" published in 1996, 884 species of fish in 143 families were reported. There are still about 100 species that require further study because they may be undescribed species or species recorded for the first time in Japan (Hirata et al. 1996), and the number of species is now said to exceed 1000. The number of species is about one quarter of all Japanese fishes. The sea of Kashiwajima is a miracle sea with the largest number of fish species in Japan (Fig. 12.2).

12.1.2 Satoumi Created by Humans and Nature

As a researcher of nature, I find the sea of Kashiwajima attractive not only because of its high transparency and many colorful fish. Such a sea can be found in subtropical regions such as Okinawa. However, the waters of Kashiwajima are sometimes clear and sometimes murky. The clear, nutrient-poor Kuroshio Current mixes with the

nutrient-rich murky waters of Sukumo Bay, creating a complex tidal flow and an ecosystem that is anything but monotonous. The north side of the island faces Sukumo Bay, where the waves are relatively calm and coral communities have developed, while the south side faces the Pacific Ocean, where the waves are high and the shore is rough. The bay is steep and the tidal current is fast. There are sandy beaches, cobble gravel, boulders, rocky reefs, and seagrass beds. There are temperate fish and subtropical fish.

Although it is located in the temperate zone, it has more fish species than subtropical areas such as Okinawa and the Ogasawara Islands. As a researcher of fish ecology, especially rock fish, the more I learn about the waters of Kashiwajima, the more profound they become, and the more they stimulate my spirit of inquiry.

In addition to natural features such as topography, tidal currents, and living creatures, the sea of Kashiwajima is made up of human activities. Today Kashiwajima's fishery is dominated by aquaculture, but in the past, hook and line fishing and set net fishing flourished. One of the reasons for the richness of the sea was the construction of a dike by Nonaka Kenzan, a chief retainer of the Tosa Domain in the early Edo period. During the Edo period, the strait between Kashiwajima and the mainland was constantly frequented by tuna, but the tide flowed quickly and the coast was cut off, making it an unsuitable fishing ground. Kenzan built a stone dike 310 m long, 1.8 m high, and 3.6 m wide and covered it with white sand to create a shoal. The fish that entered the bay through the strait changed direction when they hit the shoal and turned toward the harbor, and as a result of set nets there, yellowfin tuna were frequently caught.

Fascinated by the sea of Kashiwajima, the author has been conducting research there for many years. When I rented a house on the island for 4 months during my master's course and lived there to conduct research, the islanders treated me as if I were a member of their village family. I realized that Kashiwajima is not only a place with a wonderful sea but also a place of great humanity. Driven by a strong desire to preserve the sea of Kashiwajima, I moved to the island by myself and have been involved in activities to create Satoumi. Preserving the sea of Kashiwajima does not mean protecting it by drawing a line and shutting out humans. Rather, I saw it as my mission to "preserve the landscape" of the rich nature and human activities along the seashore that have been passed down from generation to generation.

12.2 The Kuroshio Zikkan Center

12.2.1 Whole Island as a Museum

The purpose of the Kuroshio Zikkan Center is sustainable Satoumi creation. The image of Satoumi I had had since I started the activities in 1998 was a sea where people and nature could harmonize with each other in a balanced relationship, with people cultivating, fostering, and protecting the sea rather than unidirectionally receiving the rich blessings from it. I truly think that the sea of Kashiwajima gave

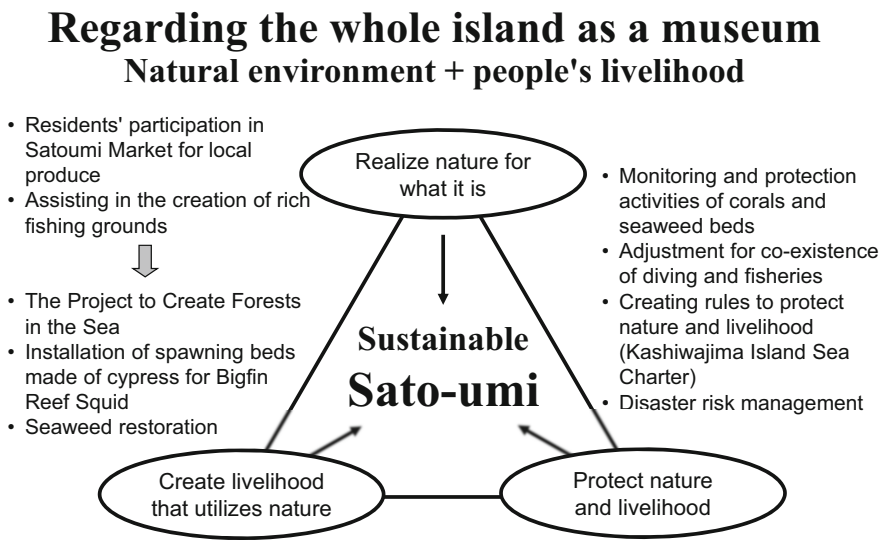

Fig. 12.3 Activity diagram of the Kuroshio Zikkan Center

me the word "Satoumi." Although Prof. Tetsuo Yanagi (one of the editors of this book) had coincidentally defined Satoumi in the same year as "the coastal sea with high biodiversity and productivity under the human interaction" (Yanagi 1998), I arrived at the term Satoumi separately from his definition, based on the relationship between humans and the sea.

Thus, by using this rich Satoumi as my motif, I decided to think of the whole island as a field museum to provide environmental education which all residents, including children and adults, can take part in. While the campaign titled "Forests are Lovers of the Sea" being conducted in Miyagi Prefecture by an oyster fisherman is well known, I had been wishing to start activities on Kashiwajima with which everyone would be able to realize the connections among the sea, rivers, villages, and mountains for themselves. Aiming at an open museum which can enable people to have hands-on experiences with the actual natural environment and ecology of organisms, I got the permission to use an empty classroom in Kashiwajima Junior High School and started making efforts to establish the Kuroshio Zikkan Center in March 1998. Three years later, following the closing of the junior high school in 2001, I obtained the lease of the school building from Otsuki Town and established the NPO, the Kuroshio Zikkan Center, in October 2002. Furthermore, because of the high academic value of the sea of Kashiwajima, I decided to work in cooperation with research institutes including universities so that the Center can take on a role of a research center for marine organisms. In a far corner of Kochi Prefecture, I was yearning to spread the wonderfulness of Satoumi through the Center, a community-based education and research center for marine life. That was the enthusiasm I had when I started the Kuroshio Zikkan Center (Fig. 12.3).

12.2.2 Activities to Experience Nature

First, we are conducting research on marine life. In order to objectively assess the value of Kashiwajima's natural environment, we are working in cooperation with Kochi University and other organizations. In 2001, we launched the Kashiwajima Project, a joint research project with Kochi University's natural science and social science faculty. The results have been used to open a common course, "Environmental Studies of the Sea of Tosa: Thinking from the Sea of Kashiwajima," at Kochi University since 2002, which has produced textbooks, videos, and symposiums. Since 2005, we have been holding a new type of course called "Kashiwajima University," which combines a lecture at the university with a camp on Kashiwajima and in which university students and local residents participate.

In addition, we hold marine environment study sessions and hands-on learning for children and eco-tours for adults and disseminate information within and outside of the prefecture (Kanda 2005). Every year, many children, parents with their children, and school excursions from various schools come from all over Japan (Fig. 12.4). As the reputation of Kashiwajima increases, local residents, who have taken the sea for granted, recognize its value and become attached to it and proud of it. Recently, we have been providing environmental education programs for local children in Otsuki Town as "Terakoya (learning hut) of the Sea."

Fig. 12.4 Eco-tour participants enjoying snorkeling

12.2.3 Activities to Assist with Livelihood that Utilizes Nature

The main actors in creating a lifestyle that makes the most of nature are not divers or tourists from other areas but the people who live there. It is often said that no matter how good the environment is, "you can't earn a livelihood only by environmental protection," but we need to create a system to protect the environment so that we can live in a rich environment. We have continued our activities from the stance of helping local people to take the initiative.

For example, the "Satoumi Market," led by the Kashiwajima Development Association, was designed to make people fans of Kashiwajima by selling fish and local food to divers and sports fishermen who come to the island. However, when we actually started the market, we found that the initial customers were local elderly people. When a group of women set up a stall selling "heda-zushi," a local dish that was made and eaten at home on special occasions on Kashiwajima, elderly people who no longer had the opportunity to eat heda-zushi because they lived alone willingly came to buy it. Initially, the goal of the project was to activate the island by attracting non-island visitors, but we realized that one of the ways to revitalize the island was to have island residents willing to come out and buy sushi. In addition, when we sold "tempura" made from fish paste, which had been made by each household on the island, many customers began to buy it. What had been eaten as a side dish in their own homes could now be sold to such delighted customers. This has given them the confidence to start a fish processing and sales group, a restaurant, and other small businesses that take advantage of the natural environment (Fig. 12.5).

12.2.4 Activities to Protect Nature and Livelihood

The basic premise of Satoumi is that there is abundant nature and that people can make use of it in their daily lives. When nature is about to break down, it is necessary to preserve and restore it. For example, the author participates as a team scientist in a reef check to measure the health of corals, which is organized by the Sukumo Bay Diving Group in the Otsuki area, and presents the data to local divers. Coral and seagrass beds are important diving sites, and they play a vital role in maintaining the marine ecosystem. It is necessary to investigate the state of the nature that needs to be protected, but we are not only conducting research but also working on activities to restore nature. Together with local divers, we are exterminating coral-eating snails and crown-of-thorns starfish [*Acanthaster planci*] that cause coral damage and repairing corals damaged by typhoons.

In recent years, the beauty of the sea at Kashiwajima has attracted attention, and many divers and leisure tourists have come to the island. But this has led to various problems such as illegal parking, abandoned trash, bad manners, and wasteful use of water. Kashiwajima is not a resort that provides an extraordinary experience, but a

Fig. 12.5 Sales at Satoumi Market

place for the daily lives of the islanders. In order to maintain the beautiful environment of the island for many years to come, residents are taking the initiative in formulating the Kashiwajima Satoumi Charter, a set of local rules for protecting nature and people's lives.

12.3 Installation of Artificial Spawning Beds for Bigfin Reef Squid

12.3.1 Toward Coexistence of Marine Leisure and Fishery

Divers and fishermen worked together to install artificial spawning beds for bigfin reef squid, which was particularly significant in preserving the sea of Kashiwajima as a "Satoumi." It was an initiative that triggered a change from a confrontational relationship to a cooperative relationship between fishermen and divers who make their living in the sea.

The sea of Kashiwajima has been exclusively a fishing ground, and diving for the enjoyment of seeing fish and coral has only recently become a popular activity. Kashiwajima is a treasure trove of rare species and dynamic fish schools, and by 2000, the small island was home to 14 diving shops. However, the sea has fallen into

a state of overuse. The fishermen grew distrustful of the divers who interfered with their fishing by diving without permission, and the divers insisted that the sea belonged to everyone, and the relationship between the fishermen and divers deteriorated. In order to break the ice, the Kuroshio Zikkan Center first attempted to create rules for the sea. The first step in this process was to bring the fishery cooperative and the diving industry to the same table. The author tried to mediate between the fishermen's association and the diving company, but since I was making a living as the chief guide of a diving shop at the time, the fishermen saw me as a diver's crony, and the divers were wary of the staff of one particular diving shop. At that time, there were many diving shops in Kashiwajima, and they often competed with each other fiercely, and there was no momentum for divers to unite. However, in order for the fishery industry and marine leisure to coexist, I felt the need to create a forum for discussion, so I decided to quit my diving business, which was my forte, in order to become a neutral position.

Finally, the fishery cooperative and the diving group (now the Sukumo Bay Diving Otsuki District Committee) came to the same table, but the talks did not go well. The fishery cooperative tried to keep divers out by using fishing rights as a shield, while the divers insisted that the sea belonged to everyone and that they could dive anywhere as long as they didn't engage in poaching. At the same time, similar problems were occurring on Miyakojima Island in Okinawa Prefecture (see Chap. 8) and Numazu City, Shizuoka Prefecture, and were being fought out in court. When a court decision is made, there is a winner and a loser. But for those who will continue to make their living in these waters, it is not good to have lingering bitterness. We thought that the two sides should come to a compromise in the form of a gray area without a black and white decision and sought a compromise plan. As a result, we decided not to propose a 50-50 rule from the beginning, but rather a rule of 70 for the fishermen and 30 for the divers, and as we built a relationship of trust between the two sides, we decided to try to bring the ratio to 60-40 or even 50-50. We settled down. Naturally, there were some divers who did not follow the rules, but as the members of the diving group tried to persuade each other to follow the rules, the opposition gradually calmed down. However, all rules do not satisfy 100% of each need, and it is only a kind of pain sharing. In order to build a better relationship between divers and fishermen, the rule itself is not enough. The fishermen complain that no matter how many divers come, there is no benefit to the fishermen. So, they started the aforementioned "Satoumi Market" to attract divers and sports fishermen from other areas to become their customers. In this way, the fishermen and divers respect each other's existence and sought a way to coexist.

On the other hand, the local fishermen were facing the problem of not being able to catch bigfin reef squid, which had been a source of their cash income. At the "Satoumi Seminar," which the Kuroshio Zikkan Center held, fishermen voiced the opinion that they could no longer catch squid because many divers were diving. When I looked into the sea, I thought that the cause was not the divers but the decrease of seaweed beds. In May and June, the squid come to the seaweed beds where *Sargassum*, one of the large algae, grows and spawn. The seaweed bed is not only a place for squid but also a place where many fish gather to raise their young.

However, the number of large algae on which the squid lay their eggs seemed to be decreasing. In fact, the beach of Ryu on the other side of Kashiwajima was almost full of seaweed beds more than 20 years ago, but now there are only ragged stones covered with pink sessile calcareous algae and no large algae.

This type of sea desertification is said to be caused by feeding damage by algae-eating fish and sea urchins, insufficient supply of nutrients from the land, and rising seawater temperatures due to global warming. Although it is difficult to determine the root cause of sea desertification, we thought that the lack of spawning habitat may be causing the decline of bigfin reef squid.

There is a high possibility that the cause of the decline of the bigfin reef squid is not the divers, but something else. And if fishermen and divers are at odds with each other, we cannot protect the ocean and our livelihoods. Therefore, I asked "Rather than kicking out divers, why don't we work with them to increase the number of squid? and we have been working on this since 2001 by setting up artificial spawning beds.

12.3.2 The Challenge We Cannot Fail

As the relationship between the fishermen and divers deteriorated, we proposed to set up spawning beds. If we failed, the relationship would deteriorate even further, and we would not be able to create Satoumi. The challenge began with a sense of urgency: "we cannot fail."

In Kashiwajima, fishermen use a fishing method called "shibazuke," in which they tie a stone to a broad-leaved bush of Ubamegashi [*Quercus phillyraeoides*] and put it into the sea, and catch the fish in the bush. We decided to apply this method. The issue was where to set up the spawning beds. I dove into the sea as if I were a squid, looking for the best place to spawn. How about a shallow seaweed bed? If the branches and leaves are shaken by waves, the eggs will be torn off. As we dove further, we saw the squid spawning on the coral species *Antipathes grandiflora* in the deeper water. In this area of the ocean, waves do not affect the spawning at a depth of about 15 m or more. We set our target at a sandy area about 20 m depth near the coral species.

In the first year, divers and fishermen went into the mountain together and cut down the branches of the Ubamegashi. Divers attached sandbags to the branches, placed them at the installation point, and dove down to fix them in place. There was a risk that the bushes would be swept away by the tide if they were just thrown into the sea. It was expected that the branches would function effectively as spawning beds if divers fixed them in the sea. However, working for a long time at a depth of 20 m was a tough job with a high risk of decompression sickness.

After the spawning beds were installed, the seabed looked like a Satoyama (Sato Mountain) in the sea. The squid responded quickly, and eggs were laid one after another (Fig. 12.6). Observing the eggs laid, we found that they were laid in order from the bottom of the branches. The egg sacs, which were transparent immediately

Fig. 12.6 Bigfin reef squid spawning on the branches

after laying, turned white and then brown. The brownish egg sacs were clustered at the bottom of the branches. The brownish eggs are those that have been laid for a long time, and if we consider that the squid lay their eggs from a "good place," the branch with the brownish eggs would be the best place. In other words, the squid prefer to lay eggs in the shaded area between the seabed and the branches (Fig. 12.7).

In this year, the squid laid up to 10,000 egg sacs per spawning bed, and the number of eggs was 70,000–80,000 per spawning bed. Normally, it is said to be a success if tens to hundreds of egg sacs are laid on a single spawning bed, so we can call this a great success. The work of diving to the bottom of the sea to check the number of egg sacs was very difficult, but the joy of the fishermen was great when they saw the videos and photographs of the spawning scenes and the plenty of egg sacs in the spawning beds.

12.3.3 Deepening of Techniques and Spread of Cooperation

In the second and third years of the project, technical improvements were made, and the number of collaborators expanded to include the forestry cooperative, the children of Kashiwajima, and schools outside the island. From the fifth year, the local fishery cooperative took the lead in this project with the full cooperation of the diving groups.

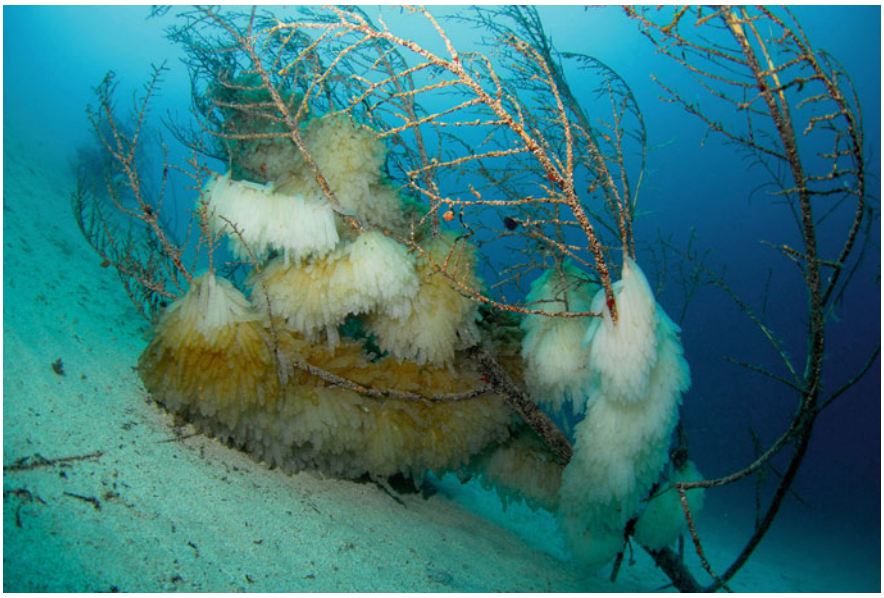

Fig. 12.7 Enormous amount of egg sacs spawned on spawning beds

One of the technical improvements was a change in the branches used for spawning beds. If too many Ubamegashi trees are cut down to increase the number of squids, the mountains around the island, which function as fish-breeding forests, will be devastated. Furthermore, Kashiwajima is designated as a Type 1 Special Area of Ashizuri-Uwakai National Park, and there are restrictions on cutting down trees. Therefore, in the second year, we decided to use branches of cedar and cypress trees thinned in the planted forests instead of Ubamegashi trees. The forests in Kashiwajima are mainly broadleaf trees, but there are many planted forests in the vicinity, so it is necessary to thin the forests to let sunlight in. We decided to use the unwanted branches and leaves from the thinning to create spawning beds. However, the squid did not lay as many eggs as the first year (up to about 5000 sacs per tree). It seemed that we could secure the total number of eggs laid by increasing the number of spawning beds, but as a researcher, I wanted to know why cedar and cypress would not work. I checked the chemicals emitted from the trees, but it turned out to be irrelevant. As a result of diving into the sea and observing the spawning beds from the perspective of the squid, I learned that the squid spawn at the base of thin branches, not tree trunks; that the thicker the foliage, the better as a barrier; but that if the distance between branches is too narrow, they cannot penetrate to the base of the branches when spawning and that they rarely spawn too high up from the seafloor. In other words, the spawning beds preferred by the squids are with a moderate amount of foliage but with enough space to penetrate to spawn. Considering these conditions, the broad-leaved Ubamegashi was more suitable than the coniferous cedar and cypress, which made sense.

Fig. 12.8 A diver fixing spawning beds on the seafloor

So, in the third year, we carefully pruned the cedar and cypress trees to make the branching more "squid's favor" and fixed the spawning beds at an angle making the branches flowed along the seafloor as much as possible so that the squids would want to spawn there (Fig. 12.8). These technical improvements were successful, and in the third year, the number of eggs laid per tree exceeded that of the first year, with a maximum of about 15,000 egg sacs (about 100,000 eggs) laid per tree.

In the third year, with the cooperation of Otsuki Town Government and the Sukumo City Forestry Cooperative, we turned this activity into an environmental learning program for children. Each child can write a message on a plate made of thinned wood and attach it to a branch to make one "My spawning bed" (Fig. 12.9). The results of the spawning are shared with the children in environmental education sessions using underwater photographs and video images. From the fourth year, they worked together not only with children from Kashiwajima but also with children from the nearby village, leading to exchanges between children of the sea and mountains. The circle of activities has expanded to several towns, and the installation of artificial spawning beds has spread throughout Sukumo Bay, expanding the network of environmental learning for children. This initiative, in which local children play a central role, has encouraged the participation of people who previously had poor or tenuous relationships with each other to cooperate for the sake of the children (Fig. 12.10) (Kanda 2005). As a result, the circle of cooperation expanded to include fishermen, divers, forest cooperatives, elementary schools, PTAs, and the governments.

Fig. 12.9 Children putting their personal spawning beds, with attached message plates for bigfin reef squid, into the sea from a boat

12.3.4 Challenges for Satoumi Creation

The installation of artificial spawning beds for bigfin reef squid, which began in 2001, entered its 20th year in 2020. The challenges are economic sustainability and natural regeneration. We have received subsidies from private foundations and other organizations to cover the costs, but these are limited. In addition, the more people involved, the more complicated the preparation work becomes, and the more economically viable the system needs to be in order to pay for it. As an attempt to achieve this, we launched the "Squid Foster Parent System" (now renamed the "Squid Owner System") in 2012. The idea is to collect donations of 10,000 yen per spawning bed from all over the country, have people write a message plate for the squid and create their own "spawning bed," and then purchase and send about 1 kg of squid from the fishermen per unit. At the same time, we also send underwater photos of the squid spawning, the eggs laid in the "My Spawning Bed," and recipes on how to prepare the squid for delicious eating. We have been working with local people to solve local problems, and we have learned that there are people all over Japan who are interested in and support these activities, even if they are not directly related to Kashiwajima. One of the challenges for the future is to create an economic foundation to support the spread of these activities.

The installation of artificial spawning beds is a stopgap measure to secure spawning grounds for squid in response to changes in the natural environment, such as sea desertification. In the sense of relieving the pain of fishermen, that is, the

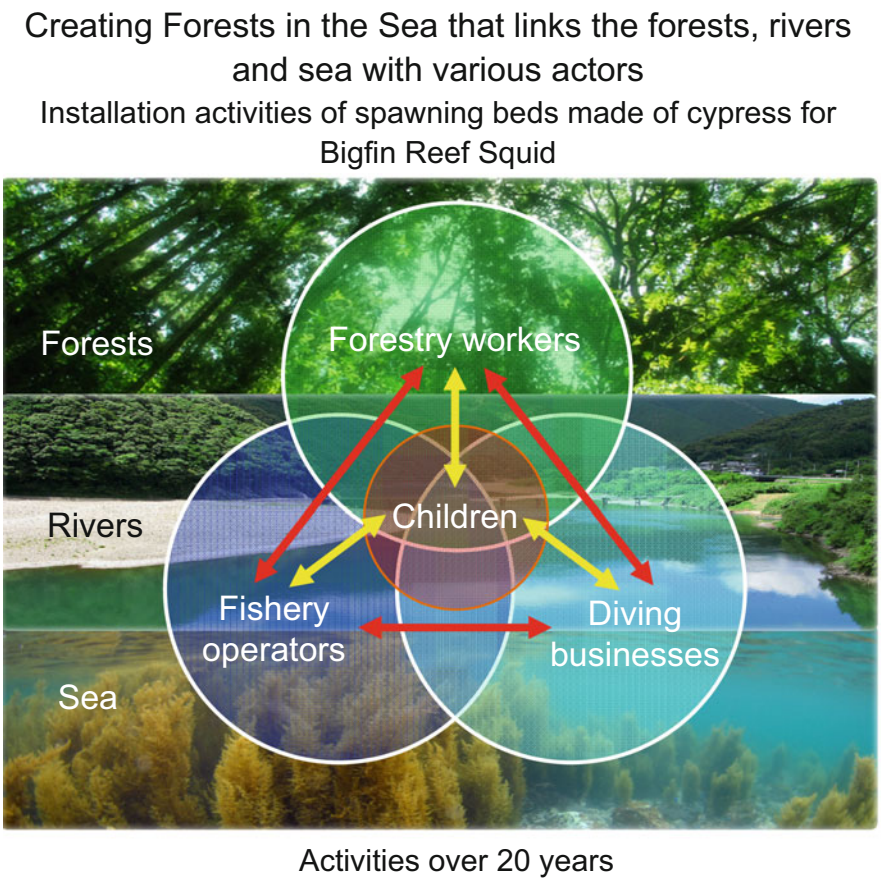

Fig. 12.10 Relationship diagram of the Project for Create Forests in the Sea with children at the core

pain of not being able to catch squid, it is a Western medical prescription. On the other hand, if the fundamental reason for the decrease in the number of squid is due to the decrease in seaweed beds, then regenerating the seaweed beds that existed in the past is the goal that we should ultimately aim for. However, sea desertification is caused by a complex and structural set of factors, and it is difficult for a single organization or local place to produce immediate countermeasures. In our previous research, we suspected that the cause of sea desertification at Kashiwajima was the rise in seawater temperature due to global warming and the increase in predation pressure on seaweed due to the abnormal proliferation of algae-eating sea urchins. Therefore, although the seawater temperature cannot be lowered, regular extermination activities are being conducted to reduce the density of sea urchins to an appropriate level. In addition, to prevent algae-eating fish such as rabbitfish and parrotfish from eating the seaweed (*Sargassum*) which originally existed there, we

put the seaweed in net bags and place them in the scorched areas to produce spores. Returning to the original natural environment is a fundamental treatment that enhances natural healing power and is an Oriental medical prescription like Chinese herbal medicine that does not have immediate effects but works slowly. We are trying to solve the problem by applying both the fast-acting Western prescription and the Oriental prescription that enhances natural healing power.

Having installed spawning beds made of cypress for 20 consecutive years, I now believe that Satoumi creation stands for the human activities of cultivating the sea for the aim of making the sea a richer place. This is a way of interacting with the sea that is extremely similar to agriculture. Although some may claim that this is not "real" nature, nonetheless, it is an attempt of people to work on nature to derive its potential, and we must continuously observe how the nature changes in the future as a result of our activities.

For me, Satoumi used to mean the beautiful seascape off Kashiwajima. However, now that I have undertaken various activities on the Island, Satoumi creation seems to be the human activities to work on the sea with all their wisdom and ingenuity in order to obtain blessings from the sea in various forms.

12.4 Residential Researchers and Satoumi Creation

12.4.1 Characteristics of Residential Researchers

The establishment of the Kuroshio Zikkan Center on Kashiwajima and its 20 years of efforts to develop the Satoumi can be said to have been "residential research" in which research and practice were inextricably linked. Tetsu Sato (one of the editors of this book) defines a residential research institute as "a research institute with researchers who live and work in the local community, and who are clearly aware of their mission to contribute to solving local problems by conducting research directly related to the issues of the local community, such as the local environment and ecosystem services" (Sato 2008; see Chap. 1). Naoki Kikuchi, who himself settled in Toyooka City, Hyogo Prefecture, and participated in the stork wild reintroduction project as a residential researcher, compares the characteristics of visiting researchers and residential researchers and summarizes them as shown below (Kikuchi 2016):

- Position in the local community: someone who comes occasionally (visitor)/ someone who is always present (resident)
- Purpose of research: progression of his or her own research (visitor)/solving local problems (resident)
- Research method: method commonly used in one's area of expertise (visitor)/ transdisciplinary method tailored to the issues (resident)
- Presentation of research: academic society, local community (visitor)/local community, academic society (resident)

- Evaluation of research results: academic society (visitor)/local community, academic society (resident)
- Research and practice: do not circulate (visitor)/circulate (resident)

With these definitions, residential researchers are different from general researchers who aim to produce knowledge in accordance with scientific and academic methods. In addition to knowledge production, they also play complex roles in the practice of solving local problems by using the knowledge and in creating networks that promote collaborative problem-solving among diverse actors. The activities described so far represent the characteristics of the residential researches.

First of all, the primary function of the residential researcher who engages in local issues through intellectual inquiry is related to the production, dissemination, and utilization of knowledge. In my case, the primary function as a residential researcher is to produce and disseminate knowledge necessary for the use, conservation, and restoration of the natural environment of Kashiwajima. When I first came to Kashiwajima as a graduate student, I was a "teacher of the sea," striving to convey the splendor of Kashiwajima's sea. This has not changed, but over time, I have come to understand the nature and environment through the empirical knowledge of fishermen and to invite outside knowledge providers to help solve local problems, rather than just communicating scientific knowledge. In this way, my own communication style has changed from single direction to a bilateral one. I have come to make bilateral translation.

If the works are done on the spot only, such as checking coral reefs in cooperation with divers, reporting the results of joint research with universities at seminars, or teaching children about marine life as part of their environmental studies, the knowledge is irrelevant to the daily lives of local residents. For adults, in particular, one-way knowledge-transfer communication alone is unlikely to lead to internalization of knowledge, or, in other words, to learning, or to changes in behavior. Rather than ending with the transmission of scientific knowledge, changes in behavior related to the sea are necessary (see Chap. 10). In order to take action for the conservation and restoration of the Satoumi, it is important to design practical activities by translating various knowledge in multiple directions among the people involved, such as utilizing knowledge in their daily lives and presenting options for actions by selecting various knowledge to meet the needs of the community.

For example, the extermination of sea urchins and the installation of matured seaweed to regenerate seaweed beds are practical activities that make use of scientific knowledge, while the installation of artificial spawning beds for bigfin reef squid, although making use of my scientific knowledge, was inspired by the wisdom of "shibazuke," a technique taught by fishermen, making use of traditional knowledge. Traditional culture, such as local cuisine and festivals, also provides a wealth of clues to the nature of the island. Knowledge generated in daily life is easily linked to people's actions, and there are many activities born from the study of indigenous knowledge.

Residential researchers are involved in the distribution of a wide variety of knowledge beyond their academic field of expertise. Residential researchers do not have large funds or organizations, but they try to connect people with knowledge and create actions. In the case of myself, I collected and utilized knowledge on all kinds of topics related to the island, including forest, hydrology, and other natural environment-related knowledge, as well as the history, folklore, and administration of the island. Although scientific knowledge production is possible mainly in the field of fish ecology, which is my specialty, I also actively utilized knowledge from other fields in the practical activities.

This includes knowledge about the ecology of the local community. I actively communicated with the islanders I met on a daily life, and as I lived as a member of Kashiwajima, I tried to understand what they thought and how they perceived the sea in every situation. This was a study of human society. This played a very important role in connecting various knowledge to practical activities. The experience of the residential researcher who lives as a member of the local community was also utilized in his efforts to find a way for the two parties to come to an agreement and coexist in the gray zone by standing between the fishermen and divers, conveying the details of fishery rights and actual cases of litigation in other regions.

12.4.2 Kashiwajima Model Which Reweaves the Relationship Between People and the Sea

In order to convey the value of the sea of Kashiwajima to its children and maintain the relationship between people and the sea forever, it is necessary to restore the health of the sea and for the adults on the island to develop a relationship where they can cooperate with each other. Although I have routinely run into various local issues which I worked to solve each time, each of the numerous trials and errors that I have made thus far may not have been a detour or an ad hoc decision. In other words, I think I may have been working on a grand social experiment of creating the Kashiwajima Model for Satoumi creation under the grand hypothesis that Satoumi creation is the restoration of relationships among people as well as between people and nature.

One of the characteristics of the Kashiwajima Model is that it deepens the relationship between people and the sea by tackling the issues in economy and education, as they are essential for local sustainability. Regarding economy, we have aimed to change the two vocations, fisheries and tourism, so that they foster and receive blessings from the sea rather than temporarily exploiting the rich sea. Though the reasons may have been different to start the activities, the objectives were the same for all of the spawning beds for bigfin reef squid creation undertaken with fishermen and divers, Satoumi Market, reef checks, and more. Regarding education, I believe it is important to nurture young adults with pride and affection for the nature and livelihood of the island. The economy would spontaneously

change for better if even one or two of the young adults could be involved with the sea from the perspectives of people as well as organisms and start to support the livelihood on the island.

Another characteristic of the Model is that it connects people of different positions and restores or creates the relationship between them through involvement with the sea. These people include fishers, divers, forestry workers, children on Kashiwajima, children in other areas, researchers, and fans of Kashiwajima all over Japan. Now that 20 years will have passed since I commenced my activities on Kashiwajima, the environmental education programs have settled in the school curriculum, and the installation of spawning beds made of cypress for bigfin reef squid is also continuing while expanding its circle of support. It is crucial that, while constantly communicating with the school teachers, we do not merely teach the children through the environmental education programs but also encourage adults of various vocations through the children's actions, so that they can take pride in the fact that they are increasing the resources of the sea by themselves. In addition to self-evaluation, we also made efforts to notify the wider public of our activities through mass media in order to receive evaluations from those outside the area.

The Kuroshio Zikkan Center has been making efforts to convey information on the activities to protect the richness of the sea to the outside of the island. It has received much attention and good evaluation from mass media and academic societies. The Center has received numerous awards, including the Prize for Publication and Culture from the Japanese Association for Coastal Zone Studies (2005), the Director-General of the Fisheries Prize from the Japan Association for Promotion of a Prosperous Sea (2007), the 6th Ecotourism Prize (2010), the Japan Prime Minister's 5th Commendations for Contributors to promote the country as a "Maritime Nation" (2012), and the Grand Prix for the 5th Japan Awards for Biodiversity (2017). Through these prizes, many people learn for the first time that the sea of Kashiwajima where they live is valuable. I believe that receiving external evaluations had an effect of changing the perspective of the local residents on the sea. Moreover, if these local activities on a small island are providing new findings to the universal themes such as Satoumi creation, ecotourism, and biodiversity conservation, then it means the universal themes and local activities are affecting mutually. Mediating these may be one of the functions of the residential researchers and institutes.

I believe that the Satoumi model discovered on Kashiwajima indicates that the point of intersection between the desire to protect the sea and that to utilize the sea for richer livelihood should not be fixed at one "correct" point. Rather, the point drifts constantly, and people should agree on it at each occasion. This can be referred to as a form of adaptive governance (Miyauchi 2013). However, nature has its own environmental carrying capacity, which sets a threshold over which point the nature will no longer be able to return to its original state. Though not audible to the humans, it is necessary to listen to the voices of nature to discern the threshold so that a balance can be maintained between protection and utilization. I believe that my roles as a residential researcher are to provide the fundamental information for reaching agreement, to create options for actions that can achieve a balance between

protection and utilization, and to assist in connecting people of different positions and their execution of the actions.

12.4.3 Dilemmas of Residential Researchers

Unlike the researchers at universities and research institutes whose primary purpose is to produce knowledge, residential researchers are characterized by their practical purposes, which include solving local issues and fostering human resources. Because of this, residential researchers sometimes feel dilemmas about their own existence.

I have been undertaking activities by establishing an NPO, without belonging to organizations such as universities and municipalities. While I started the activities solely out of my own volition, I was fortunate that I had people who also loved the sea of Kashiwajima and sympathized with my feeling for the future of the island. They supported me materially and mentally, and because of them, I have been able to continue the activities. Now that the activities are receiving high social evaluation and a large number of people are involved in them, it is becoming difficult to manage the activities on my own. Even though there are people who have strong affection and the spirit of inquiry for nature and want to undertake the efforts for Satoumi creation, it is hard for them to establish themselves because of the weak economic foundation. Sometimes I cannot help but ask myself whether residential researchers need to take all the burdens themselves. I do feel that organization management skills are also necessary, yet, being burdened by daily activities, I have not yet managed to develop sufficient foundation for it.

Furthermore, I think that the most difficult dilemma faced by residential researchers is the problem arising from their positions in interpersonal relationships in the local community. Any researcher who becomes a member of the local community, which used to be his or her target of observation, and does research that directly affects the lives of the local residents, will cause various reactions regardless of his or her intention. The reactions are not necessarily positive all the time. For me, my position has changed beyond my expectations, and sometimes, I get obstructed even when I want to proceed to the next step. Residential researchers must be able to see nature and the local community objectively, without feeling restrained. However, by becoming a resident and therefore involved in the community, there will be scenes where you cannot simply look at the community with an objective perspective. If you become perceived as taking a certain side based on your actions, there will be times where you will not be able to obtain the cooperation of those on the opposing side. In other words, your existence will be embedded in the community where your research was supposed to take place, and you will not be able to proceed. However, as long as we were to ultimately respect the consensus formation of the community rather than just the accuracy of the scientific findings, I believe it would be difficult to avoid these dilemmas over power politics of the local community. Unfortunately, there are no definitive prescriptions for this, yet as I look

back on my own experiences, sometimes it is important not to point out things as black and white. If we try to decide which party wins and which party loses based on who is right, even in cases where you can prove that your opinion is correct for some reason, you will leave an unpleasant feeling. This is not the best option for the community. Unlike general scientific research seeking the truth, residential research pursues "positive results" for the community rather than clarifying the scientific "correctness," and this is probably the reason why it can still be valid even while including ambiguity.

Finally, taking the dilemmas I have had into account, I would like to talk about the future of residential researchers (and institutions) based on the 20 years of experience at the Center. The natural environment of each locality has unique characteristics that are not as described in the textbook. People with expertise in biology and ecosystems like myself can review the close relationship between nature and people and may be able to detect the balance which is the best for the local livelihood and the future. This activity is not meant for personal profit but is an activity for the public interest including the future generations, and it is also an activity that creates the most important foundation for community development. In order to undertake this activity stably and continuously, guaranteeing the public nature of this activity in a clear manner, such as positioning of residential researchers by each municipality as its staff member, may be a solution. However, in Japan, which is a shrinking society, most of Satoyama and Satoumi regions are experiencing population declines, and their public services are also on the decline. In particular, many public elementary and junior high schools are being closed and merged, and there is increasingly less space for residents to gather for their children and community. Although residential researchers are especially necessary for such situations, the foundation for their existence is very weak. I believe it is necessary to develop a social system for supporting residential research, which is as highly public as advanced scientific research.

12.5 Aiming for Sustainable Satoumi Creation

For over 20 years since establishing the Kuroshio Zikkan Center in hope of preserving the sea of Kashiwajima, I have conducted various activities in cooperation with many people. Through re-connecting people to people and people to nature, making interactions with the sea and cultivating the sea, our activities are aimed at creating Satoumi that can provide us with rich blessings. Although there remain issues to be solved, as long as we continue the activities, they will be sure steps to sustainable Satoumi creation.

Whereas the Kuroshio Zikkan Center has been conducting activities as an NPO, the existence of residential research institutes and researchers are still new to the society. Many of the various activities for Satoumi creation introduced in this book are in fact supported by residential research institutes and researchers. As a residential researcher working to solve issues in a local community, I sincerely hope that

many other residential research institutes and researchers working elsewhere with similar aspirations will be able to exert their abilities to a greater degree in the future.

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Chapter 13
Models for Implementing the Satoumi Concept via Residential Research Institute Collaborations with Citizen Scientists in the United States

Michael P. Crosby and Barbara Lausche

Abstract Mote Marine Laboratory (Mote), a private research institute in Florida, USA, has been engaged in research and practice related to the conservation and sustainable use of various marine resources as a residential research institute, part of the local community for over 66 years. Volunteer citizen scientists work with Mote to conduct scallop restoration, environmental monitoring for coral reefs, coral reef restoration using innovative technologies, and tag and release and monitoring of snook, an important local fish resource.

Keywords Residential research institute · Citizen scientist · ILEK · Scallop · Coral reef · Fishery enhancement

13.1 Introduction of the Concept of Satoumi and the Role of Citizen Scientists in the Conservation and Use of Marine Resources

13.1.1 Conservation and Sustainable Use of Marine Resources

Achieving sustainable human use of natural marine resources is a complex process of balancing competing human needs with various natural resource management goals at all spatial and temporal scales (Crosby 1997). Among the most important of these goals are promoting sustainable economic production; sustaining cultural values that are intimately linked with the marine environment; providing basic information to understand the condition of the marine environment; and conserving

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natural marine resources and biodiversity. Integration of scientific research activities with community-level education is essential to achieve comprehensive management for sustainable use and conservation of marine biodiversity.

Three core challenges for improving interactions between scientists, the public, and resource managers have been previously identified (Crosby 1997) as challenging communications between these stakeholders, a relative scarcity of truly management-oriented research to address local community issues, and science-based resource management policies being influenced by political goals with poorly informed public pressure.

13.1.2 Transdisciplinary Approach

To facilitate the incorporation and sharing of new and existing knowledge between scientists and various stakeholder groups, a new paradigm for the interaction and role of integrated, multidisciplinary science, management, and education/outreach efforts was developed in the late twentieth century (Crosby 1997). Implementing this new paradigm in the twenty-first century requires that scientists and the public work together to identify and understand ecological, economic, and social driving forces behind losses of marine biodiversity and destruction of marine and coastal ecosystems.

Community-based decision-making (Gilman 1997) is the process in which scientists and other interested stakeholder groups participate in making decisions and coordinating management of natural resources. Societal and scientific practices in such a process through a transdisciplinary research approach (see Lang et al. 2012). In order to better understand marine biodiversity and ecosystem processes, a full spectrum of user-friendly data and information, along with validated analytical models, should be available and accessible to scientists, decision-makers, and the public to explore possible consequences of alternative management and policy decisions. All stakeholders must be involved together in a multilateral process of integration, translation, and transfer of technical as well as empirical knowledge. This process, when combined with the expansion of local science networks for environmental sustainability, leads to the formation of *integrated local environmental knowledge* (Crosby et al. 2018).

13.1.3 Satoumi Concept and Citizen Scientists

The literal translation of the phrase “Satoumi” is village communities (sato) associated with the sea (umi). It is a Japanese concept of harmony between human communities and the productivity and biodiversity of marine ecosystems (see Chap. 3). The Satoumi concept offers major benefits at the intersection of marine science, sustainable resource management, and engagement of local communities.

Under a framework of Satoumi, researchers, grassroots community groups, and volunteer citizen scientists can blend traditional, local, and scientific knowledge and techniques to restore, conserve, and sustainably use marine resources from restoring scallop populations and coral reefs to enhancing key fisheries and their essential nursery habitats. A foundation for successful implementation of the Satoumi concept is integrated local environmental knowledge (ILEK).

The term "citizen science" is used in many ways, takes a variety of approaches, has different goals, and involves many disciplines of science. Citizen science has been defined most recently as simply engaging the public in a scientific project (Kobori et al. 2016; Bonney et al. 2014; Shirk et al. 2012; Silvertown 2009). Citizen science has become increasingly important in recent years for its ability to engage large numbers of volunteers to generate observations at scales or resolutions unattainable by individual researchers. Citizen science can contribute to a paradigm shift taking place in science, wherein scientists and the public work together to investigate and address emergent environmental issues. However, quality collaborations among scientists, project organizers, government agencies, and the public are still relatively rare (Kobori et al. 2016). From the next section, we show the examples of the introduction of the Satoumi concept to the United States and the implementation of such collaboration.

13.2 Scallop Restoration

13.2.1 Community-Based Scallop Restoration in Sarasota Bay

Mote implemented a model for Satoumi and ILEK in 2012 when it launched a novel shellfish initiative for Sarasota Bay, Florida, that involved international and local research institutions and community-based environmental organizations and became one of ILEK project's 11 case-study sites in its worldwide project. The Satoumi concept was initiated via a new paradigm partnership of local grassroots community organizations with volunteers and trained citizen scientists that pursued all aspects of strategy design, collection of spawning stock, release of stock, and monitoring under the oversight of professional Mote scientists and input of the Florida Fish and Wildlife Conservation Commission (FWC). To facilitate close coordination, representatives from Mote, FWC, Sarasota Bay Estuary Program (SBEP), Sarasota Bay Watch (SBW), Bay Shellfish Company, Inc., Sarasota County, New College, University of South Florida-Sarasota/Manatee, University of Florida, and Nagano University met regularly over the course of 2 years. Special workshops on essential elements for innovative science-based scallop restoration in Sarasota Bay were also organized with Mote's local partner representatives and invited experts from around the United States. The outcome of those workshops was a consensus strategy entitled *Coordinated Strategy for a Sarasota Bay Scallop (Argopecten irradians)*

Restoration Initiative. This serves as a general coordination guide for interested parties to use in development and implementation of a scientifically defensible strategy for bay scallop restoration that recognizes the most effective and efficient approach for achieving restoration of Sarasota Bay scallop populations is partnerships and positive leveraging of capabilities, expertise, and resources. The guiding principle is to strategically coordinate efforts for employing the best scientific methodology available, selecting restoration sites with a high probability of success, and utilizing quantitative monitoring tools capable of defining successful restoration.

13.2.2 Participation of Citizen Scientists in Restoration Activities

An important community engagement component of the Program was recruitment of a large pool of dedicated volunteer citizen scientists for all aspects of the initiative. For example, volunteers, consisting of high school students, teachers, and adults supervised by Mote scientists, established a scallop nursery area at a Mote facility that was used to grow seed to sub-adults for placement in natural habitats in protective cages. Strong community support in the Central Florida region was shown by annual scallop searches that are the hallmark of Mote's partner, the Sarasota Bay Watch, and draws large numbers of participants. Mote scientists and staff also trained high school students to build spat and juvenile scallop collectors to monitor scallops settling in Sarasota Bay. These collectors where then deployed in restoration sites, allowing Mote scientists to monitor the success of released scallop larvae and spat to transition to the next phase of their life cycle. Interest and involvement of the Mote citizen scientists in this restoration effort led to was heighted community interest and an enhanced level of public literacy regarding ecological connectivity and role of scallops in Sarasota Bay.

13.2.3 Sarasota Bay's Satoumi

As part of this Program, international scientists, fisheries representatives, and nearly 100 members of the local community gathered at Mote Marine Laboratory for a public forum. This forum focused on how communities around the world are conducting science-based conservation, with a highlight on Satoumi. Drawing upon Mote's Community-Based Scallop Restoration Initiative and cases from Japan and Spain, the forum discussion included how Satoumi is being put into practice as new paradigms for environmental restoration and sustainable use of natural resources are being created around the world, leading to tangible conservation benefits.

Sarasota Bay is a promising site for implementing Satoumi. World-class scientists at Mote work closely with successful grassroots efforts and have strong connections with local fishing communities. Mote's institutional philosophy is that scientists have much to learn from those who live and work in the natural environment and that knowledge circulation and sharing are essential among all stakeholders. A clear consensus of the forum was that many parts of the world could benefit from Satoumi practices by developing ways to share and exchange scientific and traditional or local knowledge.

13.3 Environmental Monitoring of Coral Reefs with Citizen Scientists

In the Florida Keys, Mote invites the public to report environmental changes through its "C-OCEAN" (Community-Based Observations of Coastal Ecosystems and Assessment Network) project and its "BleachWatch" program.

13.3.1 C-OCEAN

C-OCEAN is designed to provide early detection and assessment of biological events (Fig. 13.1) occurring in the Florida Keys National Marine Sanctuary and surrounding waters. The goal of the network is to help the scientific community better understand the nature and causes of marine events that adversely affect marine organisms and assist ongoing research efforts to assess and monitor events as they develop. Understanding these events will help scientists and managers determine whether the events are natural or are linked to human activities.

The key to the early detection of marine events is the people who are on the water. Most of them have a considerable knowledge of the area and an understanding of when things are not as they should be. Anyone who is on the water frequently is encouraged to report observations as soon as possible. There is no paperwork involved, no specialized training needed, and no other participation or effort required. By simply utilizing an online report site (Mote website) and providing what, where, and when something unusual was observed, residents can provide scientists with the information needed to detect potentially large-scale events as they develop (Fig. 13.2). Since 1997, C-OCEAN has received over 6000 reports.

Fig. 13.1 Types of unusual marine events that are reported to the C-OCEAN Program

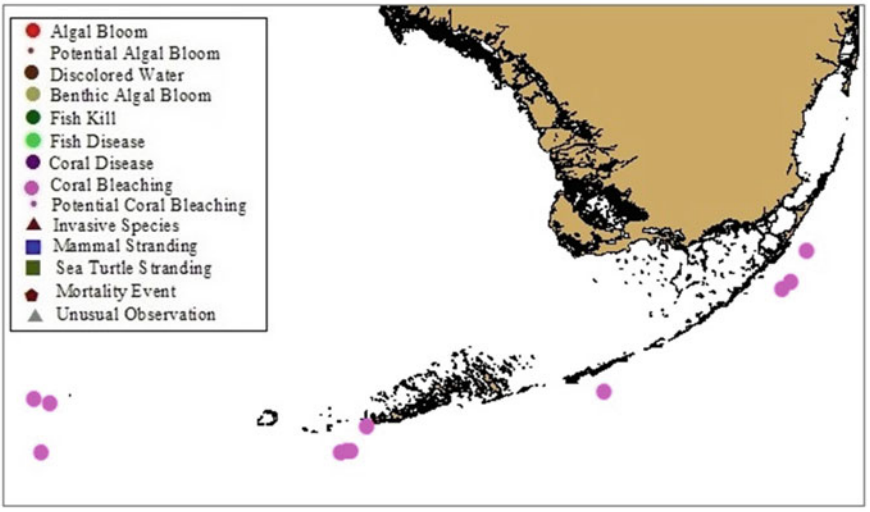

Fig. 13.2 September 2017 Mote Marine Laboratory C-OCEAN Program volunteer citizen scientists' monthly reports of unusual marine events in the Florida Keys

13.3.2 BleachWatch Program

The BleachWatch program provides early warnings of potential coral bleaching events in the Florida Keys National Marine Sanctuary and surrounding waters. Bleaching (Fig. 13.3) occurs when heat or other stressors cause corals to lose their zooxanthellae—the symbiotic algae that give corals color and necessary nourishment. Corals that don't recover their zooxanthellae will ultimately die. The frequency and severity of these bleaching events have steadily increased since the 1980s and are potentially devastating to the coral reef ecosystem.

BleachWatch engages trained volunteer citizen scientists with researchers who together help elucidate bleaching patterns and ultimately coral death by contributing data to Keys-wide reports by the Florida Reef Resilience Program. BleachWatch averages 300 reports a season, and there have been at least 500 trained volunteers to date.

These observer reports, as well as Coral Reef Watch coral bleaching prediction products from the US National Oceanic and Atmospheric Administration (NOAA), are consolidated to form a Current Conditions Report, sent out monthly or bimonthly throughout the summer depending on environmental conditions. All Current Conditions Reports since 2005 are archived on Mote website (Fig. 13.4).

Fig. 13.3 Appearance of healthy, paling, and bleached coral

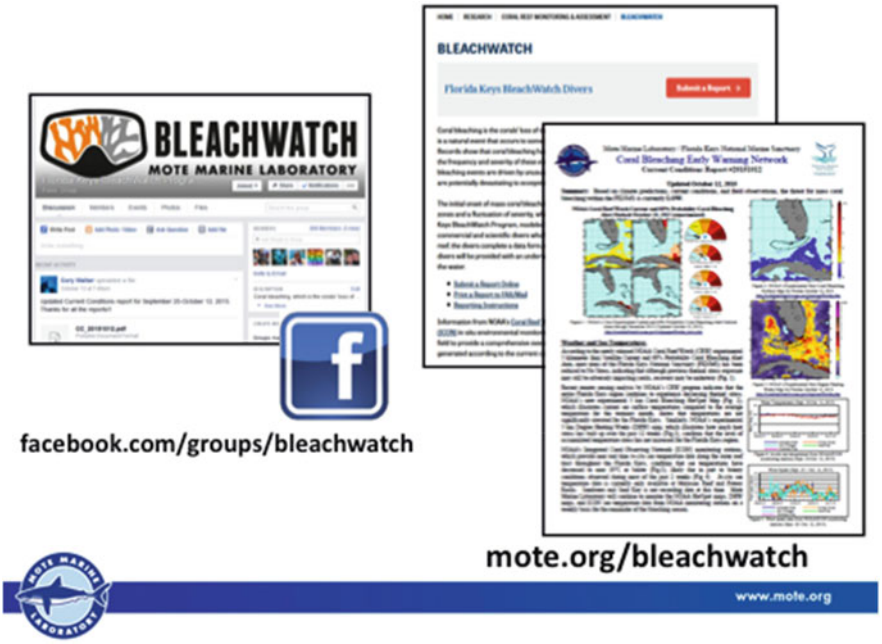

Fig. 13.4 BleachWatch reports, Facebook, and websites

13.4 Coral Restoration with Volunteer Citizen Scientists

13.4.1 Science-Based Coral Reef Restoration

Coral reef ecosystems provide vital shelter and feeding and breeding habitat for myriad fish and invertebrates such as crabs, shrimp, and lobsters. Reef structures also help protect shorelines during tropical storms and hurricanes. Ten years ago, Mote established an underwater coral nursery where scientists grow colonies of the threatened staghorn coral (*Acropora cervicornis*) for replanting on decimated or damaged sections of reef within the Florida Keys National Marine Sanctuary. When the colonies reach a suitable size, small fragments nearly 2 inches long (about 5 cm) are snipped off and used to create a new colony—similar to the way new plants are grown from cuttings of existing plants (Fig. 13.5). Then these cuttings are mounted on the reef so they can grow and develop into new colonies.

Science-based coral reef restoration (Forsman et al. 2015; Koch et al. 2021; Morin 2014; O'Donnell et al. 2017; Page 2013; Page and Vaughan 2013; Page et al. 2018) is a major priority at Mote, which is expanding these efforts at its new Elizabeth Moore International Center for Coral Reef Research and Restoration (IC2R3), opened May 2017 at one of Mote's existing campuses on Summerland Key. Mote scientists are working to restore large areas of these corals in 1–3 years—instead of the hundreds of years it might take for natural recovery. Using research

Fig. 13.5 Small fragments ~2 inches long (~5 cm) of staghorn (*Acropora cervicornis*) coral mounted on the reef so they can grow and develop into new colonies on decimated or damaged sections of reef within the Florida Keys National Marine Sanctuary

infrastructure funded by the National Science Foundation, Mote scientists are working to identify a variety of genetic strains of corals that are more resilient and resistant to disease, warming ocean temperatures, and ocean acidification—important traits for restoration success.

Mote currently has approximately 20,000 colonies of staghorn coral in its underwater nurseries, which includes more than 130 genotypes, allowing researchers to determine which corals have the heartiest genetic makeup and the best chances of survival. To date, Mote has planted more than 120,000 reef-building coral fragments to help restore Florida's reef. Mote is also working on a new coral microfragmenting technology that is also allowing the organization to restore larger reef-building boulder corals on the reefs.

13.4.2 Combat Wounded Veterans Challenge and the SCUBAnauts International

Mote's goal is to plant more than a million corals working in partnership with a number of groups and volunteer citizen scientists—including member of the Combat

Fig. 13.6 Mote scientists partnering with Combat Wounded Veterans Challenge (CWVC) and the SCUBAnauts International (SNI) to restore coral reefs in the Florida Keys National Marine Sanctuary

Wounded Veterans Challenge (CWVC) and the SCUBAnauts International (SNI) (Fig. 13.6). The Mote partnership with CWVC and SNI implements the Satoumi concept by directly engaging innovative science, young citizen scientists, and wounded veterans who are sharing their leadership skills.

CWVC improves the lives of wounded and injured veterans through rehabilitative, high-adventure, and therapeutic outdoor challenges while furthering the physiological, biomedical, and pathological sciences associated with their injuries. The veterans who participate in the outdoor challenges have suffered from traumatic brain injuries or post-traumatic stress syndrome or have lost limbs. SNI involves 12-year-old to 18-year-old students who undertake intensive advanced SCUBA diving and marine science training while conducting numerous marine conservation and restoration projects.

Approximately 36 members of CWVC and SNI joined forces with half-a-dozen scientists from Mote Marine Laboratory for the 1-day record-breaking mission on the reef in 2017. In a single day, marking the sixth year of a unique partnership involving science, conservation, and restoration, researchers and volunteer citizen scientists planted 500 corals near Looe Key in the Florida Keys National Marine Sanctuary. The number of corals planted marked the most ever the groups have planted in a single day since they began working together in 2012. Since that time,

Fig. 13.7 Sgt. 1st Class (retired US) Billy Costello (L) of the Combat Wounded Veteran Challenge and Mote President and CEO Dr. M.P. Crosby (R) completing implementation of the Satoumi concept for coral restoration at "Hero's Reef" in the Florida Keys

this implementation of the Satoumi concept has resulted in restoring more than 2300 corals in an area unofficially named "Hero's Reef" (Fig. 13.7).

13.4.3 Coral Restoration in Historic State Park

In addition, Mote researchers are working with other local community groups to restore corals in waters of Fort Zachary Taylor Historic State Park in Key West, Florida, through a partnership project by Mote, Florida Park Service, NOAA Florida Keys National Marine Sanctuary, and the Monroe County Tourist Development Council to restore corals in park waters while engaging and educating volunteer citizen scientists. In summer 2016, project partners planted about 5500 coral fragments into park waters, with coral rate of survival at approximately 90% after 1 year. This 2-year project, funded by Monroe County Tourist Development Council, involved planting more than 12,000 fragments of 5 coral species along a publicly accessible snorkel trail during summer 2016 and 2017. Most of the restored corals were rescued by NOAA, propagated by Mote scientists, and outplanted in the same general area where they were initially found.

To educate visitors, the current project at Fort Zachary Taylor Historic State Park features a publicly accessible coral restoration area represented by educational signs on shore and at NOAA's Florida Keys Eco-Discovery Center in Key West. Due to the proximity of this outplanting to the beach, tourists and locals are able to see the ability of the Satoumi approach to restore reefs and be ready to scale up such efforts toward a future goal of planting one million corals. In the process, the public learns about coral research and restoration methods, threats to coral reefs, and the efforts of a volunteer citizen scientists, major research institution (Mote), local community government bodies (Monroe County Tourist Development Council), Florida State government (Department of Environmental Protection), and Federal government (NOAA) partner in conservation, research, and restoration of coral reefs.

13.5 Replenishing and Enhancing Wild Snook Fishery and Habitat

13.5.1 Decline of Snook Stock: An Important Fish Resource

Snook (*Centropomus undecimalis*) are one of the most sought-after catches in Florida's saltwater recreational fishing industry. According to the American Sportfishing Association, Florida is the top-ranked state in economic output from recreational fishing, which draws more than $8 billion to the economy annually. Saltwater fishing alone generates about 80%—more than $6 billion—of that income.

Increased fishing pressure and environmental concerns such as weather patterns and toxic algae (*Karenia brevis*) "red tides" contributed to a serious decline in snook population, which placed them on the state's list of "species of special concern" in the 1980s. As a result, fishing restrictions and careful monitoring led to a rebound in snook abundances in the 1990s. However, occasional environmental pressures such as red tide and extreme winter low water temperatures (in 2010, a winter cold spell resulted in the deaths of millions of snook and the closure of the fishery) continue to reduce snook stocks periodically. Thus, for more than 25 years, Mote and Florida's Fish and Wildlife Conservation Commission (FWC) scientists have partnered on research studies designed to evaluate whether stocking hatchery-reared snook can be an effective fishery management tool for rapidly replenishing snook stocks following the periodic mortality that red tides and cold weather can cause.

13.5.2 Phillippi Creek

Mote is now implementing a new privately funded Fisheries Conservation and Enhancement Initiative that follows the Satoumi concept (Brennan 2017; Locascio et al. 2017). Mote fisheries researchers are partnering with the Florida State FWC

and local community groups to tag and release 10,000–15,000 hatchery-reared snook in several locations in Sarasota and Manatee counties, including Phillippi Creek. Phillippi Creek, Sarasota Bay's largest freshwater creek, is an estuarine tidal creek system that drains approximately 56 square miles through more than 100 miles of ditches and canals within the Sarasota Bay Watershed. Along its 7 mile length are parks, businesses, and residences offering diverse habitats for young snook and other species. Over time, erosion filled portions of the creek with sediments and reduced flow. Local residents and the Sarasota County government have launched an initiative to improve the creek's water quality (Phillippi Creek website).

The Phillippi Creek study site is a mosaic with some seawall and some natural vegetation. By dividing fish among different pilot release experiments along Phillippi Creek, a 7 mile, estuarine tidal creek system that offers diverse habitats for young snook, scientists and local community groups can learn which shoreline habitat types juvenile snook prefer and gain a greater understanding of the local snook population dynamics. The different sights are among shorelines that vary in complexity from seawalls that are clear of vegetation to seawalls that have vegetation and completely natural sites. The goal is to determine how snook utilize these different shoreline types and whether or not snook reside in natural habitats longer or disperse more quickly from seawalls with no vegetation than those seawalls with vegetation. The ultimate goal is to provide this information to local community homeowners so that they can make fish-friendly decisions with their shorelines and how state resource managers might enhance creek benefits. In addition, this initiative will develop responsible guidelines to release hatchery-reared snook into the wild to help keep the population sustainable.

13.5.3 Tag and Release of Snook

Volunteer citizen scientists helped researchers tag and release a total of 3500 snook in the Phillippi Creek waters in local community homeowner's backyards from November 2016 to June 2017. In addition, the local community homeowners that allowed researchers to install equipment in their backyards have allowed us to collect data on 376,629 detections of tagged snook in Phillippi Creek to date (representing 1848 of those released fishes on 332 unique days). It would never be possible to collect that much data without involvement of local community groups and volunteer citizen scientists. The Phillippi Creek Satoumi concept is now engaging students of the local Riverview High School in a new citizen scientist component to work with researchers to rear juvenile snook that will be released in their community. The goal is to help teach students about water quality and habitat concerns through hands-on experience in rearing, releasing, and post-release monitoring of snook in Phillippi Creek along their backyards.

Mote is monitoring the released snook in Phillippi Creek using passive integrated transponder (PIT) microchip tags. These tags communicate with PIT tag antenna arrays (Fig. 13.8), which are placed at all eight release sites. Any time a snook with a

Fig. 13.8 Scientist at Mote passes a bucket of water with juvenile snook to Mote senior biologist Tom Waldrop for release into Phillippi Creek. An array of antennas on posts will detect the tagged fish

PIT tag swims over a wire loop receiver that stretches across the creek under the water, an electromagnetic field charges this tag, which then gives out a pulse that has the information regarding which individual fish was at that spot at that time. With participation from local community residents and private homeowners, Mote researchers and volunteers installed eight special antenna arrays along Phillippi Creek to detect tagged snook within range.

By releasing the fish into Phillippi Creek, Mote scientists are examining how much time the fish spend near seawalls without vegetation, seawalls with vegetation, or natural shoreline sites. The scientists want to know whether or not snook reside in natural habitats longer or disperse more quickly from seawalls with no vegetation than seawalls with vegetation. Preliminary data from Phillippi Creek suggest that shorelines with complex vegetation support higher survival of the fishes that use them (Schloesser pers. comm.; Locascio et al. 2017). Through this effort, local residents are learning that supporting healthy vegetation along their shoreline is beneficial for fish, even if the shoreline is artificially hardened (Schloesser pers. comm.).

A sister project that scientists are also working with these 10,000–15,000 snook into Phillippi Creek is to document how snook releases may impact the fishery, now that Mote scientists have identified optimal release strategies based on many years of research. By tagging most of the fish with coded wire tags (CWTs), Mote scientists can identify Mote-raised fish recaptured later and know where and when they were released. In addition, the snook that are fitted with PIT tags provide a “barcode”

identifying individual fish and containing other specific data, which can be "read" using a special handheld scanner. Scientists are then able to identify how hatchery-reared fish impact the local fishery and if they are caught by fishers.

13.5.4 William R. Mote Memorial Snook Shindig

The *William R. Mote Memorial Snook Shindig*, which is an annual catch-and-release research tournament involving the community, is one method Mote uses to recapture snook and evaluate the success of releases. Mote and Florida Fish and Wildlife (FWC) scientists have partnered with local fishermen on research studies designed to evaluate if stocking hatchery-reared snook can be an effective fishery management tool for replenishing snook stocks.

This annual event since 1998 allows Mote researchers to document snook caught during the tournament to identify individual hatchery-reared fish they previously tagged and released, recovering vital data that can be used to adjust release protocols (Fig. 13.9). More than 40 anglers participated in the November 2017 *William R. Mote Memorial Snook Shindig*, a research-based catch, sample and release

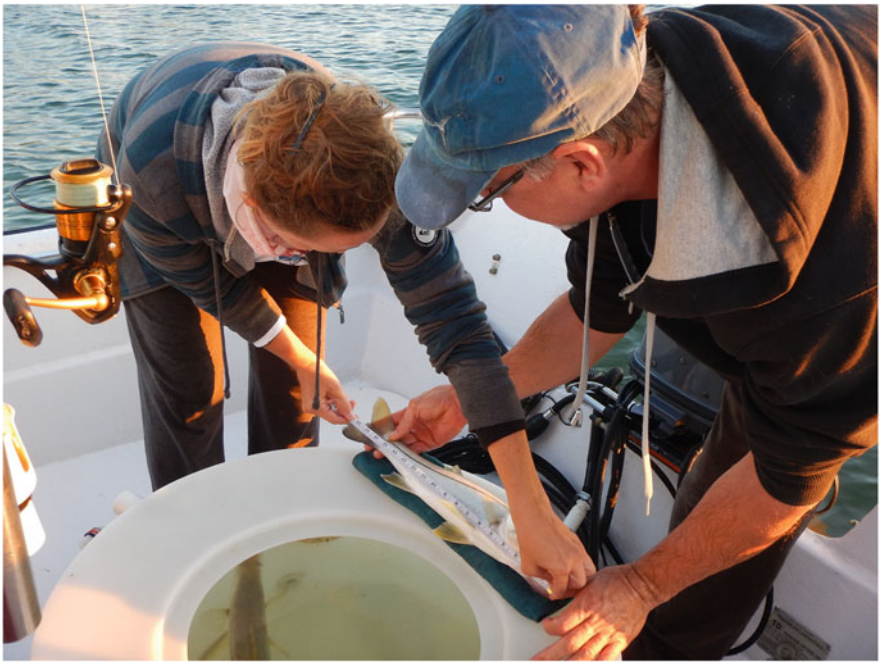

Fig. 13.9 Jennifer Castilow and Dr. Nate Brennan of Mote Marine Laboratory measure a snook during the November 2017 *William R. Mote Memorial Snook Shindig*

Fig. 13.10 Mote Staff Fisheries Scientist Carole Neidig speaks with young next-generation fishers at November 2017 William R. Mote Memorial Snook Shindig

tournament. This unique tournament involves the public in monitoring for snook released in fisheries enhancement studies.

The Mote Snook Shindig is the only scientific fishing tournament in which anglers of all ages (Fig. 13.10) focus on hatchery-reared and wild common snook. The goal is to estimate the contribution of previously tagged and released snook to the Sarasota Bay snook fishery and to learn valuable information such as how different habitats affect snook growth, survival, and migration patterns. This important tournament engages researchers and local fishers in collecting data to better understand how stock enhancement may help this snook population recover from large mortalities in the wild. Over the past decade, Mote scientists have released more than 61,000 snook into Sarasota area waters. Past Snook Shindig results have revealed that changes in snook release strategies, based on Mote pilot studies, have improved survival of stocked snook by as much as 200%.

13.6 The Sarasota Bay Satoumi Process

As fundamentally community-based ecosystem management partnerships, Mote's Community-Based Scallop Restoration, C-OCEAN, BleachWatch, Coral Restoration, and Phillippi Creek Fisheries Initiatives demonstrate the evolution of knowledge translation and circulation between, and among, traditional knowledge holders,

diverse stakeholders, volunteer citizen scientists, and formal scientific researchers, with all participants having different types of valuable knowledge.

These Mote case studies serve as models for how a residential research institute embedded as part of the local community for 66 years can serve as a vehicle for community knowledge sharing and solution building on a local socio-ecological problem. In each case, significant new scientific understandings of marine ecosystems were gained, restoration of critical habitats and biodiversity initiated, increased level of public ocean literacy furthered, and enhanced community engagement in marine resource management achieved in the spirit of the Satoumi concept.

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Chapter 14
Epilogue: Opening the Way to Sustainable Futures with Satoumi

Shinichiro Kakuma and Tetsu Sato

Abstract The authors extract and reorganize components of the case studies that we found useful to understand the challenges of Satoumi and to examine what we should do for Satoumi creation toward sustainable futures. We need a new relationship between people and the sea, in which people are deeply involved in coastal social-ecological systems. Effective Satoumi creation involves (a) social networks of Satoumi with mutual learning systems; (b) residential researchers and bilateral knowledge translators as key actors; (c) technical development for active measures in Satoumi; (d) formal and informal institutions for Satoumi creation; (e) sustainability of Satoumi activities with leaders and funding mechanism; (f) sense of ownership and legitimacy of local actors; (g) adaptive processes in improving Satoumi activities; and (h) evolution of Satoumi science for the future.

Keywords Transdisciplinary science · Residential researcher · Knowledge translator · Satoumi network · Sustainability · Adaptive processes

This book provides descriptions and analyses of the diverse forms of Satoumi in Japan and in the world from multilateral perspectives of diverse authors. Thus, it is natural that readers understand these Satoumi in diverse ways. Scientists may have scientific interest in various parts in this book and interpret them through the lens of their research. Practitioners may use a variety of components of Satoumi co-creation activities as references for creating their own Satoumi. We hope that such diverse perspectives, ideas, and criticisms on this book will lead to the future progress of research and actions for Satoumi.

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In this epilogue, we try to extract and reorganize components of the case studies of this book that we found useful to understand the challenges of Satoumi in the complex social-ecological systems and to examine what we should do for transdisciplinary collaborations of diverse stakeholders including scientists in Satoumi creation toward sustainable futures. Our understanding may differ from that of the readers, and we have no intention of forcing our understanding or interpretations on the readers. We would like the readers to think of it as the tips for solving issues suggested in this book for Satoumi creation.

14.1 New Relationship Between People and the Sea

There is a history of degradation of the environment and resources of coastal areas due to human activities, including land reclamation, water pollution, and overuse of marine resources. For this reason, there has been a tendency, at least in the past, to try protecting the pristine nature by environmental conservation and resource management that eliminates human influence as much as possible.

However, this approach makes it difficult to maintain the livelihoods and quality of life of people who are deeply dependent on the resources and other ecosystem services of coastal environments. Therefore, we need a new relationship between people and the sea, in which people are deeply involved in coastal social-ecological systems, making appropriate collective actions for environmental conservation, resource management, and restoration of ecosystems. This is the Satoumi.

In this book, we have shown that there are two types of interventions that people can make for the Satoumi areas: active measures (direct interventions) and passive measures (indirect interventions). Typical active measures include coral reef restoration (Chaps. 8, 11, and 13); seagrass bed restoration (Chap. 6); reconstruction of the stone tidal weir (Chap. 5); integrated multi-trophic aquaculture (Chap. 7); giant clam release (Chaps. 8 and 10); crown-of-thorns starfish eradication (Chap. 9); squid spawning bed installation (Chap. 12); and scallops and fish release (Chap. 13). Typical passive measures include control of red soil runoff (Chaps. 5, 8, and 11); various types of fisheries resource management (Chaps. 8, 9, and 10); marine protected areas (Chaps. 3, 8, and 10); local product markets operated by residents (Chaps. 5, 6, and 12); and interaction among people and cultural inheritance in many chapters. This book has shown that a good combination of these active and passive measures will lead to effective Satoumi creation to tackle wicked problems.

14.2 Spread of Satoumi

Satoumi is spreading not only in Japan but also worldwide. Why? The reason Satoumi is spreading in Japan is most likely not because more areas are adopting Satoumi as a new concept, but many areas decided to label their existing collective

actions as Satoumi creation, because narratives associated with the word "Satoumi" closely matched their perceptions. Regarding the Satoumi of Kashiwajima, Kanda had been using the word Satoumi even before Yanagi published the Satoumi concept in a journal in 1998. Similarly, the word Satoumi had already been used in various areas of Japan at the time. Yanagi's announcement of the word in an official setting led to rapid spread of the concept and its adoption into government policies. As specified in Chap. 3, the Satoumi process, in which people are closely involved with the sea and sustainably use its ecosystem services, has existed in Japan since the Edo period (1603–1867). When Kakuma first started using the word Satoumi, some of the coral reef researchers were critical of human intervention in coral reef ecosystems. However, practitioners conducting conservation activities of coral reefs or managing fisheries resources in various parts of Okinawa received Satoumi concept in positive ways. The Satoumi approach was not new or foreign to these people, but they had probably been familiar with such approaches before they became to know the word.

The image of the word Satoumi in Japanese language also seemed to influence the spread of Satoumi. It is easy to imagine that many people currently involved in Satoumi creation felt that the word Satoumi and its concept matched their activities and aspirations well when they first heard the word. When we organized a joint research meeting on Satoumi at Kyushu University in 2009, Norio Kinman, a fisher from Chiba Prefecture and the leader of the NPO "Banzu Satoumi team," stated in the beginning of introducing his definition of Satoumi that he felt Satoumi was the sea that stimulated nostalgia and provoked memories of the actions triggered by their emotions.

We should understand Satoumi as a comprehensive concept prescription (see Chap. 1) that envelopes highly diverse Satoumi in all of Japan and across the world, rather than defining it in rigid, exclusive terms. People in various areas should use the word Satoumi as a term to describe the perceptions of their own involvement to the sea. Rather than examining the precise definitions or what Satoumi comprises, we should concentrate on solving various difficult challenges associated with complex Satoumi social-ecological systems to ensure tangible progress of sustainable Satoumi creation.

In the process of spread of Satoumi in the world, the Satoumi concept seemed to be accepted relatively smoothly in Asia-Pacific countries because people in these countries tended to focus on the harmonization and coexistence of humans and nature. Chapter 3 described how Sunia, a former Governor of American Samoa, suggested the adoption of Satoumi-type MPAs that allowed traditional use by indigenous peoples against the government policy to establish no-take MPAs to eliminate human use. On the other hand, Chap. 2 described how negatively the Satoumi concept was received at the EMECS (Environmental Management of Enclosed Coastal Seas) Conference in 1997 when Yanagi introduced the concept to the world for the first time. However, at the same EMECS Conference held 9 years later, the concept was highly evaluated as "a symbiosis between human communities and coastal/marine areas – a more rational vision of co-existence." The first International Satoumi Workshop was held at the EMECS Conference 2 years later. Yanagi proposed that academic and social environments had changed in the world

in the 2000s to promote recognition of the importance of coexistence of humans and the sea by implementing appropriate human interventions.

14.3 Networking Satoumi

To bring solutions for various difficult challenges of Satoumi to ensure tangible progress of Satoumi creation toward sustainable futures, social networking of relevant actors of Satoumi (including women fishers introduced in Chap. 4) is essential (see Chap. 1). Practitioners of Satoumi in coastal areas with diverse social-ecological conditions need to improve and broaden transdisciplinary collaborations for Satoumi co-creation through mutual learning. The Ministry of the Environment of Japan has developed a networking tool called Sato-umi Net (Ministry of the Environment website n.d.). However, the Sato-umi Net is unlikely to assist mutual learning effectively since it is a unidirectional tool for disseminating information to its readers by providing teaching materials and information on Satoumi creation in various areas.

The FLMMA network in Fiji introduced in Chap. 10 is a social network among MPAs. Above 400 communities and 466 MPAs are connected to each other through the network. The FLMMA network is designed to promote mutual learning. Likewise, we need to consider creating national transdisciplinary networks of stakeholders including scientists for mutual learning among Satoumi areas in relevant countries including Japan. It is also important to consider the possibility of establishing an international network to connect researchers, practitioners, and supporters of Satoumi worldwide.

There are 62 Satoumi cases in Japan introduced on Sato-umi Net. According to a survey conducted by the Ministry of the Environment of Japan, there were 122 districts conducting Satoumi activities in 2010, and the number increased to 216 in 2014. The fisheries multi-functionality program implemented by the Fisheries Agency of Japan supported activities that fishers led to conserve or restore seagrass and algal beds, tidal flats, coral reefs, and inland waters. There are more than 600 organizations implementing Satoumi processes through this program, though they may not be referring to their coastal areas as Satoumi. If these districts and organizations can form a network to construct a system of transdisciplinary collaboration and mutual learning, it is highly likely that they will be able to improve their Satoumi to bring solutions to challenges facing the coastal social-ecological systems.

Local communities and the outside world can be connected through the activities of bilateral knowledge translators, as exemplified in the case studies introduced in this book. If we deliberately search among people associated with Satoumi creation activities, we may find people and organizations in each Satoumi area who are capable of taking the role of bilateral knowledge translator. For example, fisheries extension officers are candidates for bilateral knowledge translators (see Chap. 8). As of 2016, there are 433 fisheries extension officers in Japan (Kakuma and Kitolelei 2018).

14.4 Residential Research Institutes/Researchers and Bilateral Knowledge Translators

One role of this book is to introduce and analyze the transdisciplinary functions of residential research institutes/researchers and bilateral knowledge translators for Satoumi creation (Sato et al. 2018). In Shiraho, a residential researcher, Kamimura, played a major role in conducting various partnership-type projects in which people with varying values and positions cooperated with each other, including scientists from outside the community. As well, Yanagida, a fisher in Okinawa City, studied the recruitment of important fish species and red soil pollution as well as monitoring of an MPA. He also invited outside researchers, and they produced knowledge necessary for resource management through transdisciplinary collaborations. Higa, a worker of Onna Village Fishery Cooperative, independently collected and analyzed scientific data necessary for active measures for Satoumi creation, such as Mozuku seaweed aquaculture, aquaculture and planting of corals, and crown-of-thorns starfish extermination. Kanda in Kashiwajima established an NPO and led the research and put its results in action to solve challenges in Satoumi creation through collaboration with visiting researchers from outside the area. Shimizu, the representative of the Local Science Network for Environment and Sustainability that comprised residential researchers in various areas of Japan (139 researchers in 2016), analyzed the roles and functions played by Kanda in Chap. 12. The Mote Marine Laboratory in Florida is a typical residential research institute, which has been conducting a wide variety of research and promoting collective actions to solve local challenges related to the Sarasota Bay.

All residential researchers introduced in this book were indeed working as bilateral knowledge translators at the same time. In Hinase, Takehiro Tanaka, the head of the secretariat of the NPO Satoumi Research Institute, gathered information necessary for Satoumi creation from outside the community by critically analyzing its relevance to the region, translated it by providing new meanings, and shared it with the local stakeholders. Simultaneously, he provided integrated local environmental knowledge created through their experiences in Hinase to the outside by creating their broader meanings. Sachoemar in Indonesia applied the Satoumi concept that he had studied in Japan to fit to the actual conditions of the country to solve serious environmental problems. In Malawi, Chief Makanjira integrated fisheries management regulations by the government to local autonomous rules and systems to apply effectively. He also introduced his village's Satoumi process to the entire country by being on radio programs and mobilized networks of traditional authorities in the country by inviting chiefs of lakeshore areas to the beginning and ending ceremonies of their seasonal closure, thereby spreading their efforts of resource management to the entire country. In Fiji, *Turaga-ni-koro* (see Chap. 10) or village chiefs and elders connected the local community and the outside world as bilateral knowledge translators.

Bilateral knowledge translators play effective roles in mutual learning among Satoumi areas that are connected via networks (horizontal translator). They are also

expected to promote mutual learning across different spatial scales and governance levels (cross-scale translator). In the cases of effective cross-scale translation introduced in this book, multiple bilateral knowledge translators are often working at different scales and levels (see Chap. 9). For example, in Okinawa City, Kakuma had been working as a fisheries extension officer by providing prefectural, national, and sometimes even global level information necessary for resource management to local fishers by adding new meanings relevant to the local community. Simultaneously, he conveyed the experiences and achievements of Okinawa City to the opposite direction. Likewise, Yanagida, the leader of the fishers, had been performing cross-scale knowledge translation within the region standing between Kakuma and the fishers. In Malawi, the Department of Fisheries of the government and Chief Makanjira had played the roles of cross-scale knowledge translators, as well as researchers at the University of the South Pacific and *Turaga-ni-koro* in Fiji. The diversity and multiplicity of the horizontal and cross-scale knowledge translators will be more important in transdisciplinary Satoumi creation contributing to localized and broader-scale transformations (Sato et al. 2018).

14.5 Technical Implications of Satoumi Creation

Whereas all three Satoumi areas in Okinawa discussed in this book experienced land-based red soil pollution, other land-based pollutants known to disturb coral reef ecosystems also include excessive nutrients. However, there are some coastal areas in mainland Japan where insufficient nutrients have caused discoloration of laver in aquaculture. In the integrated multi-trophic aquaculture processes in Indonesia, insufficiency of dissolved inorganic nitrogen has reduced the growth rate of the seaweed Cottonii. As analyzed in detail in Chap. 2, rather than simply reducing land-based nutrient runoff, we should improve the material circulation in Satoumi by clarifying the balance between nutrient concentration and transparency that can maximize the primary production. Development of technologies to maintain this balance is critically important for future Satoumi managements.

Many technical challenges of Satoumi are indicated in active measures intended to enhance biodiversity and productivity by direct human interventions. In the case of stone tidal weir in Shiraho, the nature conservation organization investigated whether the stone tidal weir would produce positive or negative impacts on the coral reef ecosystems. Biological monitoring around the construction site was periodically conducted on various organisms such as fish species, and it was confirmed that biological diversity was enhanced by the construction of the stone tidal weir. For the restoration of seagrass beds in Hinase, improvements were made on the techniques for seeding of eelgrass (seagrass) and sediment improvement in a long-term adaptive process with repeated trials and errors, and, although it required a long time, the seagrass beds are currently recovering.

In Indonesia, they worked on a difficult problem of revitalizing an area with many abandoned fishponds due to prevailing diseases by developing a new aquaculture

technique. They succeeded in developing techniques to improve the aquaculture environment and productivity of closed water systems through integrated multi-trophic aquaculture of shrimps, fish, seaweeds, and bivalves. Concerning Onna Village Fisheries Cooperative, it seems that their eagle eyes to observe marine organisms and their habitats as fishers bring success of quick and effective development of coral reef aquaculture and restoration techniques compared to professional researchers. The recovery of fishery resources in Okinawa City, installation of spawning beds for squid on Kashiwajima, and releasing of scallop in Florida are also successful cases where transdisciplinary processes of technical improvements deeply rooted to the community played significant roles.

14.6 Formal and Informal Institutions for Satoumi Creation

In Satoumi where humans are closely involved with the sea, design and implementation of local rules of resource use, including arranging the relationship between fishery rights and customs and managing increased marine leisure activities, are inevitable for the sustainable governance of commons. While these problems were analyzed in detail in Chap. 8, they are not easily solvable in the complex social-ecological contexts. Research and collective actions to craft formal and informal institutions for Satoumi are desperately needed.

As of 2016, the number of fishers in Japan is approximately 160,000, and 38% of them are 65 years old or above. The number has fallen to make up only 0.2% of all workers (65 million) who are 15 years old and above in Japan. To create and maintain Satoumi, it is necessary to ensure the involvement of those who are not fishers, such as local and urban residents. The following cases of institutional arrangements introduced in this book are useful to consider the processes of transdisciplinary collaboration for Satoumi creation among fishers, local and urban residents, and scientists: the Satoumi creation activities conducted in cooperation with local farmers in Shiraho, the attempts by Onna Village and Hinase Fisheries Cooperatives to provide urban consumers with opportunities to participate in the Satoumi creation processes, and the activities in Kashiwajima to gather donations from all over the country by the bigfin reef squid ownership system.

Satoumi is a concept for the interaction between people and the sea, and many cases in this book focused on the interactions and networking among people to produce indirect impacts on ecosystem functions and services. Many activities promote communications and interactions among people with different backgrounds through formal and informal institutions, including the International Satoumi Workshops; Sunday Market in Shiraho; Gominoichi (five tastes market) in Hinase; Satoumi Market in Kashiwajima; the Satoumi Workshop in Indonesia; various awareness activities in Okinawa City; the beginning and ending ceremonies of their seasonal closure in Malawi; the social network for MPAs in Fiji; collaborations

of the fishers, food processing companies, and consumers' cooperatives in Onna Village; collaborations among fishers, divers, and forestry workers in Kashiwajima; and the networking and collaborations of professional and citizen scientists in Florida.

14.7 Sustainability of Satoumi Activities

Even with close involvement of people with the sea and appropriate human intervention for Satoumi creation, recovery of ecosystem functions and services including resources does not happen at the sufficient speeds. The eelgrass restoration activities in Hinase had not resulted in tangible success of the recovery of seagrass beds for a long time. It was only after 20 years of patient efforts that the seagrass beds suddenly started to expand. Sustainability of Satoumi creation activities themselves is critically important. There are more than 1000 MPAs in the Philippines, and a system was developed to evaluate the effectiveness of the MPAs to improve their functions (National CTI Coordinating Committee 2011), with the minimum criteria of 7 years continuation for the MPA to be judged as best practices in terms of sustainability.

Several cases introduced in this book are amazingly long-lasting. In Malawi, resource management activities have been continued for 70 years since the 1950s. Seagrass bed restoration in Hinase has continued for more than 30 years, coral reef restoration in Onna Village for 30 years, Satoumi creation activities in Kashiwajima for 22 years, the FLMMA in Fiji for 20 years, and Satoumi creation in Shiraho for 17 years. Satoumi creation in Okinawa City, the development of integrated multitrophic aquaculture in Indonesia, and Satoumi collective actions in Florida have been continued for more than 7 years.

Kakuma has investigated community-based coastal resource management in 12 island countries in Asia-Pacific and summarized factors contributing to the sustainability of resource management practices. The presence of dedicated leaders was an important factor, as shown in this book. The former head of the fishery cooperative in Hinase, Kazuo Honda, and his leadership made it possible for the activities to continue for more than 30 years. Kamimura in Shiraho, Yanagida in Okinawa City, Higa in Onna Village, and Kanda in Kashiwajima demonstrated excellent leadership of Satoumi creation as residential researchers. Sachoemar in Indonesia, Chief Makanjira in Malawi, *Turaga-ni-koro* in Fiji, and Crosby in Florida also played the roles of leaders as bilateral knowledge translators.

A few women leaders have played significant roles in some cases of Satoumi. For example, late Yukiko Ashikaga (NPO Nakatsu Waterfront Conservation Association) had been the leader of Satoumi creation at Nakatsu tidal flat, Oita, Japan, for a long time. Hikaru Nishino (General Incorporated Association Umikara, Obama, Japan) have been leading various Satoumi activities including eelgrass restoration and recycling of marine plastic debris in Obama Bay, Fukui, Japan. However, the

contribution of women on the Satoumi creation processes has not been recognized enough, mainly due to outdated gender role perceptions (see Chap. 4).

Successors of the leaders and new members of institutionalized management systems to maintain the effectiveness of the Satoumi activities are required to achieve adaptive and dynamic transformation of Satoumi. After Kamimura left Shiraho, the activities were taken over by the NPO Natsupana (summer flower) which is led by young leaders. In Hinase, the passions of late Kazuo Honda have been passed down to the current executive board of the fishery cooperative. In Malawi, the Traditional Authority has been leading the activities for over three generations, and the fourth-generation descendant is already starting to play the role of the leader.

Another crucial factor for the sustainability of Satoumi is the mechanism to secure funding. It is especially important in cases where Satoumi creations are led by small-scale NPOs and informal institutions with relatively weak funding bases and supports.

In Shiraho, the central organization leading the activities is changing gradually from the WWF Japan (Coral Reef Conservation and Research Center) to the NPO Natsupana. Natsupana apply Sunday Market, study tours for planting greenbelt to prevent red soil pollution, and product development and sales of a plant used in greenbelt to secure funding for their activities. In Okinawa City, the Satoumi creation activities were transferred from an NPO to the Satoumi Council financially supported by the prefectural government, greatly increasing the extent of their activities. However, prefectural projects are limited in time, and additional funding mechanism is required to maintain the same level of activities.

Although resource management activities have been practiced on a voluntary basis in Malawi, economic incentives of fisheries resource management activities may become crucial to motivate the participation of young fishers and other stakeholders in the village. In Fiji, there were many communities that have used MPAs for tourism to pay for the management costs. In Onna Village, although the activities have been led by local fishery cooperative with relatively stable funding bases, they have also developed an innovative system called the Mozuku Foundation to connect fishers and urban consumers through the supply chains to acquire funds for coral reef restorations. Kashiwajima has adopted the bigfin reef squid ownership system to acquire funds while inviting people living outside the area to participate in their Satoumi creation activities.

14.8 Sense of Ownership and Legitimacy

For the environmental conservation and resource management of the coastal seas through Satoumi creation, the local residents should have the sense of ownership regarding their coastal sea. The sense of ownership produces affection and pride for local Satoumi and the sense of responsibility and motivation to conduct time-consuming management activities. In Shiraho, the restoration and use of stone

tidal weir enhanced biodiversity and productivity of the coastal sea and fostered the sense of ownership for the Satoumi among local residents including farmers. In Okinawa City, the fishers investigating the fishery resources of the sea by themselves generated their sense of ownership through accumulating integrated knowledge essential for resource management.

Legitimacy refers to the right and acceptance of authorities, leaders, institutions, or groups of people to make decisions related to societal and environmental issues (including Satoumi creation) on behalf of and representing social structures and members. It is usually embodied as a governing rule (Bekkers and Edwards 2007). In Malawi, the Beach Village Committee introduced by the government was functioning effectively with the leadership of highly respected Traditional Authority and chiefs of villages. The committee secured legitimacy as it matched the traditional decision-making systems of the community. The legitimacy of this autonomous resource management system was strengthened when it was incorporated into the legal framework of the government.

Legitimate leaders, institutions, or any other actors (individual of group) have a huge potential to lead activities for Satoumi creation. In Shiraho, when the nature protection organization rephrased coral reef conservation in the context of succession of coral reef culture, it started to gradually gain legitimacy and eventually reconstructed the relationships with the fishers and farmers who had been hindered by airport construction issues. In Kashiwajima, Kanda even quit working as a diving instructor, which was his strongest expertise, to stay neutral to secure legitimacy in the community, making it possible for him to connect the fishers with divers. In other areas introduced in this book, legitimate actors and institutions have taken critical roles in Satoumi activities.

14.9 Adaptive Processes

In Malawi, the seasonal closure was originally intended to ensure the safety of fishers during the rainy season. It happened to contribute to conserving breeding grounds of important fishery targets as a byproduct. As the community-driven closure of fishing began gaining more attention, people started to regard the latter as the main purpose of the closure. Through transdisciplinary collaboration with the Department of Fisheries of the government and external scientists, the community adaptively improved and strengthened fisheries resource management systems even during fishing seasons. In Shiraho, the implementation of conservation activities in the context of coral reef culture which was desired by the local community adaptively mobilized participation of broader community members in conservation activities of coral reefs. While the restoration of seaweed beds initially aimed to increase the yield of small set nets in Hinase, the focuses have shifted to stabilizing the productivity of oyster aquaculture, which has become the primary source of income today.

At the ILEK project symposium "Satoumi of Japan, Satoumi of Okinawa" held in Okinawa in 2012, there was a question from the audience requesting a panelist to share his episodes of failures since he wished to learn from the mistakes. To this request, Higa, who led Satoumi activities of Onna Village Fisheries Cooperative, answered by saying he could not think of any failures. However, it was hard to imagine that he had never experienced any failures in coral reef restoration activities for more than 20 years. We can reasonably assume that he adaptively dealt with small failures to learn from them to improve collective actions. Most likely, he did not recognize any failures in this process, as each case of the failure was the learning opportunity to move forward.

In Okinawa City, the Satoumi creation activities of NPO INO were transferred to the Satoumi Council, which was officially supported by the prefectural government and the fishery cooperative, strengthening their legitimacy to expand their collective actions. In the Satoumi of Kashiwajima, installation method of spawning beds for the squid had been adaptively modified in 20 years. In Fiji, the community joining the FLMMA has a mandate to perform adaptive management. As the challenges of Satoumi in complex social-ecological systems are highly uncertain and predicting the consequences of actions is extremely difficult, adaptive processes and mutual learning are prerequisites for moving toward sustainable futures.

14.10 Evolution of Satoumi Science for the Future

The transdisciplinary Satoumi science is yet to be systematized as an established academic practice. That is an issue for the future. In many chapters of this book, the need of transdisciplinary processes to integrate scientific knowledge with ILEK to share with the actors in local community was suggested. Research that can be useful for advancing science is not necessarily be useful for solving complex challenges in local social-ecological systems. The conventional approach was incapable of solving challenges related to Satoumi with high levels of uncertainty and unpredictability.

Therefore, it is obvious that sophisticated transdisciplinary Satoumi science, that is issue-driven, comprehensive, and solution-oriented, is essential. This book introduced many cases where transdisciplinary researchers or experts from outside the locality collaborated with various local actors, including residential researchers and other legitimate actors. They co-designed the research agenda, co-produced knowledge and technologies, and put the results of the research in collective actions to mobilize adaptive processes. The scientific knowledge brought by external researchers or experts was translated by local bilateral knowledge translators to fit local framing, integrated to the preexisting local knowledge systems of the community, and resulted knowledge set is transformed through mutual learning. By putting the outcomes of this transdisciplinary science into action, new knowledge is co-created, tested, and improved. Integrated local environmental knowledge (ILEK) refers to the integration and dynamic transformation of various types of knowledge through the transdisciplinary processes. The readers of this book will

certainly understand how ILEK is dynamically produced, shared to contribute to decision-making and actions, and implemented to revitalize sustainable Satoumi by people in local communities themselves.

Local Science Network for Environment and Sustainability (2011) created the Guidelines on Collaboration Between Local Communities and Scientists, intended to assist efficient research in transdisciplinary science. The guidelines include "17 Articles for Creating Networks for Solving Problems" and "17 Articles for Producing and Using Knowledge." The guidelines emphasize that, in cases where various local actors and researchers are not collaborating based on mutual trust, their transdisciplinary research cannot be conducted properly and bringing solutions to local challenges is difficult. To establish mutual trust, researchers need to have a humble attitude that they are also learning from the local community.

Research on Satoumi is being carried out not only in Japan but also worldwide. For 12 years since 2008, the International Satoumi Workshop has been held annually somewhere in the world. Researchers and practitioners of Satoumi worldwide should promote trust-based collaborations to promote transdisciplinary Satoumi science through this network.

The visions and approaches of Satoumi science themselves will adaptively and dynamically transform through the mutual interactions and learning among local stakeholders and scientists. We look forward to the evolution of Satoumi science through such transdisciplinary processes to contribute to mobilizing decision-makings and collective actions to solve the challenges in Satoumi in the world to achieve SDG targets toward sustainable futures.

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Afterword

Shinichiro Kakuma

The most important message we want to deliver to the readers of this book is "creating Satoumi, where local people are closely connected with the sea, is more effective in environmental conservation and resource management, than protecting pristine nature that eliminate people." Additionally, I hope we have succeeded to some extent, if not fully, in achieving the objective of this book, which is to analyze and clarify the diverse Satoumi in various regions from multiple perspectives.

The first international conference on coral reefs that I attended was the International Coral Reef Symposium held in Bali, Indonesia in 2000. About 1500 people throughout the world gathered for active discussions in various fields. I listened to many presentations on coral reef conservation and resource management, and what struck me was that the fishery was being demonized. As a fisheries scientist, I was shocked. Indeed, there were countries where dynamite and cyanide (poison) fishing directly destroyed the coral reefs, but there was an atmosphere of "the fishery itself is bad for coral reef ecosystems." Since then, to keep the balance between ecosystem conservation and resource use has become one of my prime themes. Shortly afterward, I heard about Satoumi concept from Tetsuo Yanagi and came to believe that this concept was the best way to achieve the balance.

It is true that the environment and resources of coastal waters have been degraded by human involvement, such as land reclamation, water pollution, and overfishing. However, it is also clear from the examples in this book that productivity and biodiversity in coastal waters can be enhanced by human involvement. We must continue to enhance productivity and biodiversity and balance ecosystem conservation and resource use through the Satoumi creation in the future.

I would like to express my sincere gratitude to all the people who have helped us write this book in various ways. The following is a list of the people and organizations that have been especially helpful to us (alphabetical order).

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Index

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