sustainability

MDPI

Review

Satoumi Systems Promoting Integrated Coastal Resources Management: An Empirical Review

Shinichiro Kakuma

Institute of Ocean Energy, Saga University, Saga 849-8501, Japan; kakuma77@gmail.com

Abstract: Coastal areas, eco-systems, biodiversity, and fisheries resources have been devastated worldwide because of diverse reasons. In Japan, to tackle these problems, various activities have been practiced, which deeply involve local people in Satoumi. The Satoumi activities are now spreading throughout the world. These Satoumi are extremely diverse, and it is difficult to capture them with a single definition or perspective. Because social–ecological systems in Satoumi areas are extremely complicated and highly uncertain, Satoumi co-creation requires transdisciplinary approaches in which diverse stakeholders including local residents, bilateral knowledge translators, and residential and visiting scientists play important roles. This paper reviews the various types of Satoumi in Japan and around the world, and Satoumi co-creation activities through the transdisciplinary approaches from multiple perspectives. The Satoumi co-creation includes not only the traditional single approach of resource management but also approaches to enhance the resources by direct human intervention, to conserve ecosystems that support the resources, and to survey and monitor the resources by fishers. This paper also reviews the synergy and integration of fisheries and other resource management, such as tourism-related activities in marine protected areas in Satoumi.

Keywords: Satoumi; transdisciplinary science; active measure; passive measure; residential researcher; bilateral knowledge translator

Citation: Kakuma, S. Satoumi Systems Promoting Integrated Coastal Resources Management: An Empirical Review. *Sustainability* **2022**, *14*, 11702. https://doi.org/10.3390/su141811702

Academic Editor: Just Tomàs Bayle-Sempere

Received: 31 July 2022
Accepted: 15 September 2022
Published: 18 September 2022

1. Introduction

This paper is a review of Satoumi, which has recently begun to expand not only in Japan but also in other parts of the world. Fisheries resource management in Satoumi involves not only traditional management methods such as no-take zones, seasonal closure, size limits, etc., but also integrated approaches such as actively enhancing resources through human intervention, preserving the environment and ecosystems that support the resources, and conducting surveys and monitoring by fishers and local people. In addition to fisheries resources, there are also examples of the integrated management of tourism and forest resources. This paper reviews such integrated Satoumi systems focusing on examples in the book "Satoumi Science" [1] and other literature.

2. What Is Satoumi?

2.1. Definition of Satoumi

"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." 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 [2]. The author believes 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 [3].

2.2. Expansion of Satoumi

Currently, Satoumi creation is being promoted in many parts of Japan. According to the surveys conducted by the Ministry of the Environment, the number of districts in Japan practicing Satoumi activities has increased from 122 in 2010, 216 in 2014, to 291 in 2018. 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 refer to their coastal areas as Satoumi. Satoumi is also spreading overseas, and examples of Satoumi have been reported all over the world. Since the first international Satoumi workshop was held in China in 2008, an international Satoumi conference had been held annually somewhere in the world for 12 consecutive years, in the Philippines, Japan (Kanazawa), the United States (Baltimore), the United States (Hawaii), Turkey, Japan (Tokyo), Vietnam, Russia, France, Thailand, and St. Lucia/Fiji [4].

2.3. Transdisciplinary Approach

Satoumi creation requires not only interdisciplinary science that integrates natural sciences, social sciences, and humanities, but also transdisciplinary sciences incorporating co-design of research agenda, the co-production of integrated knowledge, and the co-delivery of research outcomes in collaboration with diverse actors/stakeholders outside academia [5,6]. Social–ecological systems in Satoumi areas are extremely complicated and highly uncertain. This is why solving problems in Satoumi is not easy when scientists and experts from outside the community define the problems and implement research without the involvement of the local people. 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 [7].

2.4. Active and Passive Measures (Diverse Approaches)

Satoumi creation involves active and passive measures. In coral reef areas, for example, Satoumi creation activities are divided into two types: direct human intervention (active measures), such as coral planting and coral-eating starfish extermination, and indirect human intervention (passive measures), such as red soil pollution control and fisheries resource management. Not only active measures but also passive measures are deeply related to the essence of Satoumi [7].

2.5. Residential Researchers and Bilateral Knowledge Translators

In the creation of Satoumi, there are two important actors in the transdisciplinary processes: residential researchers and bilateral knowledge translators. The term residential researchers refer to the researchers who reside and base themselves in a certain local community and become a member of the local community at the same time being an expert to produce scientific knowledge [6]. "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" [6].

3. Various Approaches to Fisheries Resource Management and the Management of Diverse Resources in Satoumi

3.1. Okinawa City

3.1.1. Length Limits of the Most Important Fish

Okinawa City is located on the east coast of Okinawa Island in Okinawa Prefecture, the southernmost prefecture in Japan. Akajin (Okinawa's local name of *Plectropomus leopardus*) and Makubu (Okinawa's local name of *Choerodon schoenleinii*) are the most important fisheries resources in Okinawa due to their high prices, but their stocks are declining in many areas of Okinawa. As the stocks are declining in the fishing grounds of the Okinawa City Fisheries Cooperative, since 2014, the fishers there 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 under the length limits are not allowed to be sold in the fishery markets [8].

3.1.2. MPA

Yanagida, a fisher and a leader of Okinawa City's Satoumi creation, succeeded in persuading fishers to establish a no-take MPA in 2015. Although the MPA is small (100-m square), it is rich in coral and fish. Buoys were placed at the four corners of the MPA to clearly indicate the extent of the MPA. Since the MPA rules are voluntary, no penalties have been set. In addition to coral planting in the MPA, the restocking of small giant clam, *Tridacna crocea*, was conducted [8].

The monitoring of fish and benthic organisms in the MPA was conducted periodically by fishers. 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-long lines 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. The other method is the quadrat method, in which 17 square frames of 2 m $\times$ 2 m are set up on the lines [8].

3.1.3. Coral Culture and Planting

Since 2010, Yanagida has cultured 13 species of *Acropora* corals on steel mesh tables set up in the sea. The cultured corals have been sold to companies that use coral planting for environmental education as CSR (Corporate Social Responsibility) and have also been planted on the coastal waters of Okinawa City through various subsidy programs. Coral planting activities are currently conducted in various parts of Okinawa with the aim of restoring coral reefs. As a result, the demand for coral for planting is increasing, and Yanagida is trying to supply the corals through aquaculture by the fishers' group. Although the scale of coral planting is still small, Yanagida's activities are frequently covered by the mass media, and are effective in educating children about the environment and spreading awareness on coral reef conservation throughout Okinawa [8].

3.1.4. Surveys by Fishers

In Okinawa City, fishers themselves conducted surveys of important resources (juvenile recruitment surveys). The survey by the fishers themselves has several advantages for resource management. First, 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 a different morphology and color from adults). 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 [9]. The fishers conducted surveys on the recruitment of Akajin and Makubu. The survey method was guided by researchers from a local government research institute. 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 intervals) of Akajin and Makubu was recorded by divers swimming along the lines [8].

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 [10], and it also has a direct impact on fisheries and aquaculture. When the red soil adheres to cultured Mozuku (seaweed), 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. Additionally, 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 sea floor. The concentration of red soil in seawater is unstable, but SPSS (content of Suspended Particles in Sea Sediment) is relatively stable [11]. In Okinawa City, SPSS has been measured by fishers since 2013 [8].

3.2. Onna Village

3.2.1. Preparation of a Coastal Resource Management Plan

Onna Village is located on the northern west coast of Okinawa Island. The Onna Village Fisheries Cooperative (OVFC) developed a regional fisheries promotion plan in 1987. This plan was a five-year comprehensive plan to revitalize Onna Village's fisheries, but the main pillar of the plan was a coastal resource management plan, and the plan was adaptively revised three times by 2007 [12]. The author assisted in the preparation of this plan as a fisheries extension officer of the Okinawa Government. The fisheries extension officers are potential bilateral knowledge translators. One direction of translation that they perform 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 [13]. The extension activities were carried out through a transdisciplinary approach. The author visited Onna Village once a month during the year of the plan development to discuss with fishers. The resource management plan was developed by integrating the information of research institutions and the knowledge and opinions of the fishers. The main tool for the resource management was MPAs for sedentary species such as giant clams, trochus, and sea urchins. At that time, the term "MPA" did not even exist. This management system has spread to other districts of Okinawa as an advanced example of autonomous management by fishers. The author also introduced the resource management efforts of OVFC at an international conference held in New Caledonia in 1995 as an excellent example of co-management [14].

3.2.2. Coral Culture and Planting

Since 1998, activities have been conducted to help corals regenerate by raising spawning corals through coral culture and planting. These activities combine two methods: "coral stick culture," in which coral is grown on steel bars driven into the sand and gravel bottom, and "coral planting," in which fragments are collected from cultured corals and transplanted to the sea bottom.

Coral stick culture grows corals on the sand and gravel bottom, where corals normally do not grow, and cultivates corals at a height of 50 cm above the seafloor (Figure 1). OVFC cultured 54 species of corals from 11 families. Since 2009, the fisheries cooperative, a Mozuku processing company, and consumer co-ops have collaborated to create the "Mozuku fund" to contribute to coral reef restoration. Specifically, one to two yen per pack of processed Mozuku is set aside in the Mozuku fund, and the money is used for coral culture. Twenty-eight co-ops (6.7 million members) across Japan had cooperated, and by 2015, more than 10 million pack money had been set aside in the fund and 24,000 corals had been cultivated [12].

The eggs and sperm from the same coral colonies cannot be fertilized. The Okinawa Institute of Science and Technology Graduate University examined the genetic information of the cultured corals of OVFC and found that there are genetically diverse corals within the same species. This means that the eggs and sperm of corals cultured, planted, and grown by OVFC are fertilizable and supply larvae to the surrounding waters. In one study, 115,000 coral larvae were obtained from 30 cm cultured *Acropora tenuis* (a species of coral). As of 2017, 24,000 $\times$ 115,000 = approximately 2.8 billion larvae were supplied to the surrounding waters [15]. The number of fish and species inhabiting the 30 cultured corals was 841 individuals of 33 species, mainly damselfish. Overall, cultured corals are estimated to have been inhabited by approximately 670,000 fish [15]. Thus, coral stick culture in sandy waters attracts small fish as the coral grows and increases biodiversity.

Figure 1. Coral stick culture in Onna Village.

Coral planting in Onna Village began in 1989 when the youth group of OVFC conducted a trial of coral planting activity. In 2003, a coral seedling supply facility was established by OVFC, and it began accepting coral planting tours. Since 2013, coral planting had been conducted under an Okinawa Government project, and by 2016, 120,000 corals were planted in a 3-ha area [12]. This was the first coral planting of this scale in the world.

3.2.3. Prevention of Red Soil Runoff

Red soil runoff became a problem in Onna Village after Okinawa's reversion from the United States to Japan in 1972. A large amount of red soil ran off into the coastal waters because of resort development and road constructions. In accordance with the "Okinawa Promotion and Development Special Measures Law", agricultural land improvement projects had begun, which accelerated the flow of red soil into the sea. The red soil runoff at that time was tremendous, and after heavy rains, mud accumulated on the tidal flats, creating rice paddies [12].

OVFC succeeded in the Mozuku culture in 1977, but the following year, 1978, the red soil runoff caused damage to the Mozuku and Hitoegusa seaweed being cultivated. Although the fishers at the time strongly protested, the social trend was all for development. Thus, fishers protesting about red soil runoff felt a sense of alienation as if they were an obstacle to developing Okinawa. Around 1989, red soil runoff became a social problem, and a council led by fishers was formed at the initiative of fishery-related organizations. This council conducted a survey of red soil runoff in various parts of Okinawa, which led to demands for the prefectural government to enact an ordinance to prevent red soil runoff, and the ordinance was enacted in 1994. OVFC established a system of prior consultation with private developers in Onna Village, whereby red soil runoff prevention measures are discussed in advance, prevention facilities are built ahead of time, and the main construction work should start only after confirmation of these facilities [12].

The prior consultation system was applied to the village's agricultural land improvement projects in parallel with the private-sector construction work. In 1994, the effectiveness of red soil runoff prevention measures in Onna Village was estimated to prevent about 97% of soil runoff compared to no measures. In Onna Village, the last red soil damage was caused by the construction of revetments on a tidal flat in 1996. The production of Hitoegusa seaweed on one of the tidal flats increased from approximately 11 tons in 1991, which was the worst year, to around 60 tons in 2002, because of red soil prevention measures. This clearly shows the effectiveness of such measures [12].

3.2.4. COTS Eradication

Crown-of-thorns starfish (COTS) feed on corals. COTS eradication is an active measure for Satoumi creation, where direct human interventions are implemented to protect biodiversity. The primary goal of COTS eradication is to prevent periodic major outbreaks of COTS. Onna Village has been experiencing small, chronic outbreaks of COTS, with three major outbreaks occurring in a 12–13-year cycle in 1971, 1984, and 1996. Fishers in Onna Village have conducted COTS eradication for many years. Since 2002, they have set a goal to prevent the fourth major outbreak, and to eradicate spawning-size starfish before the spawning season in the entire Onna Village [12].

To efficiently eradicate the starfish, the coastal area was divided into five areas and each area was determined to work on a particular day. For the eradication work, three to six people board one fishing boat and each person tows a small boat approximately 2 m long and skin dives with a harpoon or hook to collect COTS. This method allows for a wide area survey in waters shallower than 5 m in depth. The date, time, location, and length composition in 5 cm increments of the eradicated COTS are recorded for each fishing boat. The results were sorted out in length composition tables for each day and location and were presented to the fishers the next day. The size composition graphs visualized the priority areas for eradication, i.e., areas where there were leftover COTS, and increased the motivation of the fishers. In the Onna Village area, COTS increased from 2011, but the fourth major outbreak was prevented by deploying more than 500 eradication participants each year [12].

3.3. Shiraho

In Shiraho village on Ishigaki Island, Okinawa, the World Wide Fund for Nature (WWF) Japan and the local community have been collaborating on the common theme of Satoumi creation. Originally, there was a big difference in the way the two parties perceived local issues. WWF, a nature conservation organization, placed the conservation of globally precious coral reefs as the most important issue, while the Shiraho community, which had experienced community division due to the airport issue, emphasized cultural succession and community revitalization. Collaboration between the two groups has been realized by filling in the gaps of these differing goals [16].

3.3.1. Airport Problem

In 1979, a plan was announced to reclaim the coral reefs of Shiraho and build a new Ishigaki Airport. The Shiraho Community Center, the local self-governing organization, held a special meeting and unanimously resolved to oppose the plan. The small village's opposition to the large public construction project spread throughout the island, the prefecture, and the nation. In this process, the value of Shiraho's coral reefs was recognized worldwide, including the identification of one of the world's largest blue coral colonies, and WWF Japan became involved in the issue by supporting academic research [16].

The airport issue was protracted and caused a division in the community. The community was divided into "for" and "against" the airport, and in 1985, those who were "for" the airport established a separate Community Center. Since then, for 10 years until the Community Centers were reintegrated in 1995, Shiraho had the unusual situation of holding two separate Harvest Festivals and Coming-of-Age Ceremonies. These divisions left a significant lump in the subsequent community development and coral reef conservation [16].

3.3.2. Coral Village and Coral Reef Culture

In Shiraho, WWF opened the Coral Reef Conservation and Research Center (nicknamed Coral Village) in 2000 and has been conducting conservation activities in collaboration with local residents. At the time of its establishment, the impact of the new airport construction on the coral reef ecosystem was an important issue, and nature conservation activities were developed based on the concept of "protecting corals." Later, red soil runoff from farmland became an issue, and it became essential for farmers, who make up most of the local population, to take measures to prevent red soil runoff. Coral Village focused on the lifestyle of farmers when they were deeply involved with coral reefs and shifted its approach for nature conservation to community development activities to carry out "coral reef culture." Through cultural and economic activities, Coral Village developed various activities, including community development that "resulted" in the conservation of coral reefs [16].

3.3.3. Restoration of a Stone Tidal Weir

The stone tidal weir, traditional stationary fishing equipment, is a semicircular or square stone wall built with boulders on shallow coast to catch fish as the tide ebbs and flows. They catch fish that come to shore at high tide but are blocked by the stone walls at low tide, preventing them from returning to offshore. In Shiraho, there were 13 stone tidal weirs in the past, but all were lost. Coral Village and the community decided to restore the stone tidal weir to use it as a place for cultural learning and nature experience related to the sea. This fishing equipment had been used by farmers in Shiraho, and it was hoped that it would provide an opportunity for the farmers to reconfirm their connection to the sea [16].

The restoration work was a large-scale project involving the PTA (parent–teacher association) and students of Shiraho Elementary School and Junior High School. The stone tidal weir was about 200 m parallel to the coastline, 70 m offshore, and the height of the stone wall was about 1 m. Since its completion in October 2006, the site has been used as a place for local children to experience nature and for environmental education (Figure 2) [16].

Figure 2. Stone tidal weir in Shiraho used for environmental education.

Environmental surveys conducted by the Coral Village before and after the restoration of the stone tidal weir confirmed an increase in the number of fish species and individuals. This was due to the increase in fish that use the crevices of the stone structures as hiding places and fish that feed on seaweed attached to the stones. Then, the stone tidal weir drew attention as one of the examples of the definition of Satoumi, "high productivity and biodiversity in the coastal sea with human intervention" [16].

3.3.4. Measures to Prevent Red Soil Runoff

A 2007 fishing experience by junior high school students in the stone tidal weir resulted in a catch of only four fish. The students believed that the cause of this small catch was red soil runoff from the farmland, and they decided to work on the prevention of red soil runoff and proposed an activity to plant green belts (shell ginger) around the farmland. At the time, the installation of green belts around farmland was considered as one of the most important measures for the prevention of red soil runoff in Okinawa. However, due to several problems, farmers were not cooperating, and the measure was not progressing. Therefore, Coral Village visited farmers individually to obtain their consent to install green belts, and Ishigaki City provided shell ginger seedlings, which were planted by junior high school students as volunteers [16].

The green belt planting activities started with junior high school student volunteers, but later expanded to include WWF member tours, training for donor companies, coral reef conservation experience programs for junior high and high school excursions from the mainland Japan, and study tours. Participants were asked to contribute to an environmental cooperative fund to cover the cost of planting activities. This created a mechanism for conservation efforts while raising funds locally [16].

3.3.5. Restocking of Giant Clam

As the momentum for active measures in Satoumi to restore the bounty of the sea increased, the Shiraho community tried to increase the stock of giant clams (*Tridacna* spp.), a local fishery resource that has been popular in the region. Giant clams used to be abundant in the waters of Shiraho and were familiar food items served at banquets after communal activities. However, the results of surveys conducted by Coral Village showed that the stocks had declined significantly since 2003 [17].

Therefore, small giant clams were purchased from the Okinawa Government and restocked under the guidance of fisheries extension officers, including the author. The restocking was conducted at snorkeling tourism points from the periphery of the stone tidal weir to the offshore area. A total of 9100 small giant clams were restocked in 2009 and 2010. By leaving them as spawning stocks instead of harvesting them, they will spawn and help increase the giant clam resources in the surrounding area. After discussions among Shiraho residents, it was agreed that the area be closed to fishing throughout the year. The grown beautiful giant clams are also used as tourism resources (Figure 3) [17].

Figure 3. Beautiful mantle of restocked giant clam in Shiraho.

3.4. Hinase

3.4.1. Eelgrass Bed Restoration

Hinase is located in the southeastern part of Okayama Prefecture, facing the Seto Inland Sea in Japan. Eelgrass beds form on sandy and muddy bottoms in quiet bays. Eelgrass beds are important as nurseries for various juvenile fish because they reduce tidal currents and strong light, provide spawning grounds for cuttlefish and other small fish, and provide a good food source for small fish. During the 1950s–1980s, as the Seto

Inland Sea was polluted and reclaimed, the area of eelgrass beds around Hinase gradually decreased. In the 1940s, there were about 590 hectares (ha) of eelgrass beds, but by 1985, the area had been drastically reduced to about 12 ha [18].

The Hinase Fisheries Cooperative adopted the sowing method as a method for creating eelgrass beds. 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, these seeds are sown in the sea area where the eelgrass beds have disappeared. 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 [18].

The area of eelgrass beds did not increase at first. Typhoons sometimes destroyed the grown eelgrass beds. However, around 20 years after the start of the activities, the eelgrass beds suddenly began to increase, recovering to approximately 120 ha in 2008, 200 ha in 2011, and 250 ha in 2015. Simultaneously, the catches of crab, cuttlefish, and sea bream, which are closely related to the eelgrass beds, also increased [19]. This increase in eelgrass beds has been favorably influenced by the increase in transparency in this area due to nutrient influx regulations throughout the Seto Inland Sea [18].

3.4.2. Oyster Culture

The restoration of eelgrass beds was initially intended to recover the catches of small set nets. As the eelgrass beds increased, the catches of small set nets, including shrimp and fish, also increased, but the number of small set net fishers decreased. Rather, it is functioning to stabilize the production of oyster aquaculture, the main industry in Hinase. In fact, oyster aquaculture production, which had been markedly instable, had been stable at a high level for five consecutive years since 2008, when the eelgrass beds began to visibly recover, and oyster farmers see this as a benefit of the eelgrass beds [19].

Eelgrass beds and oyster farming have a symbiotic relationship. Oyster farming benefits eelgrass because: (1) oyster rafts attenuate offshore waves, preventing eelgrass roots from being washed away; and (2) cultured oysters feed on phytoplankton and other marine suspended solids, increasing transparency and helping eelgrass beds move to deeper areas. On the other hand, eelgrass has the following benefits to oyster farming: (1) it spreads its leaves close to the sea surface, creating a curtain that reduces the water temperature rises during the summer; (2) diatoms and small animals attached to eelgrass leaves are detached from the leaves by waves and drift in the sea water, where they are fed on by cultured oysters, thus improving the oyster growth rate; (3) it increases dissolved oxygen content and stabilizes oyster growth. In fact, in Hinase, the high-temperature mortality rate of cultured oysters in summer has decreased and their flesh has increased as the area of eelgrass beds has increased [18].

3.5. Kashiwa Island

3.5.1. Toward the Coexistence of Marine Leisure and Fisheries

On Kashiwa Island, located at the southwestern tip of Kochi Prefecture in Japan, divers and fishers who make the sea their livelihood have been working together to install artificial spawning beds for bigfin reef squid (*Sepioteuthis lessoniana*). The installation of artificial spawning beds, a cooperative effort between divers and fishers, was the catalyst for a change in the relationship between fishers and divers from confrontation to cooperation. In the past, fishers distrusted divers who began diving without permission and interfered with the fishing, and divers insisted that "the sea belongs to everyone," and the relationship between fishers and divers deteriorated. To break out of such a relationship, the fisheries cooperative and the diving operators came to the table for discussions, but the talks did not go far. The fisheries cooperative tried shutting divers out using their fishing rights as a shield, while divers insisted that they were free to dive anywhere as long as they did not engage in poaching. A compromise was sought, and as a result, a rule was established in which the diving side would take into consideration the fishers who have been operating the fishery for a long time [20].

In addition, the local fishers were facing the problem of less catch of bigfin reef squid, which had been a source of cash income for them. Fishers commented that they could not catch the squid because divers were diving. However, the reason for the decreased catch of the squid seemed not for diving but for a decrease in algae, in other words, sea desertification. The squid come to the algal beds where Sargassum, one of the large algae, grows thickly and spawns in May and June; but the Sargassum was decreasing. There are various causes of sea desertification, two of which are soil runoff and nutrient depletion due to lack of forest management. The lack of thinning causes a lack of sunlight and undergrowth on the forest floor, which in turn causes soil runoff due to rainfall and a decrease in nutrients that flow out to the sea. The loss of the spawning environment of algal beds seemed to be the cause of the decrease in the squids, and the installation of artificial spawning beds has been undertaken since 2001 [20].

3.5.2. Installation of Artificial Spawning Beds

On Kashiwa Island, there is a fishing method called "Shibazuke," in which fishers tie stones to a broadleaf bush called Ubamegashi and place them in the sea, and this method was applied. The installation site was in a sandy area about 20 m deep. In the first year, divers and fishers went into the mountains together to cut down branches of Ubamegashi. Sandbags were attached to the branches, placed in the installation point, and the divers dove down to secure them in place. The squid responded quickly, and one after another, eggs were laid on the spawning beds (Figure 4). This year, the squids laid up to 10,000 egg sacs per spawning bed, and 70,000 to 80,000 eggs per spawning bed. Normally, a few dozen to several hundred egg sacs per spawning bed is considered a success, so the challenge was a great success [20].

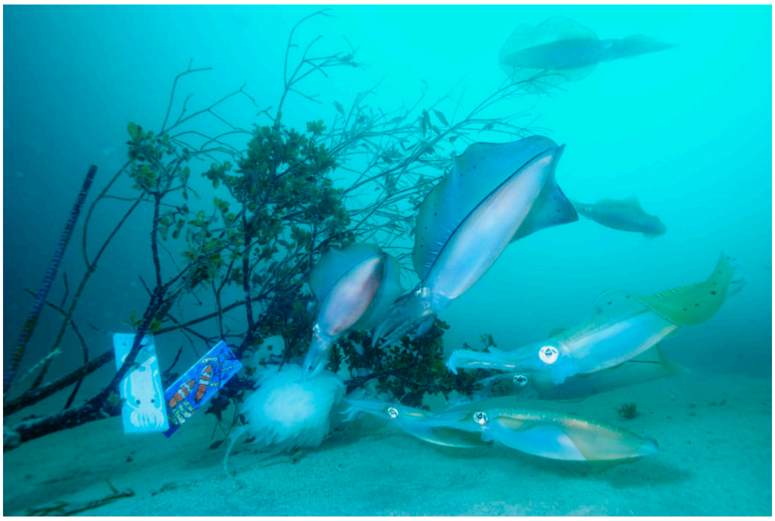

Figure 4. Bigfin reef squid laying egg sacs in Kashiwa Island. © Masaru Kanda.

3.5.3. Deepening of Technology and Spread of Collaboration

The artificial spawning bed installation project, which began with the cooperation of divers and fishers, was technically improved in the second and third years, and the number of collaborating parties expanded to include the forestry cooperatives, children on Kashiwa Island, and schools outside the island. Since the fifth year, the local fisheries cooperative has taken the lead in this effort, with the full cooperation of dive operators. One of the technical improvements was to change the branches used for spawning beds. If too many Ubamegashi were cut down to increase the squid, the mountains around the island, which had functioned as fish-breeding forests, would be devastated. In the second year, the fishers decided to use branches of cedar and cypress that had been thinned in the artificial forests. There are many artificial forests around Kashiwa Island, and it is necessary to thin the forests to let sunlight in. Unnecessary branches and leaves from the thinning work were used to create spawning beds [20].

The installation of artificial spawning beds was originally started to improve relations between divers and fishers. In the third year, with the cooperation of the forestry cooperatives of Otsuki Town and Sukumo City, the project was turned into an environmental education program for children. Children from Kashiwa Island Elementary School experience forest thinning in the mountains and take home the branches and leaves they cut. Each child can write a message on a plate made of thinned branches and attach it to a spawning bed to create his or her "my spawning bed." From the fourth year, not only children on Kashiwa Island but also those from the surrounding area have been involved in this program, leading to an exchange between children of the sea and the mountains. The circle of activities has expanded to include Otsuki Town, Sukumo City, Shimanto City, and Tosashimizu City, and the installation of artificial spawning beds has spread throughout Sukumo Bay, expanding the network of environmental education for children. This initiative, with local children playing a central role, has encouraged people who previously had poor or weak relationships to join in the effort for the sake of the children. Because of the awareness that everyone was involved, the circle of collaboration expanded to include fishers, divers, forestry cooperatives, elementary schools, PTA, and the governments [20].

3.6. Vanuatu

3.6.1. Transplantation of Matured Green Snail

In Vanuatu, an island nation located east of Australia, a JICA (Japan International Cooperation Agency) project was undertaken in 2007 to transplant the green snail (*Turbo marmoratus*, Figure 5), whose stocks had been drastically depleted. The green snail is a large marine snail with a shell height of more than 20 cm and is an important fishery resource in Pacific Island countries, where its meat is edible, and its shell is exported as a material for mother-of-pearl inlays and other applications. Recently, however, overfishing has led to a decline in its abundance throughout the Pacific. In Vanuatu, green snail has been completely banned from fishing since 2005 due to a drastic decline in the stock. JICA implemented technical cooperation projects "The Project for Promotion of Grace of the Sea in the Coastal Villages" in Vanuatu in 2006–2009, 2011–2014, and 2017–2021. The project aimed to improve the shellfish aquaculture and stock enhancement technology of the Vanuatu Government Fisheries Department and to provide technical assistance on community-based resource management for many villages [21].

Figure 5. Green snails in Vanuatu.

Under this project, in 2007, 662 matured green snails were transported from Aneityum, 300 km south of the main island of Efate, and were transplanted to the northwestern part of Efate, where the green snail stock was depleted [22]. During the author's survey in 2016, the Fisheries Department reported that green snail stocks were increasing on Efate Island and that the transplantation may be the cause [23]. However, there were no scientific data to show this. Therefore, in 2017, a scientific survey on green snail stocks was conducted, and local fishers participated in the diving survey [22].

Surveys conducted in northwestern Efate in 2003 did not find any green snails. A survey conducted by a French research institute in 2011–12 found a low distribution density of green snails on Efate, with 0.15 individuals/100 m^2 within the MPA and 0.04 individuals/100 m^2 outside the MPA [24]. The higher distribution density of green snail in the MPA despite the total fishing ban may be because poaching occurred more frequently in the non-MPA areas, whereas the MPAs are often watched by the local communities. In addition, many of the areas set aside for MPAs had been good fishing grounds in the past, which may have influenced their suitability for green snail habitat [21].

In the 2017 survey, green snails were distributed at extremely high densities of 1.6, 1.3, and 0.9 individuals/100 m^2 in the three sites where the transplantations were conducted. There were also sites with high densities of 0.9 and 0.8 individuals/100 m^2 downstream of the dominant current [22]. Few transplanted green snails remained, suggesting that the distributed snails were new recruits to this area. Based on the shell height composition and growth rate of the green snail, it is likely that outstanding cohorts (same age groups) recruited around 2012–2013, which were contributed by the transplanted green snails and their second and third generation spawning [21]. The transplantation of matured green snails is considered to have been fully functioning as an active measure of Satoumi creation.

3.6.2. Protection of Green Snail Resources through MPAs

There are various tools for fisheries resource management, including gear and fishing method restrictions, closed seasons, closed areas (MPAs), size limits, catch limits, and licenses, but MPAs are considered most effective in tropical developing countries. There are many reasons for this: MPAs can be established based on fishers' knowledge (especially spawning grounds and spawning seasons of important target species) without in-depth surveys; they apply to the much larger number of fish species that characterize tropical areas than temperate areas; they can be applied to ecosystem conservation such as coral reefs and mangroves; and the location, area and term can be changed adaptively depending on situations [25].

MPAs are very diverse. They can be completely or partially closed to fishing, closed to all fish species or to a specific target species, and established on a permanent year-round basis or only for a period of time or a limited season. Some MPAs cover less than one hectare, while others cover tens of millions of hectares. However, the key difference is whether they are established by the governments or by the local communities. Community-based MPAs, while having a weaker legal basis, are often more effective because they are watched by the local community. They are easier to operate adaptively and have relatively low operating costs [25].

The Vanuatu's green snail MPAs are community-based MPAs. The increase in green snail stocks in the three transplantation sites was due to the spawning of the transplanted snails and their second and third generation, as well as the fact that the transplanted sites were set as taboo areas (MPAs) by the local communities and the communities were conducting watching and other management activities. In other areas, there were reports of the frequent poaching of green snails; the *Vanuatu Daily Post* dated September 30, 2015, stated that Japanese supports had increased the green snail stocks on Efate Island and that the stocks were threatened by poaching [26].

3.6.3. Tourism Use of MPAs

Mystery Island, a small island south of Aneityum Island, is a famous tourist destination, visited 70 times a year by a large 1000-passenger cruise ship from Australia. The population of the adjacent village of Aneityum Island is 600. According to a 2013 survey by the author, the island was surrounded by a no-take MPA, which was primarily intended to protect tourism resources. People from the adjacent village were earning cash income in Mystery Island by opening stores selling lobsters, shellworks, clothing, and souvenirs [23].

The area around Lelepa Island, located north of Efate Island (a site where green snails were transplanted), was also set as an MPA. A giant clam species (*Tridacna gigas*) had been restocked in the MPA with the JICA project, which had grown to about 40 cm in 2016. The mantles of the giant clams were beautiful and ready to be used as tourist attractions. Although the MPA is intended to increase the fishery resources, there are few places to swim and see large green snails and giant clams, so the potential for tourism use of the MPA through snorkeling tours is sufficient [23].

The author surveyed Hydeaway Island, located west of Efate Island, in 2016. The area around the island was set aside as an MPA and protected tourism resources. The entire small island was a resort, with an entry fee to enter the island and snorkeling tours were offered. The seawater clarity in the MPA and live coral coverage were high. The number of fish species and fish abundance were also large enough. More than a dozen 2-m square steel mesh structures, called coral gardens, were set up on the seafloor, and corals were fixed to them. Compared to Onna Village, the scale of the cultured corals is smaller, but it functions as a tourist attraction. The establishment of coral gardens is also an active measure of Satoumi creation [23].

3.7. Fiji

3.7.1. Expansion of FLMMA

A networked resource management activity called FLMMA (Fiji Locally Managed Marine Area) is spreading in Fiji. This activity began in 1997 in the village of Ucunivanua on the east coast of Viti Levu Island [13]. The Fiji government formally adopted the FLMMA as a coastal resource management policy in 2004. In 2003, there were 27 FLMMA sites, but in 2013, more than 400 communities were involved in FLMMA across Fiji and 466 MPAs were established [27,28].

In 2000, the Fiji government, the University of the South Pacific, NGOs, and others working with local communities officially launched the FLMMA Network, which is characterized by its emphasis on local environmental and traditional knowledge in the collaborative management. Traditionally, Fiji has had a taboo area system where certain areas are closed to fishing for 100 days after the death of the village chief. The main purpose of the taboo area is securing seafood for the 100-day ceremony, and the knowledge that the fishing ban would increase fish stocks was passed on. Although FLMMA introduced the new concept of MPA, the concept and effects of no-take zones were already understood and readily accepted by the local communities [13].

3.7.2. MPA in Ucunivanua

In Ucunivanua, an MPA had been set up to protect a bivalve Kaikoso (*Anadara* spp.) in a large tidal flat in front of the village when the author conducted a survey in 2003 [29]. Here, the spillover effect of the MPA and monitoring by the community were verified to be effective. The spillover effect means that target species in the MPA move out of the MPA to become part of catches elsewhere. In this village, spawned eggs flow off on the current to places outside the MPA, grow in those places, and are caught by fishers. In the cases of no-take and year-round MPAs, such a spillover effect is essential. This is because fishers have no other benefit than making catches outside the MPA that have increased thanks to the MPA [13].

The establishment of a 24-ha MPA on a tidal flat resulted in a four-fold increase in Kaikoso density within the MPA after two years; the population density outside the MPA also doubled, confirming the spillover effect. MPA efficacy is monitored once a year by the local community, employing a method where population counting, and size measurement is conducted in one-meter square quadrats at ten-meter intervals along a 500-m line. The results were not statistically different from those found by the University of the South Pacific using a different method [30].

3.7.3. Tourism Use of MPAs

Cuvu

In 2003, the author surveyed the Hotel Shangri-La Resort adjacent to the village of Cuvu in the southwestern part of Viti Levu. The entire small island was a resort with 700 employees. Most of the employees were hired from the local community. Cuvu is located across a narrow channel, and the sea in front of the resort is the marine tenure of the village. Cuvu community had set up an MPA here in cooperation with the Resort. As a benefit to the resort, hotel guests can swim in the sea right in front of the resort and see many fish and beautiful corals. The community benefited from the resort's provision of funds for various village events in addition to employment. Ten MPA watches were appointed from Cuvu, and the allowance was funded by the resort to the community fund [31].

Concrete structures called Fish Houses were installed in the MPA. The structure was about 40 cm in length, width, and height, and had a void inside. Small corals were planted on the Fish Houses, and when they grew, the complex structure became hiding places for small fish. Although small in scale, they were tourist attractions [31].

Navutulevu

The lagoon of the Navutulevu village in the southern part of Viti Levu is narrow, with only about 1 km from the beach to the outer reef. A traditional taboo MPA was established in 2003 for five years. This MPA occupied about half of the western side of the narrow lagoon (about 100 ha in area). It seems too big for a no-take MPA, but the villagers, including the chief, believed that the catch would increase [31].

About 10 km west of Navutulevu was a major resort hotel called Warwick. The people of Navutulevu were hoping to generate income from MPA ecotourism by guests here. The traditional fishing method of Yavirau (yavi means pull and rau means leaf) was still practiced in Navutulevu. It is a drive-in beach seine, where fish are driven into the center of the net by attaching scare leaves to long ropes. In the end at the beach, the fish are caught by spear or by grabbing them by the hands. The Navutulevu community is closely associated with Warwick, possibly because of the Yavirau shown to Warwick tourists on the village's beach [31].

Soso

In 2017, the author surveyed the village of Soso in the Yasawa Islands, northwest of Viti Levu. The Soso village's local marine area was registered in FLMMA and a no-take MPA was established. A resort facility is located on a small island south of Soso, and the marine area in front of the facility had an MPA set by the resort to protect tourism resources. The ecologist managing the facility was a residential researcher and had a vision to set up a marine park in a large area including the MPAs of the resort and Soso to protect ecological and tourism resources. There are eight such resorts in the vicinity of Soso (28 in the entire Yasawa Islands). The people of Soso believed that the purpose of their MPA was to increase fisheries resources, and at the time of the survey, they had no plans to use the MPA for tourism. However, there is potential for tourism use of the MPA, as many tourists visit Soso with its beautiful beaches [27].

3.8. Florida, USA

3.8.1. Scallop Stock Restoration

Mote Marine Laboratory (Mote), a private research institute in Florida, USA, has been engaged in research and practice on the conservation and sustainable use of various marine resources as a residential research institute that is part of the local community, for more than 66 years [32]. Mote has adopted a transdisciplinary approach for the long-term sustainability of scallop resources in Sarasota Bay, Florida, by establishing a local community-led consortium to conduct science-based restoration and monitoring with direct community involvement. Under the professional supervision of Mote scientists, community organizations and trained citizen scientists have been coordinated in all aspects of strategy design, broodstock collection, juvenile release, and monitoring. An important aspect of the community's role in this program is the large number of volunteer citizen scientists involved. This has had three direct benefits: (1) a significant reduction in the personnel costs required; (2) increased community interest and involvement in restoration efforts; and (3) increased public understanding of the ecological connections and the role of scallops in Sarasota Bay [33].

Volunteers, including high school students, teachers, and adults from the public, built a scallop nursery facility on the Mote ground supervised by Mote scientists. They are attempting to grow the juvenile scallops to maturity size in this nursery facility and spawn them in protective cages set up in their natural habitat. Under natural conditions, the mortality rate of scallop juvenile is considerably higher than that in the later stages of their life history. Growing juvenile scallops to the mature stage in a land-based nursery facility can reduce early mortality [33].

3.8.2. Tag and Release of Snook

During 2016–2017, volunteer citizen scientists helped Mote researchers by releasing and monitoring 3500 snook, an important fish stock. Local residents allowed the Mote researchers to install monitoring equipment in their backyards. The equipment allowed the scientists to collect more than 370,000 data transmitted by the tagged snook. These data were transmitted by 1848 released fish on 332 individual days. Without the participation of local resident groups and volunteer citizen scientists, such a large amount of data would not have been available [32].

By releasing specially marked fish, Mote scientists could ascertain how much time snook spent on unvegetated banks, vegetated banks, and natural shorelines. The fish on shorelines with complex vegetation had higher survival rates. The scientists provided that information to local residents to assist them in their decision making regarding environmental conservation. Local residents learned that maintaining healthy vegetation along their shorelines is beneficial to the fish, even if the shorelines are artificially altered [32].

3.8.3. Coral Reef Restoration

In 2008, Mote created an underwater coral nursery off the Florida coast. There, the scientists are growing decreasing branching *Acropora* species for planting them in devastated reef areas in the MPAs. Once the coral colonies have grown to suitable size, they are cut into approximately 5 cm pieces and planted on the reef. Until 2020, more than 120,000 branching corals had been planted to help restore Florida's reefs [32].

Science-based coral reef restoration is one of Mote's priorities. Mote opened the International Center for Coral Reef Research and Restoration in May 2017 to expand its reef restoration efforts. Scientists are working to restore large areas of corals in one to three years, instead of the hundreds of years it might take for natural recovery. At the research facility, scientists are trying to find different coral genotypes that are resilient to disease, rising water temperatures, and ocean acidification. Mote currently has approximately 20,000 colonies of branching *Acropora* in its underwater nurseries, which includes more than 130 genotypes, allowing researchers to determine which corals have the heartiest genetic makeup and the best chance of survival [32].

4. Discussion

4.1. Integration of Various Approaches and Measures

Figure 6 shows the integration of various approaches, such as resource enhancement, ecosystem conservation and surveys and monitoring by fishers and local people, and other resources management to traditional fisheries resource management. Social–ecological systems in many coastal areas are extremely complicated and highly uncertain. It is sometimes difficult to manage the fisheries resources with only the traditional management methods and needs to incorporate such various approaches, as appeared in this review. To integrate these approaches, the transdisciplinary processes, which are the co-design of the research agenda, the co-production of integrated knowledge, and the co-delivery of research outcomes in collaboration with diverse stakeholders, are required. Satoumi processes, which are environmental conservation and resource management in which local people are closely involved, are also required.

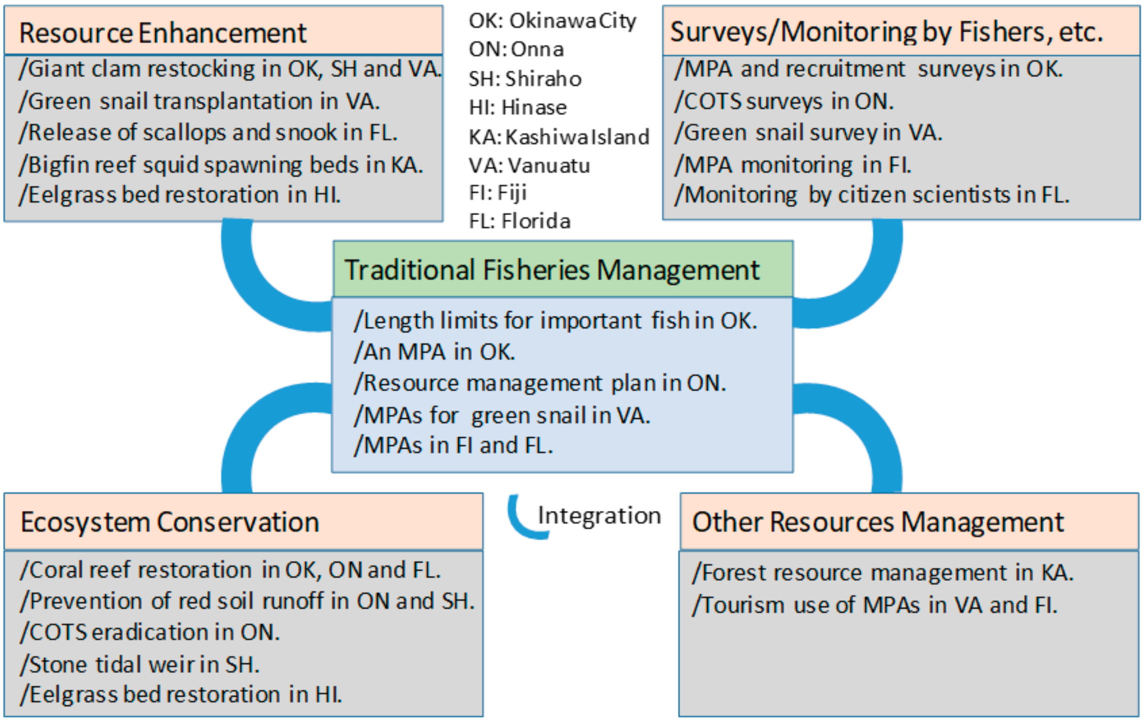

Figure 6. Integration of various approaches to fisheries resource management.

The active and passive measures in eight sites in this review are listed in Table 1. There are no passive measures in Hinase and Florida. This is because the author did not describe the passive measures in Hinase and Florida in this review. In Hinase, various traditional fisheries management activities, passive measures, are led by the Hinase Fisheries Cooperative. In addition to the active coral reef restoration in Florida, many passive coral reef conservation activities are implemented by the local communities. In all Satoumi sites that the author knows where active measures are practiced, passive measures are also practiced. However, there are many Satoumi sites conducting only passive measures, such as traditional fisheries management. On these sites, the author recommends trying any type of active measures; examples are in Table 1. Because the active measures may promote the active involvement of the members in resource management and foster a sense of ownership for the resources [9].

Table 1. Active and passive measures in eight sites.

Sites	Active Measures	Passive Measures
Okinawa City	Coral planting Restocking of giant clam	Length limits for important fish MPA
Onna Village	Coral culture and planting COTS eradication	Resource management plan Prevention of red soil runoff
Shiraho	Stone tidal weir Restocking of giant clam	Inheritance of coral reef culture Prevention of red soil runoff
Hinase	Eelgrass bed restoration	
Kashiwa Island	Bigfin reef squid spawning beds	Promoting interactions of people
Vanuatu	Transplantation of green snail	MPAs for green snail Tourism use of MPAs
Fiji	Restocking of giant clam	MPA network Tourism use of MPAs
Florida	Scallop stock restoration Tag and release of snook Coral reef restoration	

4.2. Integration of Fisheries Resource Management and Resource Enhancement

Increasing biological productivity or stock enhancement through active measures is an important feature of Satoumi creation.

In Okinawa City and Shiraho in Okinawa, a giant clam species *Tridacna crocea* were restocked. In Onna Village *T. crocea* were also restocked [14]. When the author was a fisheries extension officer, he worked with fishers in various parts of Okinawa to develop techniques for restocking *T. crocea* using a transdisciplinary approach. The techniques utilize the biology of the juvenile *T. crocea* to burrow into holes in the bedrock by drilling small holes in the bedrock with an air-powered drill and embedding the *T. crocea* in them. The author then disseminated the techniques to fishing villages throughout Okinawa, instructed them in the field and organized the techniques into a guide [34]. During the two-year period 1988–1989, the techniques were implemented in 12 districts of Okinawa.

In Vanuatu, giant clams were restocked in MPAs. The seedling production of giant clams by governments and universities for local communities, which are then restocked in MPAs and other areas, has been operated in Pacific Island countries, including Fiji [27], Samoa, Tonga, Solomon Islands, Palau, Federated States of Micronesia, and in Southeast Asia, the Philippines, Indonesia, and Malaysia. It was practiced in all Asia-Pacific Island countries surveyed by the author. Along with harvesting or tourism use of the giant clams, the objective was often to increase resources outside the MPA through spillover effects [35].

The transplanting of matured green snails in Vanuatu, the release of scallops and snook in Florida, and the establishment of bigfin reef squid spawning beds on Kashiwa Island are active measures of Satoumi creation that increase biological productivity through direct human intervention. The restoration of eelgrass beds by seeding in Hinase is also an active measure because it has stabilized high oyster aquaculture production.

4.3. Integration of Fisheries Resource Management and Ecosystem Conservation

4.3.1. Coral Reef Restoration

Coral reef restoration activities were undertaken in Okinawa City, Onna Village, and Florida. These activities are also active measures of Satoumi creation that improve biodiversity through direct human intervention. Currently, coral restoration activities centering on transplanting are being undertaken throughout the world [36]. However, there are many criticisms of coral planting. The first is that the area of coral reefs that can be directly restored through human transplantation is far smaller than the area of coral reefs that have been lost. For this reason, most coral transplantation activities in Okinawa do not directly increase the area of coral reefs by transplanting coral, but rather regenerate corals in the surrounding waters by allowing the transplanted coral to spawn.

There has been criticism of such coral reef restoration through spawning. The argument was that "there are far more corals left in the wild that are capable of spawning than corals that had been transplanted and survived to grow to the size to spawn. However, as the number of corals decreases and the distance between parent corals increases, the likelihood of fertilization failure increases. In one study, *Acropora yongei* (a species of coral) colonies that were artificially placed close together had a higher fertilization rate and were 1400 times more capable of supplying larvae than naturally surviving *A. yongei* [37]. Thus, by culturing and transplanting corals at appropriate intervals, it is possible to dramatically enhance the regenerative function of corals.

4.3.2. Land-Based Pollution Countermeasures

In all three areas of Okinawa, Okinawa City, Onna Village, and Shiraho, measures were taken to prevent red soil pollution. These are passive measures of Satoumi creation. In Okinawa City, fishers themselves were monitoring red soil pollution by measuring SPSS, which is an indicator of red soil pollution. In Onna Village, the youth group of the fisheries cooperative measured SPSS, and a prior consultation system was adopted in which the fisheries cooperative and the developers discussed red soil runoff prevention measures before starting the construction. In Shiraho, green belts around farmland, promising measures to prevent red soil runoff, were initiated by volunteer junior high school students, which developed into self-sustainable activities such as coral reef conservation tour and study tour programs.

Red soil pollution is the biggest environmental problem in Okinawa, but excess nutrient influx is also a serious factor that disturbs coral reef ecosystems [10]. High concentration of nutrients negatively affects corals for three indirect reasons: (1) increases seaweeds that compete with corals for sunlight [38]; (2) increases phytoplankton and makes seawater turbid, inhibiting photosynthesis of symbiotic algae in corals [11]; (3) increases phytoplankton as a food source for COTS larvae, leading to outbreaks of them [39]. There are reports of direct physiological effects on corals; phosphorus was recently found to inhibit skeleton formation of juvenile corals [40]. Results of rearing juvenile *Acropora tenuis* in seawater with varying nutrient concentrations showed that coral survival rates decreased with increasing nutrient concentrations [41]. Satoumi creation in Japan was initially most active in the Seto Inland Sea, an enclosed coastal sea. There, the management of material circulation, including nutrient control, was an important issue in Satoumi creation [2,4]. The problems of soil runoff and excess nutrients are not limited to Okinawa or Japan; examples of such problems and countermeasures in 33 districts throughout the world are provided [42].

On Kashiwa Island, thinned cedar and cypress were used as materials for spawning beds for bigfin reef squid. The purpose of this was not only to obtain material for spawning beds, but also to prevent soil runoff by thinning to allow sunlight to penetrate on the forest floor and undergrowth to grow. In Japan, fishers are planting trees in the mountains in many areas to prevent soil runoff into their Satoumi [43].

4.3.3. Other Ecosystem Conservation Activities

The eradication of COTS in Onna Village, the restoration of a stone tidal weir in Shiraho, and the restoration of eelgrass beds by seeding in Hinase are active measures to improve biodiversity through direct human interventions.

4.4. Integration of Fisheries Resource Management and Surveys/Monitoring by Fishers

In Okinawa City, fishers conducted MPA monitoring, recruitment surveys of important resources, and monitoring of red soil pollution. In Onna Village, a staff of the fisheries cooperative acted as a residential researcher and conducted various surveys on fishers' activities and returned the results to the fishers. In Vanuatu, local fishers joined the surveys on the distribution of green snails. In Fiji, local community members were monitoring the resources in the MPAs. In Florida, many volunteer citizen scientists were involved in various monitoring activities. Thus, scientific surveys and monitoring, traditionally conducted by professional scientists and experts, are increasingly being conducted by fishers and local residents in Satoumi through the transdisciplinary approaches, in collaboration with scientists and experts.

4.5. Integration of Fisheries and Tourism Resource Management

In the Satoumi areas, where coastal people are deeply dependent on fisheries, a different MPA system from the huge no-take, no-time-limited, year-round MPA is needed. Satoumi-type MPA that balances resource/ecosystem protection and resource use is considered suitable. A Satoumi-type MPA is a community- based MPA in which local people are closely involved. Examples are zoning-type MPAs that set up areas with strict harvest restrictions and areas where certain types of fishing are allowed, seasonal MPAs where fishing is prohibited only during spawning season, and MPAs with a limited period, etc. MPAs that allow tourism use are also Satoumi-type MPAs.

In Fiji and Vanuatu, there were cases where resources in MPAs were protected as tourism resources and used for tourism. In Shiraho, giant clam resources in the MPA were used for snorkeling tourism. The community-based MPAs sometimes involve costs for boundary buoys and watches, and financial mechanisms to cover these costs are necessary to sustain the MPAs. It would be good if the MPAs could increase the catch to cover the costs, but that is not easy. It takes time for stocks to increase, and increased catches due to spillover effects are difficult to see as a direct effect of conservation efforts [35]. For this reason, many of the community-based MPAs that had been sustained in the Philippines had financed their costs through diving user fees [44].

Tourism use of MPAs in Fiji is currently resort hotel-driven, rather than community-driven as in Vanuatu or in the Philippines. In the future, to use tourism resources in MPAs as part of Satoumi creation in which local people are closely involved, it is necessary for local people to participate more proactively in the operation of the tourism.

On the other hand, a balance must be considered between resource use by fisheries and tourism. In Navutulevu, nearly half of the fishing ground was set aside as an MPA. If a large resort is built near a village with a small fishing ground such as Navutulevu, and with the coordination of the resort and the village community, a large part of the fishing ground 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 incomes would increase [27]. However, the catch of seafood from the fishing ground would be reduced, the villagers would purchase more canned foods or meat as a source of protein. This will affect the food culture of the Pacific islanders, who, similar to the Japanese, are highly dependent on fish diet. When establishing MPAs for tourism use that are large compared to the remaining fishing grounds, not only the income but also the impact on the culture should be considered [27]. The health of the villagers should also be considered. In Tonga, there is a report of an increase in lifestyle-related diseases such as heart disease in the villagers because of a change in eating habits to imported frozen mutton with very high fat content instead of fish [45].

Furthermore, overuse due to tourism should also be noted. At Cape Maeda in Onna Village, a famous diving point called the Blue Cave attracts 380,000 tourists a year (an average of more than 1000 a day), creating a serious overuse problem [8]. In Zamami Village, located west of the main island of Okinawa, tourism based on the rich coral reef ecosystem is the village's main industry. In the late 1990s, however, an excessive number of diving tourists became a problem. At popular diving points, hundreds of divers a day would use the points, damaging the corals through fin kicking and sand swirling. For this reason, the diving operators in the Zamami Village worked with the fisheries cooperative, many of whose members also run diving businesses, set up community-based MPAs to ban both fishing and diving at three prime points [13]. In one of these points, coral coverage recovered from an average of about 30% to 50%, from 1999 to 2001 after the MPAs were established [46]. This can be evaluated as an effect of the MPAs.

Funding: This research was funded by "Creation and Sustainable Governance of New Commons through Formation of Integrated Local Environmental Knowledge (ILEK) Project" under the Research Institute for Humanity and Nature (RIHN) from 2012 to 2017 (14200085), "Transdisciplinary Study of Natural Resource Management under Poverty Conditions Collaborating with Vulnerable Sectors (TD-Vuls) Project" under the Initiative for the Promotion of Future Earth Concept program provided by Research Institute of Science and Technology for Society (RISTEX), Japan Science and Technology Agency (JST) from 2017 to 2019 (JPMJRX16F3), and "Establishment of a Sustainable Community Development Model based on Integrated Natural Resource Management Systems in Lake Malawi National Park (IntNRMS) Project" under the Science and Technology Research Partnership for Sustainable Development (SATREPS) program provided by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) from 2020 to 2024 (JPMJSA1903).

Conflicts of Interest: The author declares no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Kakuma, S.; Yanagi, T.; Sato, T. (Eds.) *Satoumi Science: Co-Creating Social-Ecological Harmony between Human and the Sea*; Springer Nature: Singapore, 2022.
2. Yanagi, T. *Sato-Umi: A New Concept for Coastal Sea Management*; TERRAPUB: Tokyo, Japan, 2007.
3. Kakuma, S. Preface. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. v–vi.
4. Yanagi, T. The History and Future of Satoumi Concept. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 21–38.
5. Sato, T. Transdisciplinarity approach: A Co-Design, Co-Production and Co-Delivery Process Driven by Small-Scale Fishers. In *In the Era of Big Change: Essays about Japanese Small-Scale-Fisheries*; Yinji, L., Tamano, N., Eds.; Too Big To Ignore, St. John's; TBTI Japan: Tokyo, Japan, 2020; pp. 413–421.
6. Sato, T.; Chabay, I.; Helgeson, J. Introduction. In *Transformations of Social-Ecological Systems: Studies in Co-Creating Integrated Knowledge toward Sustainable Futures*; Sato, T., Chabay, I., Helgeson, J., Eds.; Springer Nature: Singapore, 2018; pp. 1–7.
7. Kakuma, S.; Sato, T. Prologue: What is Satoumi? In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 1–17.
8. Yanagida, I.; Kakuma, S. Conserving Multiple Coral Reef Resources. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 123–143.
9. Kakuma, S. An Evaluating Tool for CB-CRM in Developing Countries. *Reg. Stud.* **2016**, *18*, 51–67. (In Japanese)
10. Kakuma, S. Conservation of coral reefs. In *Coral Reef Studies*; Suzuki, Y., Oba, H., Tsuchiya, M., Eds.; Tokai University Press: Kanagawa, Japan, 2011; pp. 314–337. (In Japanese)
11. Omija, T. Terrestrial inflow of soils and nutrients. In *Coral Reefs of Japan*; Japan Coral Reef Society and the Ministry of Environment: Tokyo, Japan, 2004; pp. 64–68.
12. Higa, Y.; Takeuchi, A.; Yanaka, S. Connecting Local Regions and Cities through Mozuku Seaweed Farming and Coral Reef Restoration: Onna Village, Okinawa. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 193–215.
13. Kakuma, S.; Kitolelei, J. Coastal Resource Management Connected by Marine Protected Area Networks. In *Transformations of Social-Ecological Systems: Studies in Co-Creating Integrated Knowledge Toward Sustainable Futures*; Sato, T., Chabay, I., Helgeson, J., Eds.; Springer Nature: Singapore, 2018; pp. 267–286.
14. Kakuma, S.; Higa, Y. Sedentary resource management in Onna village, Okinawa, Japan. In *Workshop on the Management of South Pacific Inshore Resource Fisheries*; South Pacific Commission: Noumea, New Caledonia, 1995; Volume 1, pp. 427–438.
15. Higa, Y.; Shinzato, C.; Zayasu, Y.; Nagata, T.; Kubo, H. Coral reef restoration efforts by a fisheries cooperative: The case of Onna Village in Okinawa Prefecture. *J. Jpn. Soc. Coral Reef* **2017**, *19*, 119–128. (In Japanese) [CrossRef]
16. Kamimura, M.; Claus, A. Enlivening Ecosystems with Human Hands: Building Satoumi through Coral Reef Culture. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 69–87.
17. Kamimura, M.; Claus, A. Satoumi Creation Inheriting Coral Reef Culture. In *Encouragement for Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Bensei Shuppan: Tokyo, Japan, 2018; pp. 71–104. (In Japanese)
18. Yanagi, T. Restoring Eelgrass Beds and Culturing Oysters. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 89–103.
19. Tanaka, T. Satoumi of Eelgrass and Oysters "Hinase: A Thousand Fisher Households 'Town'". *J. Jpn. Soc. Fish.* **2014**, *80*, 72–75. (In Japanese)

20. Kanda, M.; Shimizu, M. Divers and Fishermen Working Together to Create Satoumi. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 217–238.
21. Kakuma, S.; Terashima, H. Green Snail Resource Enhancement through Spawner Restocking in Vanuatu. *Reg. Stud.* **2021**, *27*, 1–19. (In Japanese)
22. Terashima, H.; Ham, J.; Kaku, R.; William, A.; Malisa, M.; Gereva, S.R.; Kakuma, S. A field survey of the green snail (*Turbo marmoratus*) in Vanuatu: Density, effects of transplantation, and villagers' motives for participation in transplantation and conservation activities. *SPC Tradit. Mar. Resour. Manag. Knowl. Inf. Bull.* **2018**, *39*, 15–40.
23. Kakuma, S. The Project for Promotion of the Grace of the Sea in Vanuatu. *J. Jpn. Soc. Int. Fish. Res.* **2017**, *15*, 79–97. (In Japanese)
24. Dumas, P.; Leopold, M.; Kaltavara, J.; William, A.; Kaku, R.; Ham, J. *Efficiency of Tabu Areas in Vanuatu*; IRD: Institut de Recherche Pour le Développement: Port Vila, Vanuatu, 2012.
25. Kakuma, S. Diversity and multi-functions of Marine Protected Areas (MPAs) in Coral Reefs. *Galaxea* **2007**, *8*, 91–108. (In Japanese) [CrossRef]
26. Dailypost Website. Available online: https://www.dailypost.vu/news/illegal-harvesting-of-green-snail-a-major-problem/article_7d1e789f-00bc-5620-9b6a-9c22b5f3d138.html (accessed on 5 May 2022).
27. Kitolelei, J.; Kakuma, S. Protecting Fisheries Resources through Marine Protected Area Networks–Fiji. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 169–190.
28. FLMMA Network. *FLMMA Strategic Plan 2014–2018*; FLMMA Network: Suva, Fiji, 2014.
29. Kakuma, S. Co-management of coastal resources in Fiji (Part 1): FLMMA and coastal fisheries management. *J. Jpn. Reg. Fish.* **2005**, *46*, 261–282. (In Japanese)
30. Tawake, A.; Parks, J.; Radikedike, P.; Aalbersberg, W.; Vuki, V.; Salasfsky, N. Harvesting clams and data: Involving local communities in implementing and monitoring a marine protected area. A case study from Fiji. *Conserv. Biol. Pract.* **2001**, *2*, 32–35. [CrossRef]
31. Kakuma, S. Co-management of coastal resources in Fiji (Part 2): MPA, Coral Reef Conservation and Ecotourism. *J. Jpn. Reg. Fish.* **2006**, *46*, 240–260. (In Japanese)
32. Crosby, M.; Lausche, B. Models for Implementing the Satoumi Concept via Residential Research Institute Collaborations with Citizen Scientists in the United States. In *Satoumi Science*; Kakuma, S., Yanagi, T., Sato, T., Eds.; Springer Nature: Singapore, 2022; pp. 239–256.
33. Crosby, M.; Lausche, B.; Culter, J. Community-Based Scallop Restoration: A Model for Knowledge Circulation Theory. In *Transformations of Social-Ecological Systems: Studies in Co-Creating Integrated Knowledge Toward Sustainable Futures*; Sato, T., Chabay, I., Helgeson, J., Eds.; Springer Nature: Singapore, 2018; pp. 77–94.
34. Kakuma, S. *A Guide to Release Tridacna Crocea*; Okinawa Prefectural Fisheries Extension Center: Okinawa, Japan, 1989. (In Japanese)
35. Kakuma, S. Community-based Coastal Resource Management with MPAs in the Philippines. *J. Jpn. Soc. Int. Fish. Res.* **2017**, *15*, 1–26. (In Japanese)
36. ICRI Website. Available online: https://www.icriforum.org/restoration/coral-restoration-database/ (accessed on 5 May 2022).
37. Zayasu, Y.; Suzuki, G. Comparisons of population density and genetic diversity in artificial and wild populations of an arborescent coral, *Acropora yongei*: Implications for the efficacy of "artificial spawning hotspots". *Restor. Ecol.* **2018**, *2018*, 1–7. [CrossRef]
38. Bellwood, D.R.; Hughes, T.P.; Folke, C.; Nystrom, M. Confronting the Coral Reef Crisis. *Nature* **2004**, *429*, 827–832. [CrossRef] [PubMed]
39. Fabricius, K.E.; Okaji, K.; De'ath, G. Three lines of evidence to link outbreaks of the crown-of-thorns seastar *Acanthaster planci* to the release of larval food limitation. *Coral Reefs* **2010**, *29*, 593–605. [CrossRef]
40. Iijima, M.; Yasumoto, K.; Yasumoto, J.; Yasumoto-Hirose, M.; Kuniya, N.; Takeuchi, R.; Nozaki, M.; Nanba, N.; Nakamura, T.; Jimbo, M.; et al. Phosphate Enrichment Hampers Development of Juvenile *Acropora digitifera* Coral by Inhibiting Skeleton Formation. *Mar. Biotechnol.* **2019**, *2019*, 291–300. [CrossRef] [PubMed]
41. Kakuma, S.; Teruya, S.; Ishikawa, T. Research on coral seedling production technology by sexual reproduction method using deep sea water-Effects of high nutrient concentrations in deep sea water on juvenile corals. *Okinawa Deep. Sea Water Res. Cent. Annu. Rep.* **2019**, *18*, 24–26. (In Japanese)
42. Wilkinson, C.; Brodie, J. *Catchment Management and Coral Reef Conservation*; Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre: Townsville, Australia, 2011.
43. Kawabe, M. Reforestation Activities of Young Fishers in Akkeshi from the Perspective of Coastal Zone Management. *J. Jpn. Reg. Fish.* **2006**, *46*, 219–240. (In Japanese)
44. Omori, N.; Taniguchi, H.; Koike, K.; Lawrence, M.L.; Hosaka, S. Establishing Marine Protected Areas (MPAs) in Japanese coral reef waters: A study of marine protected areas in the Visayas, Philippines. *J. Jpn. Soc. Coral Reef* **2010**, *12*, 81–99. (In Japanese) [CrossRef]
45. Hamaguchi, H. The South Pacific and Whaling. In *An Introduction to Whaling Culture*; Sci-Tech: Kyoto, Japan, 2002; pp. 71–83. (In Japanese)
46. Taniguchi, H. Effects and regret points on diving points closure in Zamamison. *Midoriishi Acropora* **2003**, *14*, 16–19. (In Japanese)