

SATOUMI APPROACH FOR REALIZING SUSTAINABLE COASTAL USE IN A RIAS-TYPE BAY: A CASE OF SHIZUGAWA BAY IN SANRIKU COAST HIT BY THE HUGE TSUNAMI ON 11 MARCH 2011

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Rias-type bays are one of the most common coasts in Japan where aquacultures have been active due to sheltered geological shape with a deep bottom. The huge tsunami hit Sanriku Coast consisting of open rias-type bays near the epicenter facing Pacific Ocean on 11 March 2011. For recovering Sanriku Coast, it is important to include sustainability in its program. Satoumi is defined as the human use and management of coastal seas for high productivity while maintaining high biodiversity. Therefore, we proposed Satoumi approach to an open rias-type bay, Shizugawa Bay, in southern Sanriku Coast. We conducted scientific researches on mapping of coastal habitats and aquaculture facilities, hydrography, and material flows of nutrients, a minor element (Fe) and organic matters in the bay including those from the rivers and from the offshore waters. At the same time, Committee for Shizugawa Bay Management of Fishermen's Cooperative of Miyagi Prefecture decided to decrease in aquaculture facilities for sustainable development of aquaculture. Based on these data, a physical-biological coupling model was used for calculating the number of aquaculture facilities that are suitable not only for yields but also for environments. These researches were established on strong collaborations among a fishermen's' cooperative, local governments and scientists. Results of this practice may help to realize sustainable coastal use of a rias-type bay.

Key words: Satoumi, rias-type bay, tsunami, aquaculture, sustainability science

I. INTRODUCTION

Rias-type bays are one of the most common coasts worldwide, where aquacultures have been active due to sheltered geological shape with a bay mouth with a deep bottom. In Japan, Sanriku Region has a coast of 600 km long consisting of Rias-type bays from Sameka (40°32'24" N; 141°34'34" E) to Mangoku-ura (38°25'33" N; 141°23'40" E). Aquacultures such as oyster, seaweeds, scallop and ascidian have been very active there [1]. The huge tsunami hit Sanriku Coast consisting of rias-type bays near the epicenter facing Pacific Ocean on 11 March 2011 [2]. Aquaculture facilities were completely damaged. After the tsunami, some fishermen cooperatives and some communities started to look for development of sustainable coastal fisheries including aquacultures and a sustainable and prospective town.

“Satoyama” is a word consisting of a village, “sato” and a mountain, “yama” in Japanese. Satoyama refers to a village near a mountain where a forest is used for firewood, charcoal and construction, and grasses [3]. This traditional practice of agriculture maintains a variety of habitats that augment biodiversity and production. As a result of this practice, a characteristic landscape is formed. Ministry of the Environment of Japan is conducting the Satoyama Initiative aiming to realize societies in harmony with nature not only in Japan but also other developing countries [4]. It has categorized related cases that have the potential to contribute to the maintenance and rebuilding of socio-ecological production and landscapes for sustainable management of natural resources as activities of Satoyama Initiative.

In coastal zones, Yanagi [5] proposed a concept of “satoumi”, consisting of a village, “sato” and the sea, “umi” in Japanese, that is a traditional practice like satoyama practice by local people in coastal areas extending from a village and offshore waters. Satoumi practice is defined as a human management of coastal seas for high productivity while sustaining high biodiversity [5]. Under a satoumi tradition, coastal waters are maintained in a successional, rather than a climax, stage to maximize biodiversity and productivity. However, satoumi activities are less developed than those of satoyama. It is necessary to increase case studies for promotion of satoumi practice.

Ministry of the Environment of Japan designated Sanriku Coast as Sanriku Fukko (reconstruction) National Park aiming to learn lessons of the tsunami and realize societies in harmony with nature along Sanriku Coast [6]. In southern Sanriku Coast, Ministry of the Environment of Japan will build a visitor center of the park in Minami Sanriku Town. It is located around the Shizugawa Bay which is a typical rias-type bay, where so many aquacultures facilities had been deployed. After the huge tsunami event, Minami Sanriku Town decided to recover its community under the concept of Satoyama Initiative, which is a community in harmony with nature which is prosperous and enlivening. After the tsunami, Committee for Shizugawa Bay Management of Fishermen’s Cooperative of Miyagi Prefecture decided to realize sustainable fisheries including aquacultures by management of the sea

through use. It is trying to develop sustainable aquacultures because deployment of too many aquacultures caused marine environmental problems in 1990s.

Recently, Japanese National Commission for UNESCO proposed sustainability science to UNESCO [7]. Concept of sustainability science is to mobilize scientists beyond disciplines and stakeholders to resolve environmental problems. General assembly of UNESCO decided to develop sustainability science. From international science framework, Future Earth was established to resolve environmental problems from point of views similar to sustainability science in 2014. However, there haven't many reports on activities of sustainability science nor those of Future Earth concerning marine or coastal problems.

This study aims to elucidate satoumi activities to develop sustainable coastal fisheries in an open rias-type bay, Shizugawa Bay by examining how some successful activities have been realized there after the huge tsunami event. Thus, details of results obtained by scientific researches are out of scope of this article. We introduce results obtained from the researches, actual situation and activities of Shizugawa Bay and discuss factors leading satoumi activities to success in Shizugawa Bay. Experiences in Shizugawa Bay will contribute to sustainability science and Future Earth.

2. INFORMATION

Location of Shizugawa Bay and Minami Sanriku Town before and after the tsunami

Figure 1 shows Shizugawa Bay and Minami Sanriku Town in southern Sanriku Coast facing the Pacific Ocean (Fig. 1). Shizugawa Bay is bounded by the line between Point Utatsu and Terahama Triangulation Point (38°38'00" N; 41°31'51" E) and the coast west of this line. Width of bay mouth and surface area are 6.6 km and 46.8 km², respectively. The maximum bottom depth and sill depth are 54 m deep. In this study, we focus on inner part of the bay where northern and southern parts belong to Shizugawa Branch and Togura Branch of Miyagi Fisheries Cooperative because the rest of the bay belonging to Utatsu Branch of Miyagi Fisheries Cooperative has different characteristics of marine environments and aquacultures from those of Shizugawa Branch and Togura Branch.



Fig. 1. Map showing Shizugawa Bay and three branches' areas of Utatsu, Shizugawa and Togura drawn with yellow characters and three major rivers drawn with white characters.

Demography of Minami Sanriku Town was decreased from 17063 in 2010 to 15352 in 2011 and 14505 in 2013 [8]. Three main rivers, Hachiman River, Mizujiri River and Oritate River, flow into the bay head. All watersheds of rivers flowing into Shizugawa Bay are located only in Minami Sanriku Town. Fishermen's Cooperative transplanted broad-leaved trees in mountains for ensuring good quality of river waters flowing into the bay.

Fisheries in Shizugawa Bay before the tsunami

In Shizugawa Bay, aquacultures, collections of sea urchin and abalone and set nets are main fisheries. Especially, aquacultures are most important. Oyster (*Crassostrea gigas*), scallop (*Patinopecten yessoensis*), ascidian (*Halocynthia roretzi*), coho salmon (*Oncorhynchus kisutch*), and brown macroalgae (*Undaria pinnatifida* (Harvey) Suringar, *wakame* in Japanese, and *Saccharina japonica* (Areschoug) Lane, Mayes, Druehl et Saunders, *makonbu* in Japanese) are cultured. Feeding aquaculture is only that of coho salmon by culturing young salmon in the sea from November to June. The number of coho salmon aquaculture was around 40. Seaweeds are cultured in the sea from October to April. Oyster have been cultured with rope and buoy in the sea for two to three years. Ascidian is cultured with the same way as oyster for two years (Mr. K. Goto, personal communication).

Ganbaru Aquacultures

Ganbaru means stout resistance against damage by the tsunami on fisheries and fight for recovery of fisheries in Japanese in this context. Fisheries Agency of Japan launched a policy to

promote fishermen to make a group that shared boats, fishing gears and aquaculture facilities, worked together and shared profits evenly among members in 2011. This policy created “Ganbaru” Fisheries and “Ganbaru” Aquacultures [9]. FAJ has supported fishermen’s groups of Ganbaru Fisheries and Aquacultures by supplying money to buy boats and materials and to cover other costs such as fuel through a fishermen’s cooperative for three years. The group refund 1/10 of support from FAJ when total revenue of the group was under the sum of funding each year. Since it has been difficult to attain the revenue to the sum of funding each year, Fisheries Agency gave 9/10 of all costs to the group eventually. Fishermen of the group shared revenue that remained after refunding to FAJ evenly. In inner part of Shizugawa Bay, two branches of Togura and Shizugawa have own groups of Ganbaru Aquacultures.

Strategic environmental study on management methods of coastal zone along Sanriku Coast consisting of open rias-type bays

Ministry of the Environment of Japan launched strategic environmental study on management methods of coastal zone along Sanriku Coast consisting of open rias-type bays [10]. We have been studying seagrass and seaweed distributions by satellite remote sensing, nutrient flow in Shizugawa Bay, Fe load from the rivers and its flux in the bay and particulate organic matters from the rivers and flux in the bay since 2014. The results of these studies are summarized as follows: Seagrass beds had been destroyed by the tsunami in the bay and haven’t recovered in the bay head area yet because of turbid water from construction along the coast and the rivers. Seaweed beds had little negative impact by the tsunami. Nutrients in Shizugawa Bay was characterized by nutrient poor waters and nutrient load from the land was less than inflow from offshore waters. Nitrogen regeneration by oyster culture is important in nutrient circulation. Fe load from the land is less than other Fe sources. Since 2014, we started to develop a physical-biological coupling model for calculating the number of aquaculture facilities that are suitable not only for yields but also for environments. The results showed that the oyster culture before the tsunami caused oxygen deficient condition of bottom water but that after the tsunami.

ASC certificate to oyster culture of Togura area in March 2016

Increasing aquacultures are impacting wild marine wild life and environments. For examples, chemical inputs against disease or parasites of cultured species, disease and parasites brought by seeds of aquaculture to wild populations, escapes of cultured species in nature, eutrophication through feeding and decrease in carrying capacity, and so on. In 2010, WWF and the Dutch Sustainable Trade Initiative co-founded the Aquaculture Stewardship Council (ASC) to manage the global standards and certification programs in order to change destructive aquacultures to sustainable ones that maintain marine environment healthy [11]. ASC works with Accreditation Services International (ASI) to accredit independent certification bodies to audit and certify compliant farms. On 30 March 2016, oyster culture in Togura Branch was

given ASC certification by the ASC to explain that this oyster culture was conducted as responsible aquaculture to natural environments and society after examination of documents and field surveys of environments [12].

3. DISCUSSION

In Shizugawa Bay, all aquacultures of oyster, scallop, ascidian, coho salmon, and brown macroalgae (*wakame* and *makonbu*) have completely been destroyed by the huge tsunami on 11 March 2011. Fisheries Agency of Japan launched Ganbaru fisheries just after the tsunami [10]. In Togura Branch, fishermen formed Ganbaru Aquacultures in February 2012 and decided to decrease number of oyster long-line culture facilities. The number of long-line oyster culture in 2015 was about 30 % of that before the tsunami in 2011. In Shizugawa Branch, oyster culture families were 39 before the tsunami and were decreased to 36 families in 2012 after the tsunami. A total of 27 families of oyster cultures formed a group of a Ganbaru Fisheries in October 2012 and decided to decrease long-line types of oyster culture by 50% before the tsunami. Why did they decide the number of long-line oyster culture facilities in Shizugawa and Togura areas? This is because they felt that the number of oyster culture facilities were so many that oysters needed two or three years till selling size. After the tsunami disaster in 2011, they could grow oysters from seeds obtained from other areas which the damage of tsunami escaped to a selling size within one year. This experience encouraged fishermen to decrease oyster culture facilities. Moreover, Fisheries Agency of Japan asked to fishermen to form a group of Ganbaru Fisheries or Ganbaru Aquacultures and ameliorate fishing and aquaculture activities before the tsunami event. This policy promoted discussions among fishermen of each group because they shared boats, aquaculture facilities and works on the sea and on land. Scientific surveys started in 2014 and a physical-biological coupling model revealed that bottom environments in both areas have been maintained in good conditions after the tsunami. A fishermen's' cooperative, local governments and scientists have organized a council to discuss marine environments in Shizugawa Bay since 2014. The scientists explained marine environments and model results. WWF Japan also participated in the council and explained merits and importance of ASC certificate. Through discussion at the council, fishermen were encouraged to continue their activities. We can call decrease in aquaculture facilities in both areas and also the council activity as Satoumi activity because optimal human activity makes marine environments sustainable.

Sea urchins have explosively increased in 2014 and devastated seaweed beds, which became barren rocky beds. It may be owed to lack of fisheries after the tsunami. Komatsu et al. found that sea urchins could survived in rocky coasts in Otsuchi Bay of Sanriku Coast north of Shizugawa Bay. Thus, sea urchins could also survive in Shizugawa Bay. After the tsunami, fishermen could not collect sea urchins. In California coast, sea otters controlled kelp beds through feeding sea urchins. That is called as top down control. In Sanriku Coast, fishermen

have played an important ecological role as top down controller similar to sea otters that feed sea urchins. Thus, fisheries of sea urchins are also regarded as Satoumi activity. However, sea urchins on barren rocky beds have no commercial values because they don't have enough gonad to sell it at markets. Committee for Shizugawa Bay Management of Fishermen's Cooperative of Miyagi Prefecture has hired divers to collect sea urchins from barren rocky beds since summer of 2015. While it is necessary to monitor regeneration of kelp beds due to this challenge, we can call removal operation of sea urchins in barren rocky beds by hired divers as Satoumi activity.

ASC certificate is a symbol of responsible aquacultures to aim sustainable marine environments and production of bivalves in good conditions, namely, good for human health [11]. Although it gave to oyster cultures only in Togura Branch area, marine environments in Shizugawa Bay are shared with Shizugawa Branch area. The healthy conditions of marine environments in Shizugawa Bay couldn't be realized by only fishermen of Togura Branch. They also owe to decrease in oyster long-lines by 50% in Shizugawa Branch area. Committee for Shizugawa Bay Management of Fishermen's Cooperative of Miyagi Prefecture played an important role to obtain ASC certificate to oyster culture in Togura Branch. Other stakeholder is WWF Japan who helped fishermen of Togura Branch to apply ASC certificate system. WWF Japan played a very important role to link fishermen to ASC and scientists who started studies on marine environments in Shizugawa Bay in 2014. The scientists supplied data on marine environments to fishermen through WWF Japan. ASC certificate proves that fishermen use marine environment in sustainable way. Now, a concept of satoumi activity can be extended to involve those of aquaculture and fisheries that respect marine environments because Satoumi practice is defined as a human management of coastal seas for high productivity while sustaining high biodiversity [5].

Modern satoumi activity must be established on sound scientific knowledge. A link between fishermen and scientists is important. However, most of scientists don't know needs of fishermen. Therefore, a council consisting of fishermen, officers of local governments including prefecture and local community, NPO and scientists. Through discussion at the council, satoumi activities realize clean marine environments with rich biodiversity and a prosperous coastal community as a sustainable way.

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