Biodiversity and Fisheries Resource Management in the *Satoumi*

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Abstract

Japanese fisheries are characterized by (1) having a large proportion of artisanal fisheries, (2) establishing territorial user rights in fisheries (TURFs) by local fisheries cooperative associations (FCAs), (3) being one of the largest national fisheries in the world, and (4) using a variety of resources, from plankton-feeders to top predators, from sea urchin to marine mammals. The marine trophic index (MTI), the average trophic level of fisheries catches, has varied from ca. 3.1 in 1990 to ca. 3.6 in 1960 and 2000. There are many autonomous marine protected areas (MPAs) in Japanese coastal waters. Most of these MPAs are not legally regulated, but managed by the associated FCAs. MPAs are established or expanded when the major fisheries resources are depleted. In the case of Shiretoko, in northern Japan, a seasonal fishing-ban area for walleye pollock was established in 1994 because its stock was depleted. The MPA was extended according to the advice of the Scientific Council of the Shiretoko World Heritage Site in 2005. After that, Shiretoko was designated a UNESCO World Natural Heritage Site. The marine management plan for the Shiretoko World Heritage Site compiles the catches and yields of fisheries in the Shiretoko area, which are used for assessment of the fisheries' sustainability. Even at Japanese World Heritage Sites, we seek a balance between sustainable use of bioresources and conservation of biodiversity, instituting UNESCO's Man and the Biosphere (MAB) Program.

Key words: co-management, fisheries cooperative associations, marine protected area, Shiretoko World Heritage, yield per catch

1. Introduction

"*Satoumi*" was first defined by Yanagi (2007) as "a coastal area with high productivity and biodiversity with human interaction." United Nations University Institute of Advanced Studies (UNU-IAS) (2011) described several examples of *satoumi* in Japan. We also know several examples of sustainable resource use in coastal areas of the world. In Chile, for example, a co-management policy grants exclusive territorial user rights for fisheries (TURFs) to artisanal fisher organizations in well-defined inshore coastal areas (Matsuda *et al*., 2010). These areas are known as Management and Exploitation Areas for Benthic Resources (MEABRs). MEABRs encourage sustainable use, like *satoumi* areas. Species diversity and abundance of target species are enhanced in MEABRs compared to outside of MEABRs (Gelcich *et al*., 2008). It is noted that biodiversity in these areas is no higher than in no-take zones (Castilla *et al*., 2010).

Japanese *satoumi* areas are characterized by fisheries co-management. This is achieved by the government, fishers, local scientists and citizens (Matsuda *et al*., 2010). In this paper, we introduce the role of co-management at the Shiretoko World Heritage Site and the effects of coastal fisheries co-management on biodiversity and sustainable resource use. We also discuss how to assess and manage coastal ecosystems.

2. World Natural Heritage and the Role of Co-management at Shiretoko

The Ministry of the Environment (MOE), Japan, organized a Scientific Council (SC) to advise the process of nominating Shiretoko as a World Natural Heritage Site. In the process of reviewing the proposal, International Union for Conservation of Nature and National Resources (IUCN) requested the government of Japan to recommend stronger conservation measures for the marine ecosystem and to investigate the effects of dams on wild salmon populations. The SC voluntarily compiled a document advising the government on how to respond, recommending additional mitigation of river structures and further marine conservation efforts. The government did not incorporate this advice into its reply

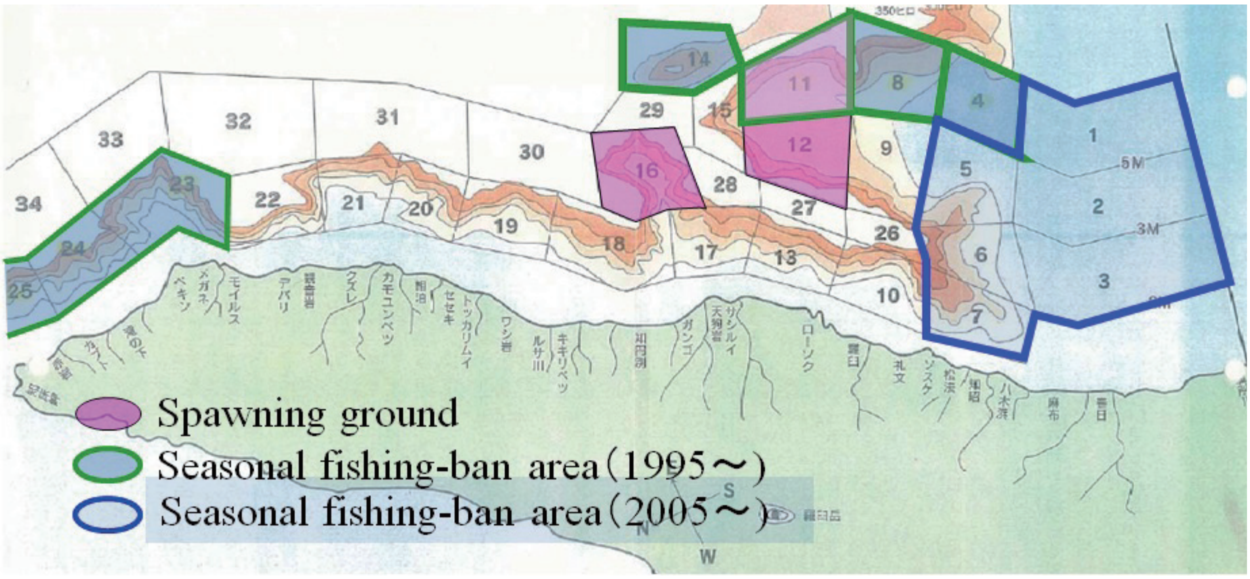

Fig. 1 Map of fishing ground of walleye pollock in Shiretoko. Grids numberd mean the fishing grounds of walleye pollock fishery; spawning ground (11, 12, 16), seasonal fishing-ban area since 1995 (4, 8, 11, 14, 23-25) and since 2005 (1-7).

to the IUCN.

The IUCN sent another letter to Japan to explicitly request expansion of the marine registered area and an expedited marine management plan. The MOE convened the SC, which compiled its recommendations and formed two working groups: the Marine Working Group (hereinafter, Marine WG) and the River Structure Working Group.

Officials from the MOE and the Hokkaido Prefectural Government promised the fisheries cooperative associations (FCAs) that the future management plan of the Shiretoko World Heritage Site would not include fisheries regulation. The SC acknowledged the conventional efforts of fishers to voluntarily regulate their fishing efforts (Makino *et al*., 2009).

Based on the SC's advice, the MOE agreed to the major points of the second IUCN letter. In addition, the Rausu FCA voluntarily expanded its seasonal fishing-ban area for the 2005 fishing season (Fig. 1). The contribution of fishers to the review process for the Shiretoko World Heritage Site was indispensable because they satisfied the IUCN and UNESCO requests to increase the level of marine ecosystem conservation. Accordingly, UNESCO accepted Shiretoko as a World Natural Heritage Site in 2005 (Makino *et al*., 2012).

In 2008, in its report on the reactive monitoring, the IUCN applauded the bottom-up approach to management through the involvement of local communities and local stake-holders, and the way in which scientific knowledge had been effectively applied to the management of the property through the SC that had been set up. It praised this approach as "an excellent model for the management of Natural World Heritage Sites elsewhere." In 2010, the International Association for the Study of the Commons selected this example as one of its Six Impact Stories of the world.

The creation of marine protected areas is not a goal of marine conservation but one of the effective methods.

Fig. 2 Fishermen and their families plant trees and maintain secondary forests in their backyards. The flags of a fisheries cooperative association stand in the forest (photo by Dr. Minoru Tomiyama, Aichi Prefecture).

Extension of the fishing ban area during nomination of the Shiretoko World Heritage Site is an example of Japanese fisheries autonomous co-management, without top-down control by the government (Matsuda *et al*., 2010; Makino, 2012).

Yagi *et al*. (2010) collected information on the locations and areas of all marine protected areas (MPAs) in Japan. They verified that at least 1,161 MPAs existed in Japan. More than 30% of the individual MPAs in Japan were established by self-imposed instruments agreed on by members of fishery co-management organizations. In Principle 6 of the Aichi Target approved by COP10, the definition of MPAs included community-based MPAs.

Japanese fishers and their families have made a point of planting backyard forests. These are called "*uotsukirin*" in Japanese, which means "fish-breeding forest" (Fig. 2). Despite the lack of full scientific evidence on how forests improve ecosystem processes in fishing grounds, it is a traditional practice of ecosystem

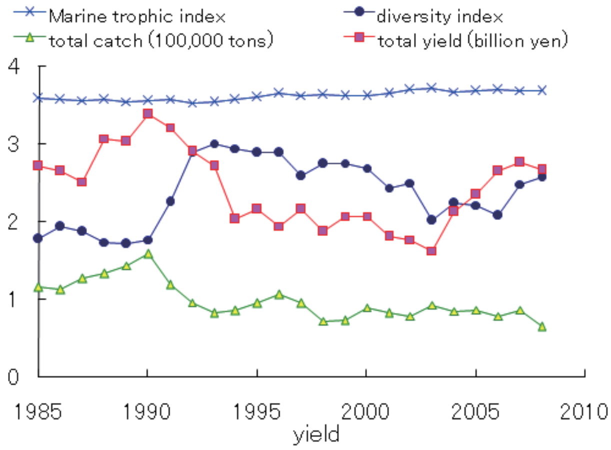

Fig. 3 The total catch amounts, total yields, Shannon's diversity indices, and marine trophic indices of fisheries in the Shiretoko World Heritage area.

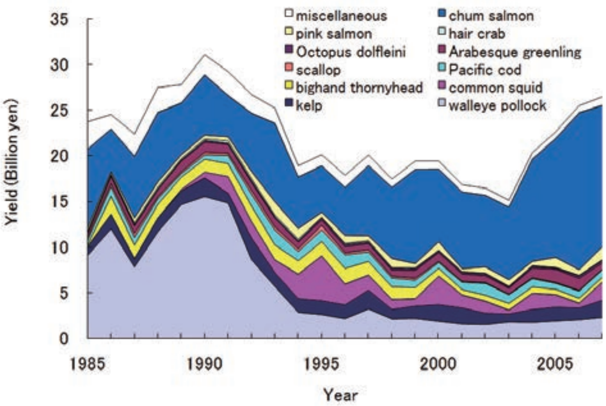

Fig. 4 The fisheries yields of thirteen major species in the Shiretoko area.

management among Japanese fisheries. Recently, Japanese scientists have investigated the contribution of the Amur River basin to the high productivity of the Okhotsk Sea (Shiraiwa, 2011; Matsuda, 2011).

3. Biodiversity in Fisheries Products of Shiretoko World Heritage Site

Matsuda *et al*., (2009) analyzed the ratio of yield per catch, $Y_i(t)/C_i(t)$, for each fisheries resource in each year. Hereafter we call this indicator YPC. Because Japanese fisheries cooperative associations compile the annual yield and catch of each of their fisheries resources, we can analyze YPC from these data.

Hokkaido Prefecture compiles catch statistics for each species or taxa in the Shiretoko World Heritage Site every year. $C_i(t)$ and $Y_i(t)$ denote the catch amount and yield, respectively, of species i in year t. Using these data, Fig. 3 shows the total catch amount $C(t)$, yield $Y(t)$, Shannon's diversity index $I(t)$ and the marine trophic index $M(t)$; which are given by

$$C(t) = \sum_i C_i(t) ,$$

$$Y(t) = \sum_i Y_i(t) ,$$

$$I(t) = -\sum_i \frac{C_i(t)}{C(t)} \log_2\left(\frac{C_i(t)}{C(t)}\right) ,$$

and

$$M(t) = \sum_i \alpha_i \frac{C_i(t)}{C(t)}$$

respectively, where α_i is the trophic level of species i. The trophic level of fish species i is obtained by FISHBASE <http://www.fishbase.org/search.php>.

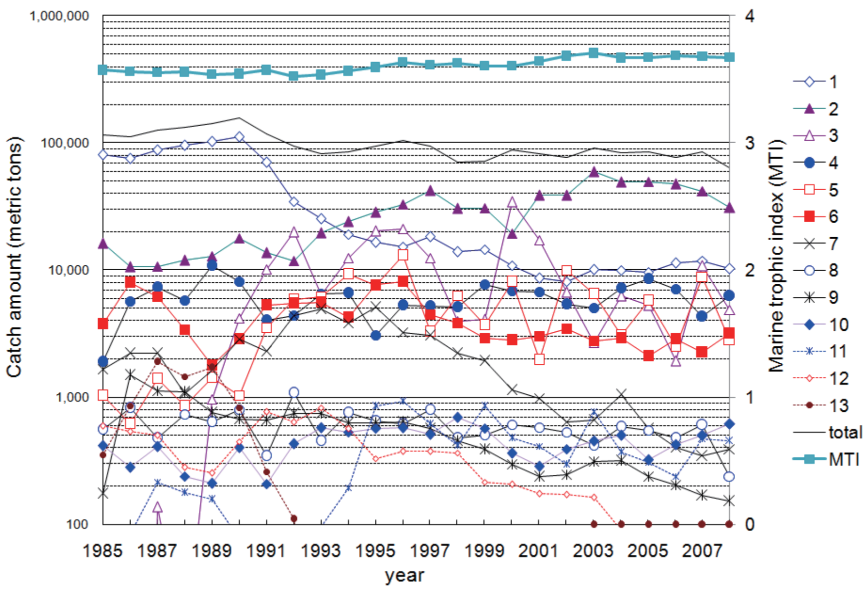

Fig. 5 Catch amounts of the thirteen major species at the Shiretoko site (updated from Matsuda *et al*., 2010).
1: walleye pollock, 2: chum salmon, 3: common squid, 4: Arabesque greenling, 5: chinock salmon, 6: Pacific cod, 7: scallops, 8: kelp, 9: bighand thornyhead, 10: *Octopus dolfleini*, 11: flounder, 12: *Neptunea polycostata*, 13: sardines.

The biodiversity index in the 1980s was lower than 2.0 because the catch of walleye pollock was very large (see Fig. 5). The biodiversity index increased in 1992, and gradually decreased during 1993-2008. The total yield did not change significantly, but the major resources have changed from decade to decade. Chum salmon *Oncorhynchus keta* and walleye pollock *Theragra chalcogramma* are two major fisheries resources at Shiretoko. The largest yield resource changed in 1993 from walleye pollock to chum salmon (Fig. 4). The reasons walleye pollock decreased and chum salmon increased at the Shiretoko site are probably independent. The walleye pollock stock decreased partly because of Russian trawl fisheries (Mori *et al*., 2012). The chum salmon stock increased probably because of artificial hatching and stocking (Saitoh & Watanabe, 2012). Matsuda *et al*. (2009) showed that the marine trophic index (MTI) in the Shiretoko area did not change significantly.

Catch statistics data supply detailed information on the marine ecosystem status because coastal fishers exploit many species and compile catch and yield amounts of each bioresource (Makino *et al*., 2009). Japanese fisheries are characterized by high diversity in catch amounts, a very high percentage of artisanal fishers, and a high MTI (Makino & Matsuda, 2011). In the Shiretoko World Heritage area, the catch amount of each bioresource and MTI did not significantly decrease, except for a few species. The reason for the decline in catch amounts of some species, such as sardines in the 1980s, and *Neptunea polycostata*, scallops and walleye pollock during the mid 1990s to 2000s, is attributable to natural fluctuations, and trends in catch amounts in other areas showed similar patterns (Fig. 5). If fishers cannot explain the reasons for decreasing catch amounts of some species, the sustainability of fisheries in this area is suspect (Matsuda *et al*., 2010).

MTI for Japanese fisheries was as high as 3.6 in the early 1970s, while it was less than 3.1 in 1990, and reached 3.6 in 2005, as shown in Fig. 6. The reason it was less than 3.1 in 1990 was because of the catch amount of sardines. The trophic level of sardines is ca. 3.0 because sardines are plankton-feeders. MTI is not a good indicator of sustainable fisheries (Matsuda *et al*., 2010; Branch *et al*., 2010).

YPC is a simple screening indicator of average body size, because the fish price per weight for many species decreases with decreasing body weight. There are several species that show significant decadal reduction in catch amounts. Most of these species, *e.g*., sardines, decreased due to natural decadal changes in stock abundance. Some of these species, *e.g*., snow crabs, decreased due to regulation of fishing impact and the price per unit weight increased. Therefore, YPC is a better indicator for sustainable fisheries than the catch amount. There are still a few species that show significant decadal reductions in YPC.

YPC of each species in the Shiretoko area is shown

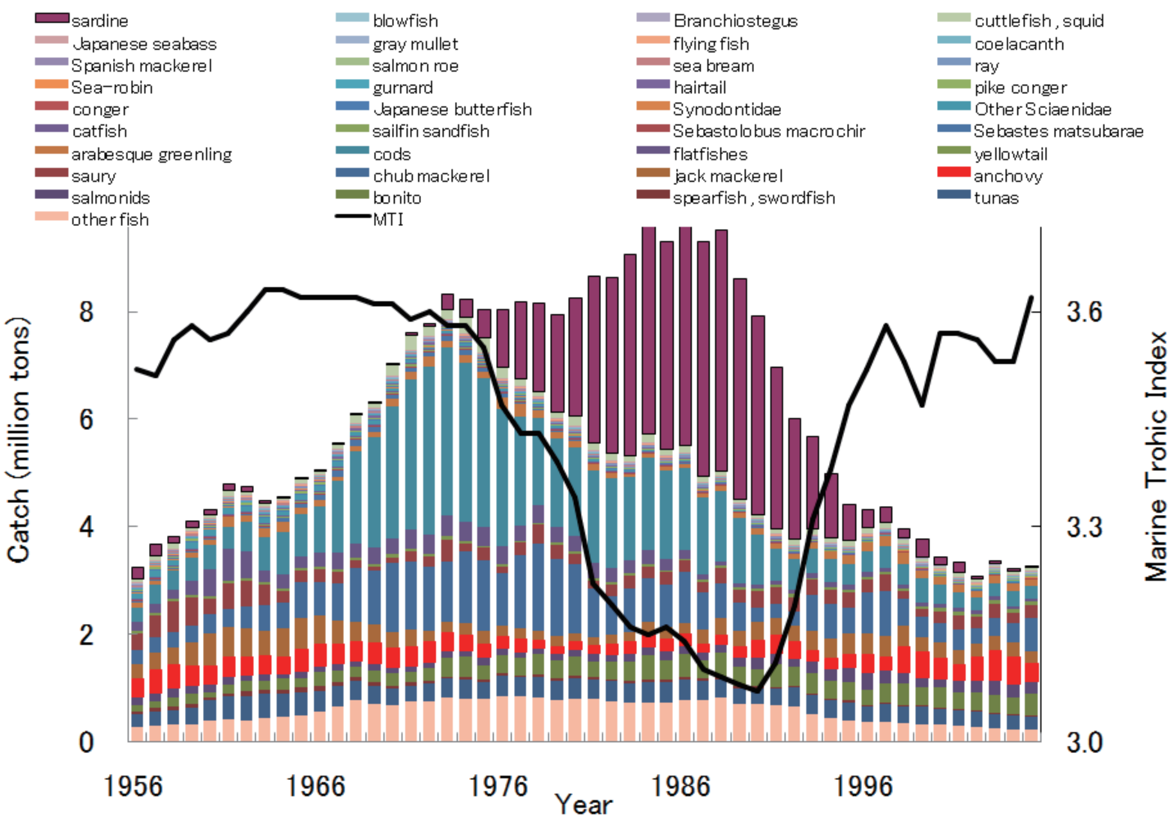

Fig. 6 The total catch amounts and marine trophic indices (MTI) of Japanese fisheries (Matsuda *et al*., 2010; JBO, 2010).

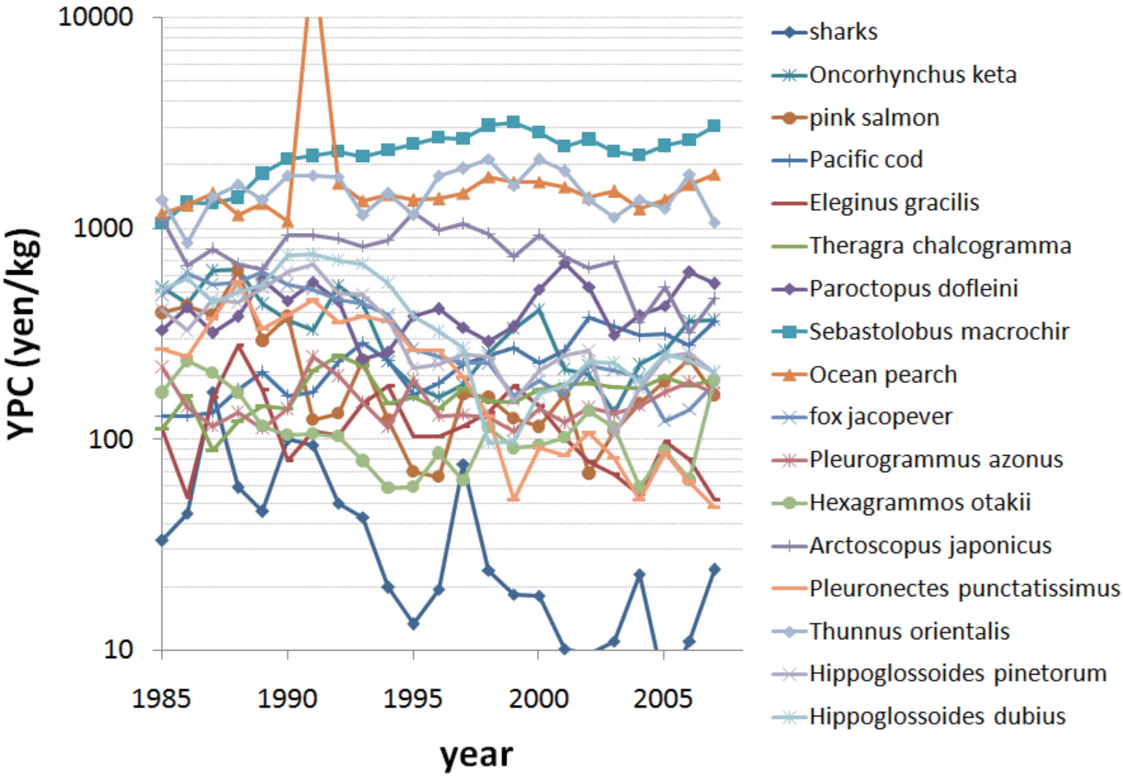

Fig. 7 Yield per catch (YPC) of major fisheries resources at the Shiretoko site.

in Fig. 7. Some species showed significantly decreased YPC, such as pink salmon, *Eleginus gracillis*, *Hippoglossoides pinetorum*, and *Pleuronectes punctatissimus*. The price of pink salmon decreased not because its body size decreased but because its stock increased during these few decades.

4. Discussion

Japanese waters are known as one of the richest regions in the world in terms of marine biodiversity (Fujikura *et al*., 2010). This is probably because Japanese waters in the economic exclusive zone include warm and cool currents, coral reefs, seasonal sea ice, coasts and deep-sea trenches, and they constitute one of the most intensively surveyed regions. Sustainable coastal fisheries may prevent significant loss of Japanese coastal biodiversity. However, the Japan Biodiversity Outlook Scientific Committee (JBO) (2010) and Japanese *Satoyama-Satoumi* Assessment (2010) reported significant degradation of coral reefs, sea grass beds and tidelands along Japan's coasts.

Japanese coastal ecosystems are characterized by the *satoumi*, which is widely used by fisheries. Activities in the Japanese *satoumi* are variable among sites, from Shiretoko to Ishigaki Island (UNU-IAS 2011, Makino 2012). The Scientific Council of the Shiretoko World Heritage Site drew a food web graph of the marine ecosystem of the Shiretoko World Heritage Site. The food web includes brown bears and eagles, because they utilize salmon and other fish. A large part of the species in the food web are utilized by fisheries or hunters. Exceptions include phytoplankton, zooplankton, starfish, polychaetes and sea birds. Although jellyfish are not shown in the food web, I believe jellyfish exist in this area and are rarely used in Japan. Fishers use these resources and compile catch and yield statistics for each bioresource, although catches of some species (*e.g*., chub mackerel and spotted mackerel) are summarized as a single bioresource in Japanese fisheries statistics. Therefore, we can investigate the status of marine ecosystems by monitoring the catch and YPC of each bioresource.

Fisheries data do not directly reflect biomass and other characteristics of marine ecosystems, but reflect those of landed individuals. We need to monitor marine ecosystems using research vessels. Despite limited information from fishery statistics, I expect that catch and YPC are useful as indicators of marine ecosystems. MTI is calculated from catch statistics, but it is not always a good indicator of marine ecosystems (Branch, 2010). For not a few species, detailed stock assessments are analyzed and published by the Fisheries Agency of Japan (*e.g*., Mori *et al*., 2012; Saitoh & Watanabe, 2012). We can assess and monitor the stock and fisheries status of sardines, chum salmon, walleye pollock, common squid and other resources. We can verify screening methods using yield and catch data shown here for these major resources. If catch per unit effort data are available for some other species, a more detailed analysis is possible.

"*Satoumi*" is defined as coastal area with high productivity and biodiversity with human interaction (Yanagi, 2007). At Shiretoko, however, there is no evidence that human activities increase marine biodiversity. Some examples are known, such as Inkachi at Ishigaki Island, in which biodiversity probably increased due to human activities (UNU-IAS, 2011). Sustainable fisheries based on appropriate zoning may eliminate loss of biodiversity in comparison with unsustainable fisheries (Gelcich *et al*., 2008).

Marine protected areas are known as a useful method of preventing overfishing. According to the *Chronicles of Japan,* originally published by Imperial Prince Toneri in 720 AD, Emperor Jito established an area where fishing was banned within 1665 m of the Muko coast in Settsu County in 689 (Ujiya, 1988). This is the oldest recorded MPA in Japan. The oldest MPA in the world is considered to be Royal National Park, Australia, designated in 1879 (James & Banks, 2002). This suggests that Japanese fisheries have an older history of fisheries management with fishing-ban areas.

On the other hand, the existence of the oldest MPA suggests that overfishing has been a big problem from the inception of Japanese history. There were two aspects to Emperor Jito's decision. First, the establishment of the MPA in 720 coincided with discouragement of the consumption of animal flesh and development of Buddhism in Japan. Second, the MPA in 720 protected juvenile fish by prohibiting small mesh sizes in fishing nets. The latter suggests that the MPA was established not only to discouraging carnivorism.

MPAs are defined as areas surrounded by evident boundaries that are legally managed or otherwise subject to effective measures adjusted to their form of usage for the purpose of conservation of biodiversity, supporting the integrity of the structures and functions of marine ecosystems and conservation and sustainable use of ecosystem services (Ministry of the Environment, Japan, 2011).

Most MPAs in Japan are not legally regulated. IUCN defined MPAs as satisfying one of six categories (Dudley, 2008). These include MPAs that are determined by local communities. At the 10th Meeting for the Conference of Parties (COP10) to the Convention on Biological Diversity (CBD), the Strategic Plan for Biodiversity 2011-2020 (Aichi Target) prescribed target ratios of protected areas by 2020 of 17% for terrestrial and 10% for marine and coastal ecosystems. It also allowed for community-based protected areas but did not give an explicit definition of MPAs.

Unlike fisheries in most modern countries, there is neither centralised nor top-down management in traditional fisheries in Japan. Although Japan was modernised in the late 19th century, the country still has a decentralised co-management system, involving fishers and the government, as well as many artisanal fishers (Makino & Matsuda, 2011). Decentralization is encouraged in the Twelve Principles of the Ecosystem Approach that was approved at COP5 of CBD in 2000. Why did fishers at Shiretoko choose to extend the seasonal fishing-ban area rather than accept further regulation by the government? In the latter case, the government would have had to pay some compensation to the fishers, whereas the fishers received no compensation under the voluntary MPA extension.

I introduced the custom of planting fish-breeding forests as an example of ecosystem management. There are several items that may contribute to ecosystem management in Japan's *satoumi*: planting fish-breeding forests, voluntary MPA definition, agreement on fishing seasons, establishment of fishing zone by fisheries cooperative associations, encouraging artisanal fisheries, and prohibition of highly technical fishing gear.

However, coastal fisheries are threatened by industrialization, globalization, depopulation, ageing and technical innovation. It is difficult to convince fishers of the need for sustainable fisheries if their children or colleagues are not succeeding them in fishery. World Heritage status definitely encourages coastal fisheries at Shiretoko. We need to establish ways of maintaining and enhancing coastal fisheries where they are not supported from the outside.

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References

Branch, T.A., R. Watson, E.A. Fulton, S. Jennings, C.R. McGilliard, G.T. Pablico, D. Ricard and S.R. Tracey (2010) The trophic fingerprint of marine fisheries. *Nature,* 468: 431-435.

Castilla, J.C., P.H. Manríquez and A. Camaño (2010) Effects of rocky shore coseismic uplift and the 2010 Chilean mega-earthquake on intertidal biomarker species. *Marine Ecology Progress Series,* 418: 17-23.

Dudley, N. (2008) *Guidelines for Appling Protected Areas Management Categories.* IUCN, Switzerland.

Fujikura, K., D. J. Lindsay, H. Kitazato, S. Nishida and Y. Shirayama (2010) Marine biodiversity in Japanese waters. *PLoS ONE,* 5(8): e11836.

Gelcich, S, N. Godoy, L. Prado and J.C. Castilla (2006) Add-on conservation benefits of marine territorial user rights fishery policies in central Chile. *Ecological Applications,*18:273-281.

James, R. and S. Banks (2002) Marine Protected Areas in New South Wales National Parks - Inventory and Role in Marine Conservation, 2002 World Congress on Aquatic Protected Areas. < http://www.asfb.org.au/pubs/2002a/apa-75.htm>

Japan Biodiversity Outlook Science Committee (JBO) (2010) Japan Biodiversity Outlook. <http://www.biodic.go.jp/biodiversity/shiraberu/policy/jbo/jbo/index.html>

Japan *Satoyama-Satoumi* Assessment (2012) *Satoyama-Satoumi Ecosystem and Human Well-being: Socio-ecological Production Landscapes of Japan*, Summary for Decision Makers. 1-36, United Nations University, Tokyo.

Makino, M., H. Matsuda and Y. Sakurai (2009) Expanding fisheries co-management to ecosystem-based management: A case in the Shiretoko World Natural Heritage area, Japan. *Marine Policy,* 33:207-214.

Makino, M. and H. Matsuda (2011) Ecosystem-based management in the Asia-Pacific area. *In*: Ommar R., I. Perry, P. Cury and K. Cochrane, eds., *World Fisheries: A Social- Ecological Analysis*: 322-333, Wiley-Blackwell, Chichester.

Makino, M., H. Matsuda and Y. Sakurai (2012) Expanding fisheries co-management to ecosystem-based management: A case in the Shiretoko World Natural Heritage area. Convention on Biological Diversity Technical Paper: 18-23, United Nations University Press, Tokyo.

Makino, M. (2012) *Fisheries Management in Japan*, Springer.

Matsuda, H., M. Makino and Y. Sakurai (2009) Development of adaptive marine ecosystem management and co-management plan in Shiretoko World Natural Heritage Site. *Biological Conservation,* 142: 1937-1942.

Matsuda, H., M. Makino, M. Tomiyama, S. Gelcich and J.C. Castilla (2010) Fishery management in Japan. *Ecological Research,* 25: 899-907.

Matsuda, H. (2011) 3-6 Risk and resource management. *In* : M. Osaki, A. Braimoh, K. Nakagami and O. Saito, eds., *Designing Our Future from Local and Regional Perspectives – Bioproduction, Ecosystems & Humanity*: 267-281, United Nations University, Tokyo.

Ministry of the Environment, Japan (2011) *The Strategy for Conservation of Marine Biodiversity*. (in Japanese)

Mori T., T. Funamoto and M. Chimura (2012) Assessment of the Nemuro walleye pollock stock in 2011. *In*: Fisheries Research Agency, Japan, ed., *In-depth Stock Assessment by Stock by Species in Fiscal Year 2010*, pp.382-397. <http://abchan.job.affrc.go.jp/digests23/html/2311.html> (in Japanese)

Saito, T. and H. Watanabe (2012) Japanese stock of chum salmon. *In*: Fisheries Research Agency, Japan, ed. *Present Status of International Fisheries Resouces in Fiscal Year 2011*, p.6. <http://kokushi.job.affrc.go.jp/H23/H23_58.pdf>

Shiraiwa, T. (2011) *Environmental Science on Fish-breeding Forest*. Showado.

Ujiya, T. (1988) *The Chronicles of Japan* (modern Japanese translation), Kodansha, Tokyo.

UNU-IAS (2011) Biological and Cultural Diversity in Coastal Communities, Exploring the Potential of *Satoumi* for Implementing the Ecosystem Approach in the Japanese Archipelago. Secretariat of the Convention on Biological Diversity, Montreal, Technical Series, no. 61.

Yagi, N., A.P. Takagi, Y. Takada and H. Kurokura (2010) Marine protected areas in Japan: Institutional background and management framework. *Marine Policy,* 34: 1300-1306.

Yanagi, T. (2007) Sato-Umi: *A New Concept for Coastal Sea Management*, Terrapub, Tokyo.

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