Ecol Res
DOI 10.1007/s11284-010-0748-5

SPECIAL FEATURE From SATOYAMA to managing global biodiversity

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# Fishery management in Japan

Received: 13 December 2009 / Accepted: 6 July 2010


**Abstract** There are few legal marine protected areas in Japan rather than fishing-ban areas. Fishers did not seek legal fishing-ban areas but they did establish fishing-ban areas by autonomous bases. We briefly introduce the institutional history and features of Japanese coastal fishery management, including the past decade's major legislative developments. Japan still has a decentralized co-management system involving fishers and the government, and ca. 98% of Japanese fishers are artisanal. There are several successful cases of coastal fisheries management in Japan. However, offshore industrial fisheries have problems in Japan. We compare coastal fisheries co-management between Japan and Chile. We finally discuss the possibility of improvement for Japanese fisheries.

**Keywords** Marine-protected area · Co-management · Artisanal fisheries · Territorial user rights for fisheries · Coastal fisheries · Chilean fisheries

## Introduction

Japan once played an important role in the international institution for marine protected areas (MPAs). A marine park system was established in Japan after the 1st Conference for World Natural Parks in 1962, in Seattle. The first International Conference for Marine Parks was held in 1975, Tokyo, Japan. Despite this, there are few known MPAs in Japan because it has not been welcome to use the term MPAs among persons who relate to Japanese fisheries. This is probably because fishers did not seek legal fishing-ban areas but they establish fishing-ban areas on autonomous bases (Yagi et al. 2010). We briefly introduce the institutional history and features of Japanese coastal fishery management, including the past decade's major legislative developments.

Japan has one of the world's oldest and most successful marine fisheries co-management regimes (Lim et al. 1995; Pomeroy and Berks 1997). According to the Japanese first legal provision to fisheries, which was the Taiho Code of 701, local fisheries resources were for common use and managed by local resource users themselves. This basic idea has been passed down and is still used today.

For example, based on the Fisheries Law of 1949 and the Fisheries Cooperative Associations Law of 1948, qualified individuals living in the coastal community were entitled as coastal fishers by rights and licenses. Fisheries cooperative associations (FCAs), the organization of local fishers, are the management body of local fisheries and resources. Based on both the traditional and scientific knowledge on the local environment, each FCA establishes detailed rules on the fisheries operations on the local fishing grounds, such as fishing gear, fishing area and season, minimum-size limit, etc., and enforce them on autonomous bases. Government supports such activities by provisioning legal and scientific information and subsidies (Makino and Matsuda 2005). Therefore, the Japanese fisheries management regimes, especially in coastal areas, can be understood as a kind of Territorial Use Rights in Fisheries (TURFs) (Christy 1992). In addition, Japanese fishers set autonomous fishing-ban areas for licensed fisheries, snow crab fishery, and sandeel fishery as mentioned below.

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Published online: 20 August 2010

In 1997, the Japanese government introduced the total allowable catch (TAC) system. The central government sets TACs, while the allocation of quotas and the determination of access rules are the responsibility of fishers' organizations. Therefore the co-management framework is still working even in the output control measures like TACs. At present, eight species are subject to TACs in Japan. To sum up, unlike fisheries in modern countries, there are few centralized top-down managements in Japanese fisheries.

In addition, ca. 98% of Japanese fishers are artisanal (Table 1). The artisanal fisheries have not been defined by Japanese law. In this paper, we define the artisanal fisheries by the size of fishing vessels in the footnote of Table 1. However, the catch of far sea fisheries and offshore fisheries, mainly by industrial fisheries have been a large part of the total catch in Japan (Fig. 1). Because of the establishment of the exclusive economic zone (EEZ) system and collapse of Japanese sardine (*Sardinops melanostictus*) stock in the 1990s, the catch of far sea and offshore fisheries has decreased, while the catch of coastal fisheries has not changed significantly throughout the past half century.

**Table 1** Status of fishers in each nation (Fisheries Research Agency Japan 2009)

| Nation | No. of fishers | No. of fishing vessels | Artisanal fishers (%)[a] |
|---|---|---|---|
| Japan | 278,200 | 219,466 | 98 |
| Korea | 180,649 | 50,398 | 90 |
| Norway | 22,916 | 8,664 | 89 |
| Denmark | 4,792 | 4,285 | 86 |
| United Kingdom | 19,044 | 9,562 | 82 |
| France | 26,113 | 6,586 | 78 |
| Spain | 75,434 | 15,243 | 76 |
| Canada | 84,775 | 18,280 | 74 |
| New Zealand | 2,227 | 1,375 | 74 |
| Iceland | 6,300 | 826 | 63 |
| USA | ca. 290,000 | 27,200 | 53 |
| Australia | 13,500 | ca. 5,000 | Unknown |

[a]The ratio of artisanal fisheries is defined as the percentage of the number of fishing vessels whose size is smaller than ISCFC (the International Statistic Classification of fishery Vessels) unit 25

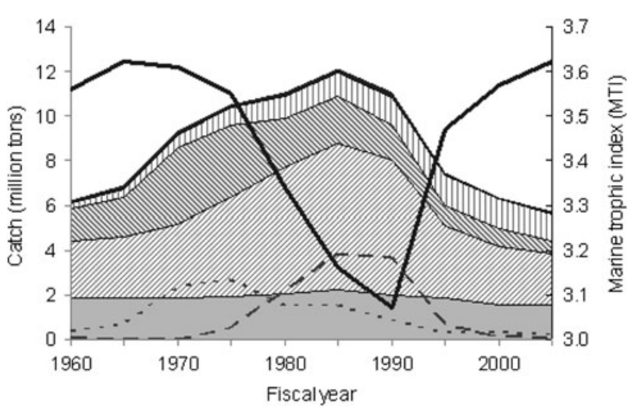



**Fig. 1** Marine trophic index (MTI) and the total production of Japanese marine fisheries from fiscal year 1960 to 2005, divided into five categories: coastal fisheries, offshore fisheries, far sea fisheries, marine aquaculture, and inland aquaculture from *bottom* to *top*. *Broken* and *dotted lines* represent the catch of sardine and walleye pollock, respectively

## Definition of "environment-friendly fisheries"

Fisheries management has played an initiative role of sustainability science because the maximum sustainable yield (MSY) has long been a key concept of fisheries management. However, the MSY theory has focused on the sustainability of fisheries yield that is a part of ecosystem service (Costanza et al. 1997). Ecosystem services include supporting services, provisioning services including fisheries yield, regulating services and cultural services (Millennium Ecosystem Assessment 2005). The existence of living marine organisms may maintain these services from marine ecosystems.

In addition, there is some criticism against the theory of MSY (Matsuda and Abrams 2008; Matsuda et al. 2008). The MSY fishing policy is not reflected in species interactions and other kinds of ecosystem services other than fisheries yield. Matsuda and Abrams (2006) analyzed the MSY from entire food webs with independent fishing effort on each species. Matsuda et al. (2008) incorporated ecosystem service into optimal fisheries policy, and they called the optimal policy that maximizes the total ecosystem services the "maximum sustainable ecosystem service" (MSES). An ecosystem service other than fisheries yield likely depends on the standing biomass, while the fisheries yield depends on the catch amount. The standing biomass likely decreases as the fishing effort increases, while the fisheries yield is a unimodal function of the fishing effort. If we consider a case of using a single bioresource, and if we ignore any contribution of fishers' activity other than fisheries yield as discussed later, it is intuitively understandable that the fishing effort to maximize the total ecosystem services (denoted by $E_{\mathrm{MSES}}$) is always smaller than the effort to maximize the maximum sustainable yield ($E_{\mathrm{MSY}}$) as shown in Fig. 2. On the other hand, a total fishing ban does not always maximize the total ecosystem service because the fisheries yield is a part of ecosystem services.

Fishing effort for actual fisheries is often considered to be larger than $E_{\mathrm{MSY}}$, and it is unsustainable. Classical fisheries science usually refer to MSY or its derivatives. Recently, marine ecologists have recommended "no-take zones" for ecosystem-based management (Pikitch et al. 2005). These recommendations largely ignore artisanal (small-scale) fisheries, which involve more than 50 million fishers around the world. Therefore Castilla and Defeo (2005) wrote the requirement of paradigm shift to the participation of fishers in the planning and surveillance of management measures, which promises a short-term solution to the current artisanal fishery crises, promoting compliance with regulations.

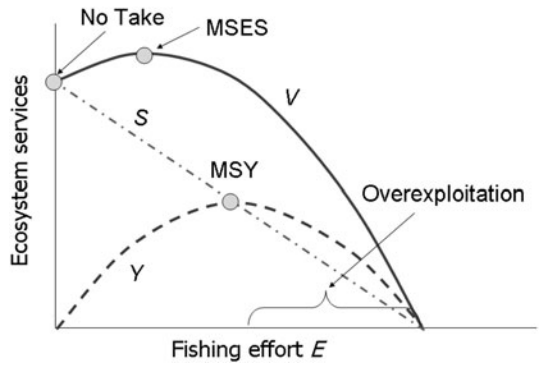



**Fig. 2** Schematic relationship between overfishing, maximum sustainable yield, maximum sustainable ecosystem services, and no take zone. *Dotted line*, *broken curve*, and *bold curve* represent the utility of standing biomass ($S$), fisheries yield ($Y$), and the total ecosystem services ($V$), respectively. *Three circles* mean the efforts for MSY, MSES, and total fishing ban (modified from Matsuda 2010)

Fishers have ever paid efforts to conserve their fishing ground. At least in Japan, fishers pay effort for forestation and believe positive effects of the backyard forests on the fisheries productivity in their fishing ground. This is called a fish-breeding forest (Uotsuki-rin in Japanese). In addition, they enclose some shore area by stones and catch fish inside of the area when there is a low tide. The area of such architecture is usually between 10 and 1 ha and it is called Nagaki'i or Ishihibi in Japanese local dialects. Similar artificial structures are seen in many parts of the world. Traditional fishers made some artificial structures in the fishing ground and circumstance including terrestrial area to sustain their fisheries resources. These are called ''Satoumi'' in Japanese, as an analogy to ''Satoyama'' in terrestrial landscape (Yanagi 2007).

Particularly in developed countries, not only the increase of human impact but also reduction of human activity may decrease or threaten biodiversity and ecosystem services. In the work of the Japan Biodiversity Outlook Science Committee (2010), there are several ecosystem services that are damaged due to a reduction of human activities in artificial forests, abandoned paddy fields, and deer overabundance. Also in coastal ecosystems, some sustainable fisheries may prevent biodiversity loss (Gelcich et al. 2008). According to a questionnaire survey of more than 500 Japanese biologists, the major cause of biodiversity loss within the past half century has been land-use change in terrestrial and coastal ecosystems (Japan Biodiversity Outlook Science Committee 2010). Reclamation is a major factor of coastal ecosystems, while offshore ecosystems are probably the result of industrial fisheries, as discussed below.

Since Japanese fisheries are not always regulated by law but more often are regulated autonomously, it is important that local scientists convince the necessity of management of fishers. If fishers face critical problems such as stock collapse, they still expect the long-term benefit from their fisheries and they have some trustful scientists, then they adopt the scientists' advice for fisheries management. There are several cases of success stories of coastal fisheries management in Japan: sakura shrimp fishery in Suruga Bay, sandeel fishery in Ise and Mikawa Bays (Tomiyama et al. 2005), sandfish fishery in Akita Prefecture, and snow crab fishery in Kyoto Prefecture (Makino 2008). The last one became the first Marine Steward Council authorized fishery from Asia.

## Trends and current status of Japanese fisheries

There are many warnings in global marine ecosystems (Pauly et al. 2002; Myers and Worm 2003; Worm et al. 2006). Pauly and Watson (2005) calculated the mean trophic level of fisheries catch (called the marine trophic index, MTI) and showed that the MTI of the global fisheries has decreased from ca. 3.5 in 1950 to ca. 3.3 in 1990. This implies overfishing, because the harvested fish are increasingly coming from the less valuable lower trophic levels as populations of higher trophic level species are depleted. The Convention on Biological Diversity chooses the mean trophic level of marine fisheries catch as an indicator of marine ecosystem integrity and ecosystem goods and services in Global Biodiversity Outlook. Pauly et al. (2002) called decline of the MTI ''fishing down''.

The MTI of the global marine landings did not show a monotonic decline but fluctuated from decade to decade. The global MTI was low in the 1970s and 1980s, when catches of Peruvian anchovy and Japanese sardines were large, respectively. The theory of ''fishing down'' is useful when the major target species is high price and higher trophic level fish. This is not true in some countries (Delgado et al. 2003). In Japan, the MTI was ca. 3.6 in 1960, ca. 3.1 in 1990, and ca. 3.6 in 2000. Therefore, Japanese fishery is characterized by higher MTI than the global average and its MTI did not show the long-term decline (Fig. 1).

Myers and Worm (2003) argued that the biomass of top predators including tuna has been reduced by 90% relative to levels prior to the onset of industrial fishing. Despite these warnings, there are some criticisms on these arguments. The magnitude of tuna stock decline estimated by Myers and Worm (2003) is overestimated (Hampton et al. 2005). Although the southern bluefin tuna (*Thunnus maccoyii*, SBT) is ranked critically endangered by the IUCN, the extinction risk of SBT is definitely smaller than the blue whale, which is ranked as endangered. It is very unlikely that SBT will go extinct within the next half century (Matsuda et al. 1997), while it is again difficult to satisfy the past target of recovering SSB to the 1980 level by 2020 by Convention for the Conservation of Southern Bluefin Tuna (Mori et al. 2001).

Some pelagic fish species, including the sardine, have naturally fluctuated in stock abundance to a great degree, even without fisheries, for several thousand years (Baumgartner et al. 1992). The collapse of the Japanese sardine in the 1990s was almost certainly caused by natural variation in the environment (Watanabe et al. 1995). When the stock is at a low level, the impact of fisheries on pelagic fishes prevents the stock from recovering (Kawai et al. 2002). To some extent, Japanese offshore fisheries still use "derby competition", although the total number of offshore vessels are restricted by the licenses from the Minister of Agriculture, Forestry and Fisheries and the determination of access rules are the responsibility of fishers' organizations. Fishers can catch any size of fish until the total catch reaches the limit. On the contrary, Norwegian fisheries are managed by the individual vessel quota (IVQ) system. The catch quota of each vessel is determined before the fishing season starts, therefore fishers often ignore smaller fish and look for older fish with a higher price per unit weight.

There is some discrepancy between coastal and offshore fisheries. The management of offshore fisheries has many problems, including chub mackerel fisheries. The TAC is often much larger than the allowable biological catch (ABC) decided by fisheries scientists. The government did not prevent overfishing of these resources. The actual catch is often smaller than its TAC because standing biomass in each fishing ground is heterogeneous and some fisheries are unable to catch their catch quotas. This is the reason why TAC is larger than ABC. However, the actual catch of Japanese sardine was often much larger than ABC, as is shown in Fig. 3.

There is a mismatch between demand and supply of fishery resources from the food-security viewpoint. In the case of Japanese fisheries, the TAC and the actual catch exceeded the ABC in some fish including sardines (Fig. 3). In contrast, the actual catch is much smaller than the ABC in some species, including Pacific saury (*Cololabis saira*, Oyamada et al. 2009) and anchovy. It should be noted that the total ABCs of these species is larger than 2 million metric tons (Fisheries Research Agency, Japan, unpublished). However, the economic

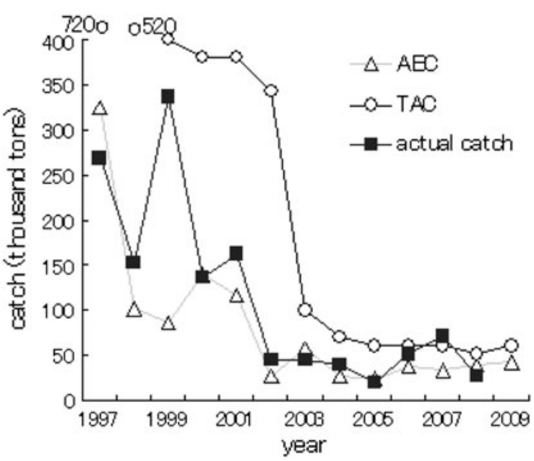



**Fig. 3** The allowable biological catch (ABC), total allowable catch (TAC) and actual catch of Japanese sardine during 1997–2009 (Fisheries Research Agency, Japan). ABC in 1999 and 2007 were revised during the fishing season and were originally 370,000 and 35,000 tons, respectively

demand of these species is low in Japan, while the economic demand of overfished species including tuna and chub mackerel is still large, partly because of overcapitalization of fishing vessels. Japanese people rarely use jellyfish despite the fact that it frequently occurs in Japanese costal regions and the Chinese eat it. Although, according to Maguire et al. (2006), there have been no new bio-resources since 1975, there are still unused bio-resources in the global oceans. According to Worm et al. (2009), about one-third of fisheries resources are underexploited, and their stock is above the MSY level.

## Some examples of successful coastal fisheries management in Japan

Unlike far-sea fisheries and offshore fisheries, the catch amount of costal capture fisheries has not significantly changed since the 1960s (Fig. 1). The catchability may have increased, but stock abundance has decreased for many resources. Therefore there are serious problems in coastal fisheries. The key problem in Japan is how to build a consensus among fishers.

### Snow crab fisheries in Kyoto Prefecture

Snow crabs are harvested using bottom trawlers. The Kyoto Prefecture Fishery Coordinating Regulation sets the official season for bottom-trawler fishing. Harvests of Kyoto's snow crab have followed a typical boom and the largest harvest volume of 369 metric tons was recorded in 1964. Landings declined dramatically afterwards, to 58 metric tons in 1980. Overfishing was said to be the cause of the decline. Various resource-recovery measures by the Kyoto Bottom Trawlers' Union were introduced beginning in 1983. Specifically, a combination of permanent and seasonal MPAs were introduced as marine reserves on voluntary bases and have been expanded since 1983. Permanent MPAs are meant to provide sanctuaries for snow crabs from fishing and were established around the snow crab's critical habitats. Seasonal MPAs are aimed mainly at avoiding by-catches of low-value crabs.

Fishers agreed with autonomous establishment of permanent MPAs because stock biomass has decreased by overfishing and a single MPA was introduced in 1983. Kyoto Prefecture government supported these activities with funding and scientific research and advice. In permanent MPAs, bottom trawling is not possible because artificial blocks were laid on the sea bottom. The number of permanent MPAs increased after fishers examined the effect of MPAs on stock recovery. As a result, the landing increased from 58 metric tons in 1980 to 195 metric tons in 1999 and the total yield increased from US$ 0.9 million in 1980 to US$ 3.6 million in 2001 (Makino 2008).

### Coastal fisheries in Shiretoko world heritage site

In Shiretoko, the fisheries sector is the most important industry. To maintain responsible fisheries, local fishers have implemented a wide range of autonomous measures under a co-management framework. Since the nomination of the peninsula and its surrounding marine areas for UNESCO World Natural Heritage, various measures have been implemented to conserve its outstanding ecosystems. The approach was not to eliminate local fishers from the area, but to place their activities at the core of the management scheme to sustain ecosystem structure and function. Fishers exploit most all taxa in marine ecosystems in Shiretoko. Fishers compiled the catch and yield statistics of these taxa of fisheries resources because most of these resources are sold in a local fish market. Like stomach content monitoring of the top predator, the catch statistics are informative in evaluating ecosystem status (Makino et al. 2008).

Chum salmon (*Oncorhynchus keta*) and walleye pollock (*Theragra chalcogramma*) are two major fishery resources in Shiretoko (Matsuda et al. 2009). The largest yield resource changed in 1993 from walleye pollock to chum salmon. Since walleye pollock stock decreased in 1991 in the Sea of Japan, the Sea of Okhotsk, and the northwestern Pacific, probably due to decadal change of global environment, Shiretoko fisheries now depend on salmon fisheries, which are probably supported by the release of hatching stock.

Experience from the co-management of fisheries in Shiretoko World Heritage site could inform ecosystem-based management in other countries where a large number of artisanal fishers take a wide range of species under a fisheries co-management regime if they compile the catch statistics. Adaptive management based on daily operations can be found in autonomous MPAs construction in the Shiretoko World Heritage site. In 1995, local fishermen divided a fishery ground into 34 areas based on local knowledge and experiences and then introduced temporal MPAs into seven of the 34 areas to conserve fishery resources.

In 2005, an additional six areas were designated as protected areas (Makino et al. 2009). These protected areas have been introduced on voluntary bases, and reexamined every year based on the results of the previous year's performance and scientific advice from the local research station. Therefore, it can be said that this decision-making process obeys adaptive management. An important next step would be scientific verification of its validities (Matsuda et al. 2009).

### Sandeel fisheries in Ise and Mikawa Bays

One of the major fisheries resources in Ise and Mikawa Bays is Pacific sandeel (*Ammodytes personatus*). Sandeel juveniles are a traditional seafood (boiled in salt water in sweetened soy sauce) in Japan and are mainly caught by pelagic trawl fleets. The stock of sandeel in Ise and Mikawa Bays once collapsed during late 1978 to 1982 because of over-exploitation and environmental deterioration. After this collapse, fishers and local scientists began to conduct regulatory measures in 1980 on a basis of the collaboration between Aichi and Mie Prefectures in Ise and Mikawa Bays. In 1990, the fishers decided on three measures: (1) the establishment of a fishing-ban area (MPA) during the fishing season, (2) a choice of the opening and (3) closing day of sandeel fishery. Establishment of autonomous MPA during fishing season is important for protecting spawners (Tomiyama et al. 2005). The area of the MPA changes with the escapement stock within the fishing season, according to consultation by local scientists earned by these prefectures (Fig. 4). To operate these adaptive management measures, fisheries' cooperative associations of sandeel fishers in Mie and Aichi Prefectures play an important role.

Throughout these successful examples, fishers agreed with the establishment of MPAs if (1) a fishery stock has once collapsed, (2) fishers expect their long-term benefit from fisheries, (3) a local scientist supports fishers, (4) an autonomous regulation can be revised if necessary, and (5) a number of meetings are had for consensus building. If autonomous regulation has once been agreed upon, the management plan is relatively well implemented with lower cost (Makino and Matsuda 2010). Makino and Matsuda (2005) also compared socioeconomic benefits between community-based and top-down management.

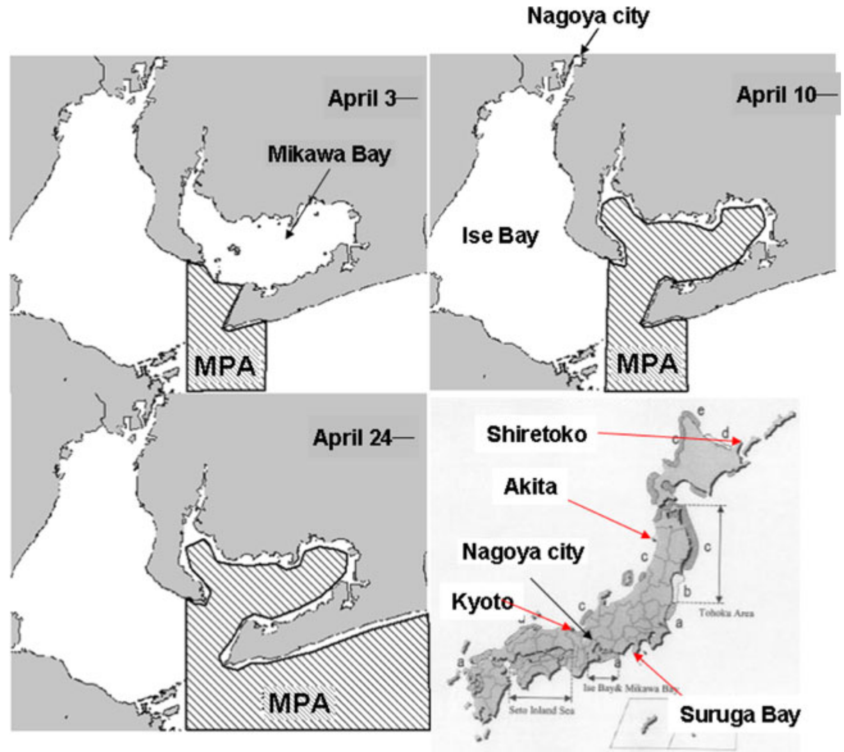
## Chilean coastal fisheries

In Chile, artisanal fisheries supply a significant fraction of highly valued finfish and the totality of small-scale benthic invertebrate and algae resource exports. For instance, in 2000, 110,050 metric tons of shellfish were landed, totalling an export revenue of approximately US $50 million (SERNAP 2004). This activity is also important from a social perspective, as there has been an explosive increase in the artisanal fisheries work force over recent years, from approximately 17,000 registered fishers in 1975 to over 48,000 in 2000 (San Martin 2001). Out of these, 22,578 fishers are registered as divers or coastal (intertidal and shallow subtidal) food-gatherers who mainly exploit benthic shellfish as part of their livelihood. Thus benthic resources play an important role in coastal areas in Chilean fisheries.

Historically, Chilean fisheries were characterized by open-access policies with specific regulations regarding size limits and seasonal operations. Up until 1974, when Chile adopted neo-liberal economic policies, most of the fishery landings were used for internal consumption (World Bank 2006).

After 1974 and until 1990, open-access fishery was accompanied by the implementation of an aggressive exchange-rate policy in 1974/1975, which substantially improved fishing export earnings, and produced the necessary incentives for Chile to become the region's leading fish and shellfish exporter (Thorpe et al. 1999).

**Fig. 4** Fishing-ban area (MPA) for sandeel fishery in 2005, Ise and Mikawa Bays, Japan. The area of MPA can change weekly. *Grey zones* in the *right bottom panel* represent fishing ground for sandeel in Japan (Tomiyama 2009)




This led to overexploitation in many artisanal fisheries. During this period, numerous management measures were inappropriate, the fishing season was regulated without monitoring schemes of stock evaluation, and the Governmental Fisheries Service could not prevent clandestine catches and smuggling.

Due to the overexploitation of many fisheries (e.g., clams, mollusks), in 1991, a new Fishery and Aquaculture Law (FAL) was created. The FAL redefined artisanal fishers and incorporated new regulations that affect their user rights through three management steps: (1) exclusive fishing rights within a zone that extends to 5 nautical miles (9 km) from the shoreline are assigned exclusively to artisanal fishers (Artisanal fisheries Exclusive Zone, ca. 27,000 km$^2$); (2) artisanal fishers are restricted to working (diving) within the coastal zone adjacent to their region of residence (regionalization); (3) the FAL assigns territorial user rights for fisheries (TURFS) to organized groups (unions/syndicates/associations/cooperatives) of fishers under what have been termed Management and Exploitation Areas for Benthic Resources (hereafter referred to as MEABR; Castilla 1994; Gelcich et al. 2005).

The FAL defined an artisanal fishery as a fishery extractive activity carried out by fisherfolk that personally direct and who normally work in coastal areas. For this purpose, and interpreting the Fishery and Aquaculture Law in 1991, "coastal" means the oceanic realm within the first 5 miles from the littoral line. An artisanal fisher must be registered with the National Fisheries Service and fishing vessels must not exceed 18 m in length and a maximum of 50 gross register tons (Castilla and Gelcich 2007, World Bank 2006). As mentioned above, the MEABRs policy was implemented in Chile as a reaction to the widespread overexploitation of benthic species that occurred during the 1980s. The first actual MEABR was formally established in 1997 (Gelcich et al. 2005). As of 2005, 301 MEABR have management plans in place, and 547 have approved decrees issued (Gelcich et al. 2008). To date, 1,032 km$^2$ are assigned as MEABRs in Chile, however, policy uptake has been highly dependant on the commitment of the government to promote, popularize, and co-finance the implementation of these management areas (Gelcich et al. 2008). In order to have a MEABR, fishery unions must contract biological consultants to undertake a baseline study and yearly follow-up direct assessments of managed benthic stock inside the management area; hence, determining yearly TAC. Unions must also pay an annual fee to the government for the right to maintain the management area.

The biological-fishery success of the MEABR policy has been publicized through scientific and government documents, which showed a significant increase in abundance and individual size of targeted resources within MEABR in comparison to open-access sites (Manríquez and Castilla 2001; Sernap 2004). Recently, Gelcich et al. (2008) also showed how MEABRs that show efficient enforcement programmes sustained greater marine biodiversity than open-access areas. In addition the Fisheries Undersecretary sees MEABR implementation as a positive change in which fisher communities have self-organized, creating partnership with the government, universities and consultants

(Schumann 2007). In this way, artisanal fishing coves are being consolidated responding to government incentives.

## Discussion

There are several similarities between Japanese and Chilean fishery-management schemes (Castilla unpublished) including artisanal territorial user rights for fisheries (TURFs). However, there are also several differences, and one of the biggest ones appears to be TURFs' legitimacy. In Japan, MPAs are often defined and determined by fishers themselves; while in Chile, MPAs are defined rather in a top-down process by the government, with limited participation of fishers. In general, Japanese and Chilean fishers do not like top-down regulations but rather seek autonomous management conducted within fisher organizations since the Modernization Era in the 19th century. Chilean fishery authorities have added numerous TURFs (at present more than 700 for extraction of benthic resources along the country) after realizing their effect on sustainable fisheries. In the case of sandeel fisheries in Ise and Mikawa Bays, the area of autonomous MPA is flexible.

Japanese law guarantees TURFs in coastal zones. There is a conflict between aquaculture and capture fisheries for space. There is also a conflict between coastal fisheries and other kinds of ocean utilization such as recreation, sea-phase development, wind farms, and reclamation. There are few studies that investigate the economic value of ecosystem services in coasts and coastal fisheries (Yanagi 2007).

Another difference between Chile and Japan exists in industrial fisheries. Individual fishery quotas and a vessel-monitoring system were introduced for industrial offshore fisheries in Chile since ca. 2000 (Castilla 2010); these systems have rarely been installed in Japanese offshore fisheries. The total landing from Chilean coastal fisheries (mainly small-pelagic species) has substantially increased since 1991 when legislation introduced five coastal miles dedicated exclusively for the artisanal fleet as well as ITQ regulations (Castilla 2010).

If Japan imitates Chilean fisheries, Japan needs a clear legal definition of artisanal fishery, such as the size limit of the boat with clearer fishing rights and duties in an international context. Japan also needs to improve top-down regulation for industrious or offshore fisheries.

In a local community, wealth is often redistributed through social inter-dependence and traditional credit systems (Makino and Matsuda 2010). That may bind fishers to their communities and occupation, as a sense of sub-cultural identity. These social norm conditions are also important in facilitating the effective co-management of local natural resources (Ostrom 1990; Armitage et al. 2009). Fishers may perceive ecosystem status of their fishing grounds and serve a role in monitoring and sustaining ecosystem services. If we count the value of fishers' activity for other than getting fisheries yield, fishing effort might give some social benefit.

The ecological footprint of the Japanese is comparative to the average European, which is about half of the average American (WWF 2008). Composition of fish consumption of the Japanese is much larger than that of the European and American. This is because the fish consumption of the Japanese is high and the mean trophic level of consumed fish is higher than the global average (Fig. 1). Recently, the Japanese frequently eat bluefin tuna (*Thunnus orientalis*, *T. thynnus* and *T. maccoyii*), despite the fact that the Atlantic bluefin tuna (*T. thynnus*) stock is rapidly decreasing (ICCAT 2008). The tuna ranching has been to blame since the late 1990s. There are two big problems in bluefin tuna fisheries, under-report of catch amount, and uncontrol of tuna ranching, despite the fact that tuna farmers must report the exact amount of tuna that are put into the ranches. Japanese consumption has been driving the expansion of these ranches and the decline of the bluefin tuna population. The price of bluefin tuna is not very high. Many Japanese people still eat bluefin tuna frequently. Japanese consumers may control the global tuna market because about 80% of Atlantic bluefin tuna is imported by Japan and detailed information of fisheries is necessary when tuna is imported into Japan based on Japanese law.

The average longevity of Japanese women is 84 years in 2008, which is the longest in the world. Japanese eat more fish than Americans on average, and fish contains higher amounts of omega-3 polyunsaturated fatty acids, which are effective in reducing the mortality rate (Zhang et al. 2009). Tuna and other higher trophic level fish are usually contaminated with mercury, and their contamination level is often higher than the health standard. The Japanese ecological footprint will decrease if consumption of lower trophic level fish such as anchovy and Pacific saury increases and consumption of higher trophic level fish such as tuna and salmon decreases in Japan. Therefore, eating lower trophic level fish is both environmentally friendly and healthy. If Japanese eat lower trophic level fish, it is effective to decrease MTI of Japanese and global fisheries. We call this "eating down", instead of Pauly's "fishing down".

**Acknowledgments** We express our sincere thanks to Drs. D. Cooper, N. Hayashi, Y. Hiyama, H. Ijima, Y. Katsukawa, T. Nakashizuka, Y. Takeuchi, and A. Yatsu for valuable comments. We also thank anonymous reviewers for valuable comments. This work is partly supported by a grant from the Global Environment Research Fund (H-092) by the Ministry of the Environment, Japan, the Global COE (E-03) by MEXT, Japan, and the Pew Marine Conservation Fellowship Grant to H. M.

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