Sandeel fisheries governance in Ise Bay, Japan

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1. INTRODUCTION

The Japanese sandeel (*Ammodytes personatus* Girard) stock in Ise Bay is one of the most important resources for pelagic pair-trawl fisheries in Aichi and Mie Prefectures. Most valuable in the catch are the sandeel's larvae and juveniles, so harvesting is intensely concentrated on the two or three weeks immediately after the fishing season opens. Nearly 90 percent of annual landings occur during this period (Fisheries Agency, 2006). However, it is also prone to overharvesting. Poor harvests in five consecutive seasons between 1978 and 1982 were attributed to overfishing and to a simultaneous unfavourable natural condition called meandering of the Kuroshio Current. Harvests declined from 14 843 t in 1974 to 2 423 t in 1978 and to a mere 515 t in 1982 (Tomiyama, 2007).

Five years of poor harvests induced sandeel fishers to implement several resource management measures, including setting opening and closing dates of fisheries and establishing marine protected areas. All of the measures were designed and implemented through collaboration between fishers and researchers from local fishery experiment stations. Stocks today are considered to be at high levels. The issue now is the extreme volatility of annual harvests, which have ranged from 915 t in 2000 to 19109 t in 2004 (Tomiyama, 2007). Recent fishery management efforts have focused mainly on creating stability in landings.

Autonomous organizations of fishers in both prefectures play a central role in managing the sandeel fishery. To help these organizations make effective management decisions, scientific information provided by researchers is integrated into the decision-making process. The close collaboration between fishers and researchers has been instrumental in helping fishermen understand the necessity of fishery management, which has led to a sense of ownership of the resource.

2. DESCRIPTION AND HISTORY OF THE SANDEEL FISHERY

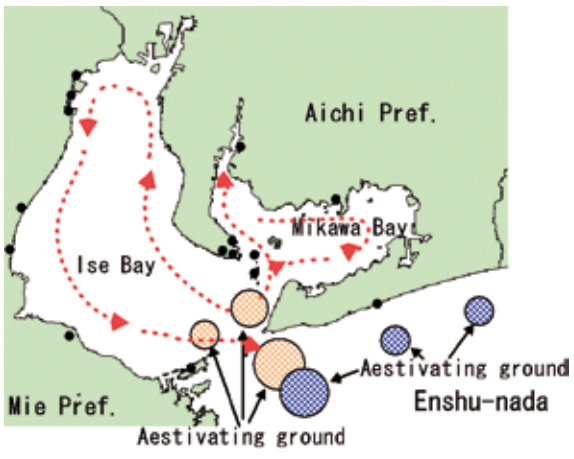
2.1 Ecology of the sandeel

Ise Bay is one of the major fishing grounds for sandeel in Japan. Others are the Tohoku area off northeastern Honshu Island and the Seto Inland Sea of western Honshu Island. Ise Bay occupies the central Pacific coast of Honshu, south of Nagoya between Tokyo and Osaka and is bordered by the prefectures of Aichi and Mie (Figures 1 and 2). The shallow, semi-enclosed bay has a mean depth of 19.5 metres and covers an area of 1 738 km^2. A narrow strait called Irago Channel connects the inner bay to the Pacific Ocean. Ise Bay is a typical estuary that is influenced by relatively large discharges from three major rivers: the Kiso, Nagara and Ibi Rivers all empty into the innermost portion of the bay.

A key characteristic of the Japanese sandeel is aestivation, an event that provides an anchor point for management of the fishery. Aestivation, a state of dormancy similar to hibernation but which occurs during the summer months, begins when the temperature of bottom waters warms to between 17 and 20° C, typically in May. When aestivating, sandeels gather and burrow into bottom substrates (Tomiyama and Yanagibashi, 2004). Their aestivation grounds are widely distributed along the coast of the southern peninsula of Aichi prefecture, where the water is generally between 20 and 50 metres deep (Figure 2). Aestivation ends around November, when the water temperature falls below 15 °C. Maturation begins in November, at the end of the aestivation period. When the water temperature falls below 12° C, usually in mid-December, the sandeels start to spawn in the mouth of Ise Bay (Tomiyama *et al.*, 1999). The sandeel larvae hatch through until the end of December. Currents then bring them into the bay. The number of sandeel juveniles that get transported into the bay, where they are harvested, depends on the direction and intensity of the currents within the bay, which are influenced by intrusions of warm water from the Pacific Ocean (Tomiyama, 2007).

FIGURE 1
Location of Ise Bay and Aichi and Mie prefectures

FIGURE 2
Migration of sandeels from spawning grounds to nursery grounds in Ise and Mikawa Bay



Sandeel larvae are about 3 to 4 millimetres long. By the time they begin to aestivate in May or June, they are 7 to 10 cm long (Hashimoto, 1991). The lifespan of the sandeel is three years and maximum body length is approximately 16 cm (see Figure 6).

2.2 The sandeel fishery in Ise Bay

Sandeels in Ise Bay are harvested using pair trawl nets. An operational unit (a "fleet") consists of two fishing boats (the pair) and one or two transporting boats (Photo 1). The two fishing boats, each about 15 tonnes, between then haul a single trawl net and both are equipped with a net winch. The transporting boats are also about 15 tonnes. About 200 harvesting units, collectively employing 700 boats from Aichi and Mie prefectures, share the sandeel stock in Ise Bay.

TOMIYAMA, LESAGE, AND KOMATSU (2005)

PHOTO 1
Fishing and transporting boats
The distance between the two fishing boats shown is approximately 100 m.

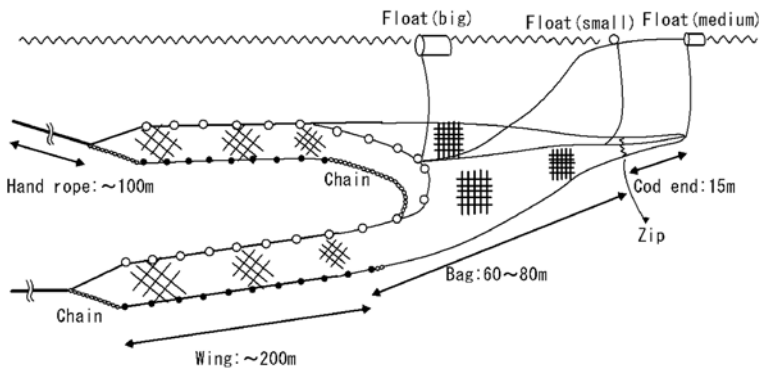
These trawlers can harvest sandeels anywhere in the water column, by adjusting the length of hand ropes and/or the rope attached to a big float (Figure 3). The towing speed is about 1.5 knots. Before deploying the net, all of the boats in a fleet, the transporting boats followed by the two fishing boats, scan for sandeel schools using echo sounder. Fishers can distinguish the species and the size of the school by the school's depth, its shape and the intensity of the echo. Once a school of sandeel is detected, the net is deployed and dragged at that depth.

The trawl net is constructed to allow fishers to quickly haul the catch onboard and redeploy the net. The key structure is the "zip system" on the net's cod end (Figure 3). Using the zipper, the cod end can be removed to open the net and then reattached quickly and easily. This allows them to collect the sandeels without hauling in the entire net. Catches are transferred from the unzipped cod end of the net to plastic baskets containing crushed ice on the deck of the transport boat while the rest of the net remains in the water. As soon as the catch is cleared and the end is reattached, the fishing boats can return to work while the transport delivers the harvest to port.

Landing procedures vary with the size of the fish. Sandeels longer than 5 cm are pumped directly from storage chambers on the transporting boat to a 1-ton container on the dock. Sandeels that are smaller than 5 cm remain in the plastic bins and are transferred by conveyor belt from the boat deck directly to the market floor or to a forklift pallet. All sandeel must be sold through an auction administered by local fishery cooperative associations (FCAs). The price received for the fish depends on its quality, which is determined mainly by size and colour (an indicator of freshness).

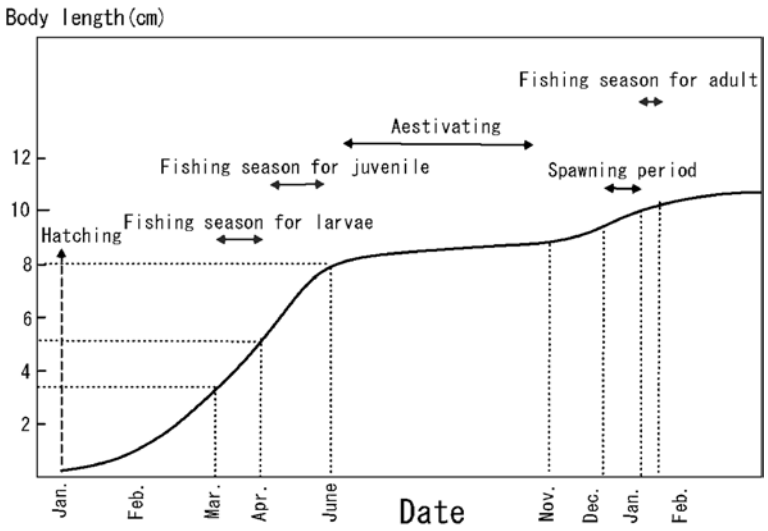
Fishers target three types of sandeels (Figure 4): (a) juveniles with a body size of 3–5 centimetres called *shirasu* (Photo 2a) that are harvested in March and April; (b) juveniles that exceed 6 cm and are harvested in April and May (Photo 2b); and (c), adult

FIGURE 3
Diagram of the pair-boat trawl nets used in sandeel fishing



Source: Tomiyama, Lesage and Komatsu (2005).

FIGURE 4
Growth patterns of the sandeel and related biological and fisheries events



TOMIYAMA, LESAGE, AND KOMATSU (2005)

PHOTO 2
Sandeel (a) larvae (shirasu) and (b) juveniles

fish caught in January and February. In terms of number of fish, more than 90 percent of the catch is *shirasu*. Fishers from Aichi prefecture target sandeel *shirasu* that are then processed for human consumption, while Mie prefecture fishers target larger sandeels (6 to 10 cm in length) that will be frozen and made into fishmeal for aquaculture.

3. DESCRIPTION OF SANDEEL FISHERY MANAGEMENT

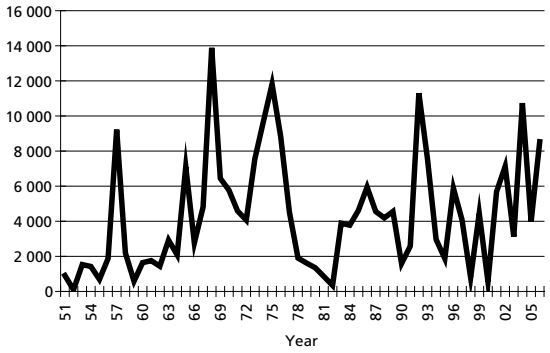
3.1 History

In both Mie and Aich, a sandeel fisher must obtain a licence for each fishing boat (but not for transport boats) issued by the prefectural government. Nonetheless, the fishery experienced a boom and bust cycle between late 1960s and early 1980s. Fishing pressure on sandeels intensified in the late 1960s and early 1970s as a result of two factors. One was technological advancement, including enhanced engine power, larger fishing gear and the use of echo sounders. The second factor was an increase in demand for adult sandeels for fishmeal for aquaculture during the 1960s and 1970s (Makino, 2007). As a result of the collapse in 1978-1982, Ise Bay sandeel fishers experienced a paradigm shift toward active involvement in fishery management.

During the period of intensified exploitation, competition among fishers was intense. According to sandeel fishers who participated in hearings conducted by the authors, each fleet endeavoured to catch all of the sandeel in the area as soon as

they were located with the echo sounder. Competition was particularly intense near the end of the sandeels' aestivation period (May to November). Since harvesting during aestivation is not allowed, fishers raced out to catch the sandeels as soon as they left their burrows and harvested them before they could spawn. Fishing pressure was particularly concentrated in the area of the spawning grounds, a destructive conservation practice. Fishers were well aware of these facts, but intense competition forced them to disregard considerations of the damage. The price was high and fishers caught as many adults as possible. In 1974, landings exceeded 14 000 t (Tomiyama, 2007).

FIGURE 5
Landing of sandeel in Aichi prefecture



Legends in the figure show implementation of various fishery management measures.
Source: Tomiyama, Lesage, and Komatsu (2005).

The paradigm shift occurred after a drastic decline in stocks. An increasing trend in harvest through 1974 abruptly reversed, and harvest volumes declined quickly. (Figure 5 shows landings from Aichi prefecture only, but gives the general picture). Meandering of the Kuroshio Current also affected the number of sandeels and accelerated the decline. This period of limited harvests lasted from 1978 to 1982. In 1982, the volume landed was a mere 515 t (Tomiyama, 2007).

3.2 Protecting spawners

Current fishery management measures attempt to protect spawning adults (spawners), and to harvest *shirasu* in an economically efficient manner. Specifically, current measures (a) control the opening and closing date for the fishing season and (b), establish marine protected areas.

Protecting spawners allows a necessary level of reproduction. Sandeels spawn shortly after aestivation. The cohort that aestivates for the first time, predominantly one-year-old sandeel adults, spawns. Escapement control is an effective measure to assure the necessary reproduction. Another measure for protecting spawners is a delay in opening the fishery so most adult sandeels have an opportunity to spawn before they are harvested.

Sandeel larvae enter aestivation approximately five months after hatching. They are targeted as *shirasu* immediately prior to aestivation (cf. Photo 2). Since natural mortality during aestivation and during the period between their emergence and spawning is low (about 10 percent), controlling the population of *shirasu* will effectively control the population of spawners. The consensus among researchers is that a minimum escapement of two billion reproductive sandeel adults is necessary for reproduction and recruitment that will ensure sustainable stock levels (Funakoshi, 1997).

Data on the volume of *shirasu* landed is thus important information. In the Ise Bay fishery, data about the number and weight of fish landed at each port and data from fishers on where *shirasu* were harvested are consolidated and analysed at Aichi Fisheries Research Institute. Representatives of fishers' unions are notified when the estimated number of reproductive sandeels drops close to the threshold of two billion, which indicates that fishing for *shirasu* (as well as adults) should soon close. The actual closing date is determined via discussions between fishers in both prefectures: sometimes it is decided quickly over the phone.

After the sandeels enter aestivation, the next decision is when to open the fishing season. Fishers have agreed to delay opening the season until approximately 80 percent of spawning sandeels have actually spawned. Researchers sample adult sandeels using

an apparatus called a *karatsuri*, which captures sandeels still burrowed under the sand. The researchers examine the samples and report the results to fishers. The opening date is then discussed and decided jointly by fishers from both prefectures.

3.3 Opening of the *shirasu* fishery

The opening date for the *shirasu* fishery, typically in March or April, is now determined by the sandeels' estimated economic value. Previously, fishers based their decision solely their experience and expectations. The opening date did not always coincide with the best price for the *shirasu*. Researchers have developed a simulation model, the Sandeel Fisheries Management Model, which models the relationships among sandeel size (body length), an opening date for fishing, and the value of the catch over a fishing season. The model estimates values for harvest revenues, costs, and profits based on information on the biological state of the sandeel, potential opening and closing dates for the fishery, and price. According to the model, the optimal size for *shirasu* is around 3.5 cm (it depends on market and resource conditions of the year). Larvae sampling is used to estimate when the juveniles will reach this optimal body size, given annual fluctuations in growth rates. Other environmental data, such as the surface water temperature and intrusion of the current, also are collected. Based on this information, fishers in each prefecture discuss and then select an opening date for *shirasu* fishing. Information on market demand from distributors and processors also is considered. The final decision on an opening date is made at a general assembly meeting attended by fishers from both prefectures.

These measures are effectively a seasonal closure set at both ends of aestivation period. Interestingly, this seasonal closure had a positive side effect. The price of *shirasu* declines as it grows beyond the optimal size of around 3.5 cm, whereas the price of adult sandeel used for fishmeal increases until the fish reaches the body length of 9 cm and plateaus out beyond that length. By closing the fishery for *shirasu* earlier before they are grown too big and delaying the harvest of adult sandeel to allow them grow bigger, fishers can focus their fishing effort when the price level is higher. For these reasons, agreement to implement these management measures was agreed relatively easily by the fishers.

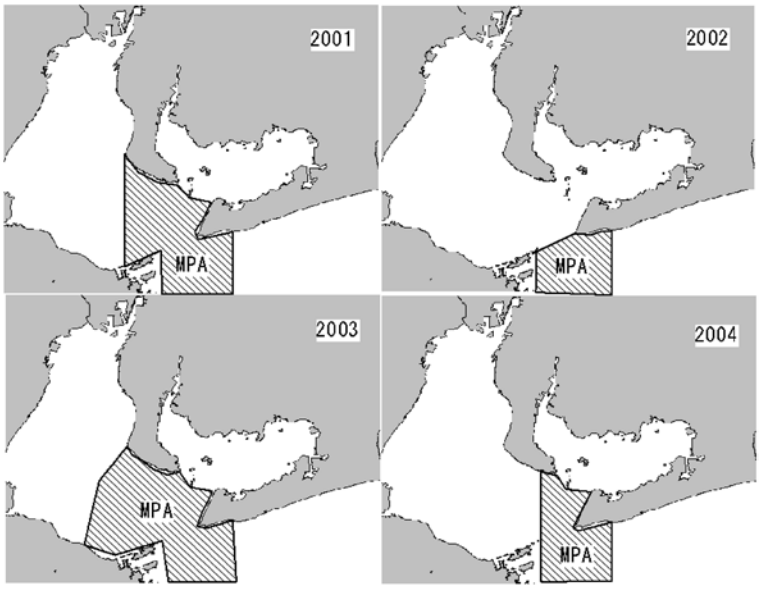
3.4 Marine protected areas

To protect aestivating sandeels, a temporary no-fishing zone is established at the mouth of Ise Bay when the sandeels begin to aestivate there in May and June. As explained, sandeels gradually migrate from the interior of the bay toward the mouth as they mature. The size of the no-fishing zone depends on the size of the stock that year. The smaller the remaining stock, the larger the no-fishing zone established (Figure 6). The location and sizes of the no-fishing zones also vary annually according to ecological information regarding factors such as the distribution of juvenile sandeels in the bay and migration paths to aestivating grounds. All non-sandeel trawl fishers are prohibited from operating within the no-fishing zone until after the sandeels have begun to aestivate, which is determined by surveying at the aestivation grounds in May and June.

3.5 Self-governance institutions

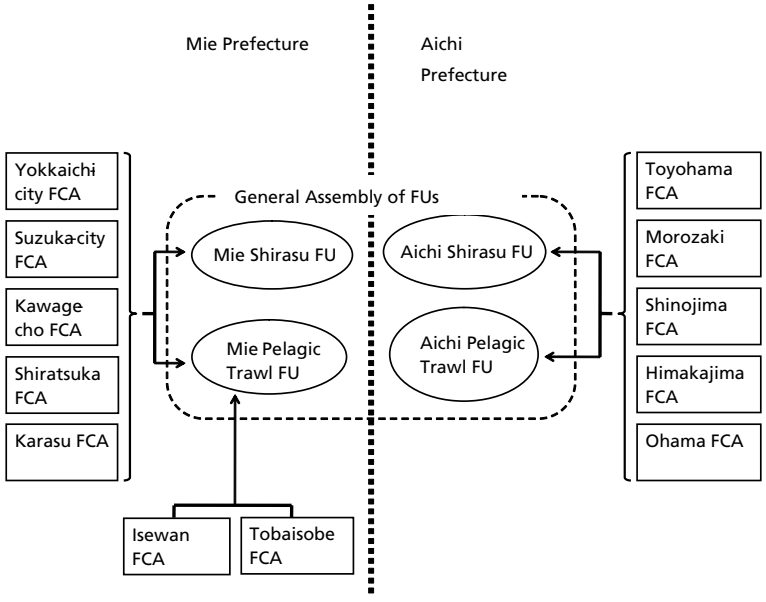
The sandeel stock in Ise Bay is shared and harvested by fishers from both Aichi and Mie prefectures. Management of the sandeel fishery thus requires an inter-prefecture partnership, surpassing the scope of local FCAs and even the borders of the prefectures, to balance the interests of fishers in Aichi and Mie. Fishery management for Ise Bay sandeels has two layers. The bottom layer is the FCAs (seven in Aichi and six in Mie) that operate along the coastline of Ise Bay (cf. Figure 2). Each sandeel fishing operator belongs to an FCA that governs its landings and docking. Atop the

FIGURE 6
Established no-fishing zones for 2001–2004



The area set aside is determined by the size of the remaining stock.
Source: Tomiyama, Lesage, and Komatsu (2005).

FIGURE 7
Organizations of sandeel fishers in Ise Bay



FCAs are four fishers' unions (FUs) (Figure 7): a *shirasu* union in each prefecture (harvesters of juvenile anchovies and sandeels) and a pelagic trawlers' union in each prefecture (for harvesting of adult anchovies, sandeels, and sardines). These four FUs are organized into a single general assembly of the sandeel fishers' unions that meets annually. This framework plays the central role in decision-making in Ise Bay sandeel self-management. Another activity implemented by this framework is the voluntary time limit for operating during the day. The official operating time prescribed in the

licence is from sunrise to sunset, but the voluntarily operating time is from 6 a.m. to 10–11 a.m.

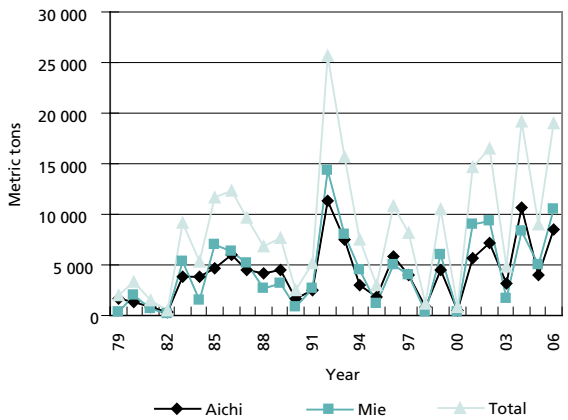
There is no direct cost specific to the licence, which is true for all fishery-related licences. There is an indirect cost, which is a fee one must pay to cover the administration of the local office. This fee applies to all licences and document that are issued, whether they are related to a fishery or something else. This cost is 3150 yen and is thus, an out-of-pocket cost for anyone wishing to obtain a licence: it has no relation to the value of the resource or industry's profitability, etc.

All major fisheries in Japan require either legal access rights to TURFs, which belong to the administrating cooperatives (FCAs). Thus, fishers do not have fishing rights as such but rights of access to undertake fishing. It is equivalent to a license to undertake commercial fishing. Whether the licence is species-specific or gear-specific varies on a case-by-case. In the case of sandeel, a license issued by prefectural governor is required. It may be noted that no fees are imposed on fishing licences issued by the central or local governments. In this particular example, the union is specifically for sandeel fishers. At the lowest local level, the Fishery Cooperative Association (FCA) encompasses all types of fisheries (species and gear-types) that are operated within its jurisdictional TURF. All coastal commercial fishers are members of at least one, though and typically only one, FCA. In the case of sandeel, the fishers have organized an inter-FCA organization specifically for sandeel fishers. Furthermore, these unions are formed by sandeel fishers within each prefecture and these uions are formed into an inter-prefectural organization – the General Assembly.

4. EVALUATION OF SELF-GOVERNANCE INSTITUTIONS

To evaluate self-governance of the Ise Bay sandeel fishery, we present the total landings (by volume and value) for both prefectures, estimated initial stock levels for each year, and the length of the sandeel fishing. The changes between 1979 and 2006 show that, compared to the depleted period 1979–1982, landings have gradually improved, though there are considerable fluctuations (Figure 8). The total harvest by Aichi and Mie prefectures improved from 515 t in 1982 to 19 109 t in 2004 and to 19 073 t in 2006. Although the two prefectures target different sizes of sandeels, the pattern of fluctuations is nearly identical. The landed value (in real [2006] terms) also has improved. The value rose from US$2.1 million in 1982 to US$15 million in 2004 and to US$12 million in 2006 (Figure 9).[1]

FIGURE 8
Landings of sandeel in Ise Bay



Source: Tomiyama, Lesage, and Komatsu (2005).

Estimated annual initial stock levels between 1979 and 2006 also show gradual improvement, although there are considerable annual fluctuations (Figure 10). The average number (count) of sandeel increased from 4.8 billion for 1979 through 1982 to 34.2 billion for 2003 through 2006. The length of the fishing season for sandeel has been extended from an average of 64.8 days during the depleted period (1979–1982) to an average of 149.5 days for 2003 through 2006 (Figure11). Despite an extended harvesting period, stocks at the beginning of the subsequent season have shown increases.

The longer fishing season is important to the timing of switching to other fisheries. Many sandeel fishers convert to the sardine

[1] An exchange rate of 118 Japanese yen to one US dollar is used throughout this paper.

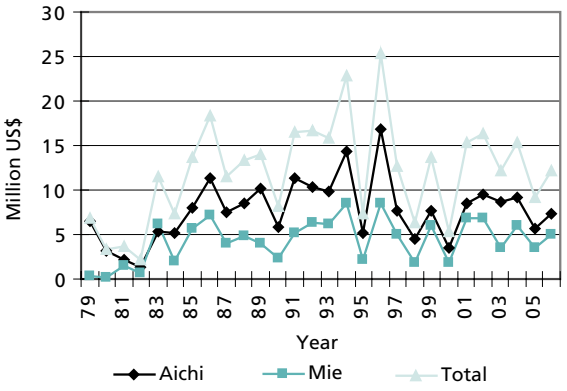
fishery (both targeting larvae, also called *shirasu*, and adults) in May or June. But the sardine opening day varies greatly from year-to-year, and it is impossible to predict at the beginning of the sandeel-*shirasu* season. If the sandeel fishery ends too early, fleets remain idle until the sardine fishery opens. Fishers favour year-round operations and therefore prefer to minimize the idle period between the two fisheries. The profitability of pelagic trawl fishery has declined in recent years, and fishers are paying more attention to efficient operation throughout the year over multiple fisheries.

5. DISCUSSION

Ise Bay's measures to protect sandeels are a good example of effective fishery co-management in Japan. Voluntary organizations of fishers from Aichi and Mie prefectures play the central role in managing the sandeel stock in Ise Bay. Through regular meetings that address issues such as when to open and close fishing, fishers from both prefectures have interacted and built trust. This has served to increase the legitimacy of decisions. This trust and sense of legitimacy have led to very strong compliance with virtually no enforcement costs to the government. The leaders of these organizations recognize that the sustainability of their management regime and that of sandeel resource are indispensable.

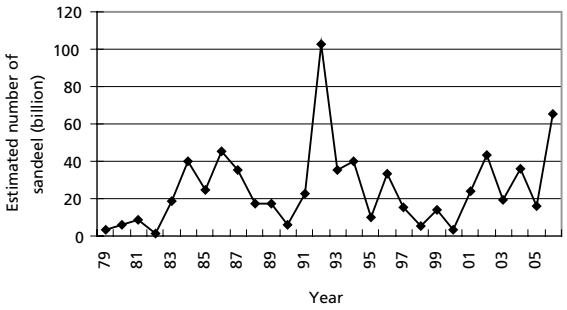
The management measures are strongly supported by data collected and analysed by the fisheries research institute in each prefecture. Self-management by fishers is motivated by their understanding of the necessity of resource management. The paradigm shift was induced by the collapse of the sandeel fishery. For self-governance to endure, a deeper understanding of the ecology of the targeted species and an ability to adjust management measures accordingly is an essential component. Collaboration and frequent communication between researchers and fishers are the keys to achieving sustainable self-governance.

FIGURE 9
Landing value (in real [2006] terms) for sandeel in Ise Bay



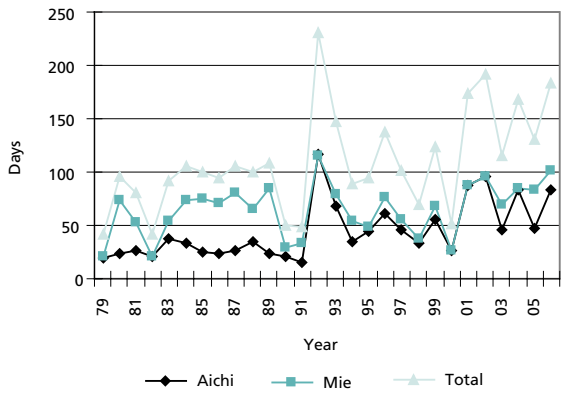
Converted to base year of 2006 using the producers price index.
Source: Tomiyama, Lesage, and Komatsu (2005).

FIGURE 10
Estimated initial stock levels for sandeels in Ise Bay



Source: Tomiyama, Lesage, and Komatsu (2005).

FIGURE 11
Length of the fishing season for sandeels (days)



Source: Tomiyama, Lesage, and Komatsu (2005).

6. ACKNOWLEDGEMENTS

We thank Dr. Funakoshi and Claire-Marine Lesage for providing us with valuable information about the sandeel fishery in Ise Bay.

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