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Lessons Learned from the Rehabilitation and Management Strategies of Sailfin Sandfish, *Arctoscopus japonicas* (Steindachner 1881) Fisheries in Akita, Japan

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Abstract

The catch of the sailfin sandfish, *Arctoscopus japonicas* (Steindachner 1881), from the coastal waters off Akita Prefecture declined to more than 10,000 tonnes in the mid-1970s and in 1991, the catch was only 70 tonnes. In 1992, on the recommendation of the Akita Prefectural Fisheries Promotion Center (FPC) the area was closed to fishing for 3 years. By 2002, the recorded catch was 2,112 tonnes, a significant improvement in 10 years. This study investigated the rationale for the acceptance of the sandfish fishing closure by the fishermen and the subsequent management strategies that led to the successful recovery of the sandfish population. The study concluded that the following factors played a vital role in the successful recovery of the sandfish population: (1) a reliable leader that was able to unite all the sandfish fishermen into a collective entity; (2) opportunity cost to sandfish fishermen were already low, so the closure had little impact on existing incomes from this fishery; (3) consensus among the sandfish fishermen; and (4) use of scientific data to demonstrate the serious decline of the sandfish stock and to predict the subsequent stock recovery.

Introduction

In Akita Prefecture, the sailfin sandfish *Arctoscopus japonicas* (Steindachner 1881) is harvested in offshore and coastal fisheries (Fig. 1). In offshore waters, sandfish are caught using bottom trawlers at depths of 200-300 m, resulting in the harvest of many immature sandfish, especially between the months of October and December (Sugiyama 1991). In coastal waters, set nets and gill nets are placed around seaweed beds to catch the mature fish that migrate to coastal

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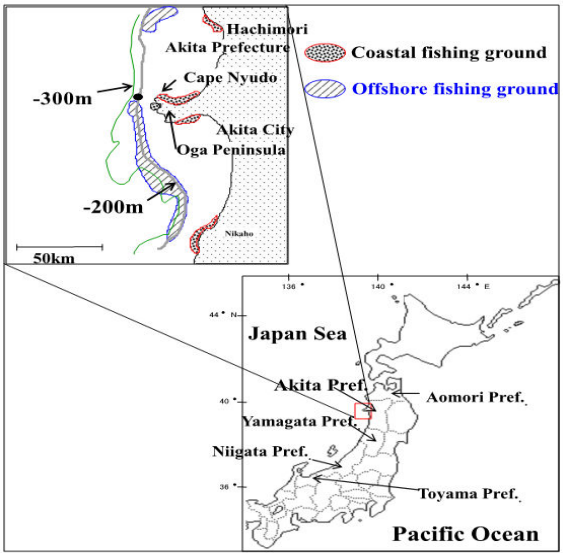
waters in December for spawning. Therefore, the fishing season is highly dependent on the spawning behaviour of the fish. The mid-season coastal fisheries are limited to 10 days in December (Sugiyama 1992).

Fig. 1. Location of Aomori, Akita, Yamagata, Niigata, and Toyama prefectures, and the fishing grounds in the offshore and coastal waters off Akita Prefecture (modified from Sakuramoto et al. 2001).



The sailfin sandfish catch from the coastal waters off Akita Prefecture fluctuated greatly during the period from the 1960s to the 1980s (Fig. 2) (Sugiyama 1988, 1992b). The catch increased markedly each year throughout the 1960s, but then decreased dramatically in the mid-1970s. In 1991, the stock was considered to be heavily depleted, with a catch of only 70 tonnes (Sugiyama 1990). Following this collapse, the Akita Prefectural Fisheries Promotion Center (FPC), which is the fisheries experimental station belonging to the Government of Akita Prefecture, recommended closing the fishery for 3 years from September 1, 1992, to September 30, 1995, in an attempt to rehabilitate the stocks.

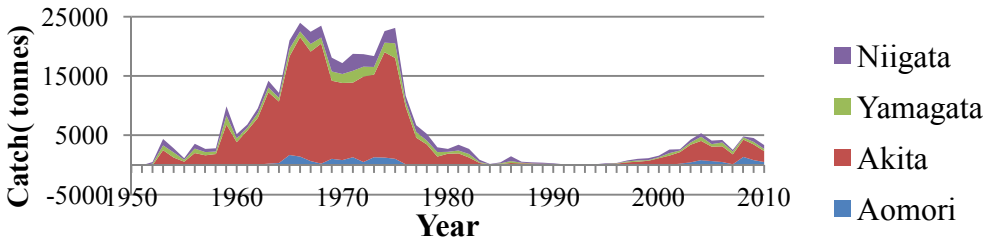


Fig. 2. Trajectories of sandfish catches in Aomori, Akita, Yamagata and Niigata prefectures.

The objective of this study was to determine the biological and socioeconomic factors that facilitated the successful 3-year closure. The information on the successful management strategies could be applied by other fisheries managers in their stock recovery programmes.

Biological characteristics of the stock

The sandfish in the Sea of Japan are divided into two stocks: the Northern Sea of Japan stock and the Korean Peninsula stock (Sugiyama 1988; Watanabe et al. 2004; Watanabe et al. 2005, 2011). The former stock migrates through the coastal waters off Aomori, Akita, Yamagata, and Niigata prefectures and returns to spawn in the coastal areas of Akita Prefecture (Fig. 1) (Sugiyama 1991).

The age of sandfish mainly targeted is 1–3 years (Sugiyama 1990). Female sandfish mature at 2 years and between 600 and 2,500 eggs are spawned, with an average of approximately 1,100 (Sugiyama 1988). The spawning season of the sandfish is short, extending from late November to December. Their spawning areas are limited to seaweed beds at a depth of approximately 2 m (Sugiyama 1992).

Materials and Methods

Information from several data sources were used to investigate the reason for the collapse of the sandfish fisheries. These data included: (1) the offshore and coastal sandfish catches (by weight) in Akita, and the ratio of sandfish landings (by weight) in Akita Prefecture to the total landings in the prefecture from 1952 to the present (Akita Prefecture 2011); (2) the monetary

value of the sandfish landings in Akita Prefecture from 1965 to the present (Akita Prefecture 2011); and (3) the number of eggs according to body length based on the survey conducted by the FPC in Akita Prefecture and the number of fry artificially hatched and released, the data for which was available for Akita Prefecture since 1984 (Sugiyama 1988).

After analysing the data and understanding the reasons for the collapse of the sandfish fisheries, subsequent management strategies were implemented to rehabilitate the sandfish fisheries management in Akita Prefecture.

Results and Discussion

Signs of overfishing

Figure 2 shows the trajectory of sandfish catches in Akita, Aomori, Yamagata, and Niigata prefectures in Japan since 1952 (Government of Japan 2012). This trajectory shows that the catch fluctuated significantly during this period. From the 1980s, there were several signs that overfishing was occurring (Sugiyama 1990; 2012).

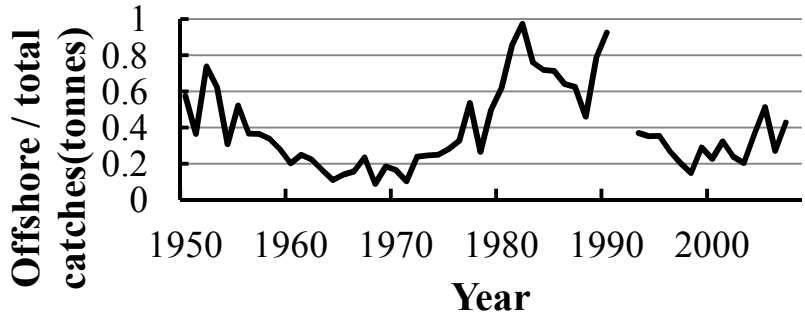


Fig. 3. Trajectories of the proportions of the total catches harvested by the offshore fisheries (modified from Akita Prefecture 2011).

Figure 3 shows the ratios of the catch harvested by the offshore fisheries to the total catch (offshore and coastal catches). Between the mid-1960s and the mid-1970s, when the total catch in Akita Prefecture exceeded approximately 10,000 tonnes (see Fig. 2), the proportion of the

catch from offshore fisheries was low, at about 20% (Fig. 3). After 1983, when the catch was heavily depleted, the ratio of the offshore catch to the total catch increased significantly (Sugiyama 1998, 2012). This means that many premature fish were being harvested in the offshore waters before they came to the coastal areas to spawn.

Recognition for the need of fisheries regulation

Figure 4 shows the monetary values of the sandfish catches in Akita Prefecture and the ratio of the monetary value of the sandfish catch to the total catch from all the fisheries in Akita Prefecture. When the catch was high from the mid-1970s to the early 1980s, the ratio of the monetary value of the sandfish catch to the total catch was also high. However, after the mid-1980s, the ratio decreased and accounted for only approximately 5% of the total yield, then valued at around 500 million yen (65,000 USD). This was one of the key economic factors that caused the sandfish fishermen to agree to the 3-year closure.

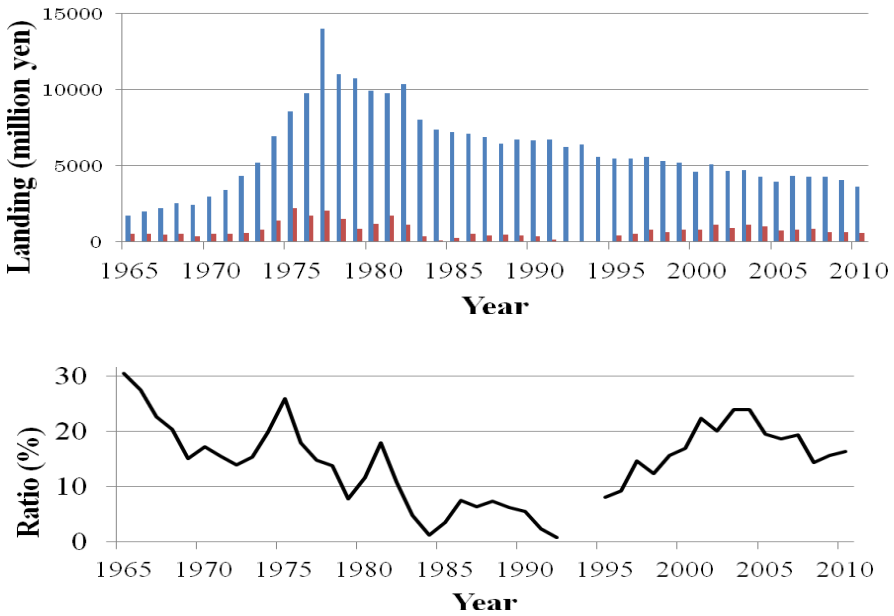


Fig. 4. Trajectories of the money obtained from the sandfish catches (red bar) and from the total catches (blue bar) in Akita Prefecture (top), and the ratio of the sandfish catch to the total landings (bottom; modified from Akita Prefecture 2011)

It was important to get the fishermen to cooperate in implementing the new regulations. To this end, the FPC and the Fisheries Division of the Government of Akita Prefecture surveyed and got a feedback on the opinion of the fishermen regarding the current status of the sandfish resource and the procedures or regulations that should be implemented to rehabilitate the resource. Table 1 shows some of the results of this survey. Nearly all the fishermen noted that the sandfish stocks had been heavily depleted and agreed that regulations should be imposed to rehabilitate the resource. The information obtained from the survey was important for scientists and the Government of Akita Prefecture because it confirmed that the fishermen understood that the resource had been heavily depleted and that some form of fisheries regulation was now necessary.

Table 1. Example of the results of the attitude survey.

Two hundred thirty-seven questionnaire recoveries were returned (multiple choices allowed)	
(1) Why had the sandfish stock depleted?	
a. Change of environmental conditions	53%
b. Decrease in seaweed beds	40%
c. Overfishing	39%
d. Water pollution	33%
(2) Is it necessary to rehabilitate the stock abundance	
a. Necessary, but no obligation for fishers	64%
b. Fishers should do something	36%
c. No need	2%
(3) What procedures should we apply to rehabilitate the stock abundance?	
a. Release fry artificially hatched	46%
b. Regulation for fisheries	32%
c. Construction of artificial seaweed	32%
d. Government and research institute should do something	20%

Procedures executed by the FPC before the fisheries closure

In addition to surveying the fishermen in Akita Prefecture, the FPC and the Fisheries Division of the Government of Akita Prefecture held several meetings with the fishermen, particularly in 1992, near the time of the fisheries closure. Several meetings were also attended by the Heads of the Fisheries Cooperatives and the Board of Directors of the Federation of Akita Fisheries Cooperatives. A series of meetings with fishermen who belonged to the local fisheries cooperatives were also held to discuss the feasibility and effectiveness of various types of management including the complete closure of the fishery. The FPC explained the current status of the stock and possible reasons for its depletion, and described the expected effects of the closure.

All these efforts focused on the implementation of a 3-year sandfish fisheries closure. In total, nearly 50 meetings were held before the sandfish fisheries closure, and during the last meeting on October 1, 1992, the Sandfish Stock Management Agreement was adopted by the presidents of all the Fisheries Cooperation Associations (FCAs). The FCA is the fishermen's union, but in Japan, the FCA is entrusted with the regulation of fish resources management under the Fishery Cooperative Act. The point of agreement was a 3-year complete closure of the sandfish fisheries off the coast of Akita Prefecture, and included harsh penalties, including the confiscation of fishing gear, for any operation that violated the agreement.

Procedures executed by the FPC and the Fisheries Division of the Government of Akita Prefecture during the fisheries closure

During the closure, an enormous effort was made to establish and implement an appropriate management plan after the fisheries were reopened. In 1993, the Sandfish Stock Management Council (SSMC) was formed, with 35 well-informed individuals who belonged to the FCAs. The SSMC consisted of four committees: 1) the Offshore Committee (24 persons); 2) Coastal Committee (33 persons); 3) Stock Enhancement Committee (13 persons); and 4) Marketing Committee (23 persons) (Fig. 5). Each committee had an area subcommittee,

comprised of all the fishermen belonging to each type of fishery. In total, 147 meetings were held from October 1992 to August 1995.

Under the auspices of SSMC, all conflicts among the different types of fishermen were first discussed by the members, to resolve solutions within each type of fishery. They then sought a consensus among the different types of fisheries in meetings attended by all the fishermen.

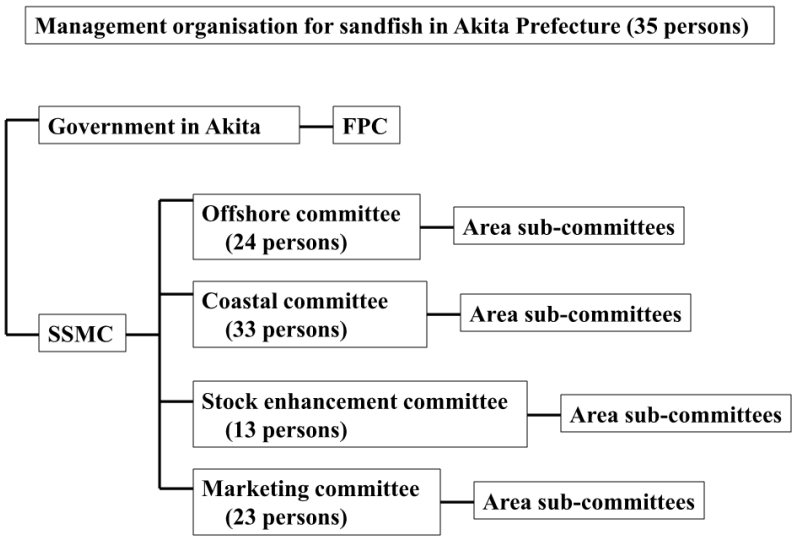


Fig. 5. The Sandfish Stock Management Council (SSMC) comprised 35 well-informed individuals.

Establishment of management plans I and II

After the fisheries was reopened, a meeting of the presidents of all FCAs instituted the Sandfish Stock Management Plan I, which was based on "input control", and mainly related to the reduction of the fishing effort. (Sugiyama 1998). The Management Plan I introduced the size limits for landings of all the fisheries (e.g., bottom trawlers were prohibited from catching fish less than 15 cm long). They also decided that the closed season should be extended from 2-6 months (i.e., the months of March and May–September were selected for closure).

A meeting of the presidents of all FCAs introduced protected areas in the coastal fisheries and closure dates to preserve the spawning areas and the migratory routes for spawning. The mesh size and height of the gill-net was regulated to reduce the fishing effort in all types of fisheries which also included the reduction of 33% of vessels from the trawl fisheries, 20% of set nets, and 40% of gill nets.

The Government of Akita Prefecture proposed the Sandfish Stock Management Plan II, which recommended a TAC system for the fisheries. This TAC is determined by the Government of Akita Prefecture, i.e., it is operated independently of the Government of Japan. The TAC was determined using a fishing rate of 0.5 (i.e., half the targeted stock would remain uncaught to ensure the conservation and sustainability of the stock, whereas the other half would be allocated as the TAC). The FPC proposed the TAC to the SSMC and the SSMC discussed and accepted it. The period of operation was from September to August of the following year, excluding the closed season. After the SSMC approval , TACs were allocated to each coastal and offshore fishery. TACs were further allocated to the FCA of each coastal and offshore fishery (Table 2) and each FCA to determine how to use the allocated TAC. Some divided the TAC by the number of fishermen, which provided an 'individual quota', and some FCAs applied a simple TAC system that allowed free harvest until the catch reached the allocated TAC. These fisheries were managed in two ways: with input control using Plan I and with output control using Plan II.

Table 2. Allocation of TAC into each FAC and allocation of TAC within FAC.

Allocation of TAC into each FCA			
Offshore fisheries（3FCAs）		Coastal fisheries（12FCAs）	
Uniform allotment	10%	Uniform allotment	10%
Past catch records	45%	Past catch records	90%
allotment by number of vessels	45%		
Allocation of TAC within FCA			
Offshore fisheries（3FCAs）		Coastal fisheries（12FCAs）	
Individual vessel quota		Individual vessel quota	
Co-operation		Co-operation	
		Olympic	
		Individual zone quota	
		Individual zone quota and Individual vessel quota	

Procedures executed by FPC after fisheries closure

After the fisheries closure, more than 40 meetings were held to discuss additional aspects of the management plan. As explained earlier, the targeted stock of the Northern Sea of Japan was widely and predominantly distributed off the coasts of four prefectures (Aomori, Akita, Yamagata, and Niigata) on the Sea of Japan (Sugiyama 1990). Akita was the only prefecture of these four to implement the fisheries regulations for sandfish. Considering this, in 1993, the Fisheries Agency of Japan established a consultative body of the prefectures concerned, called the Four Prefectures Council. In 1999, after 13 consecutive meetings on size limitations, the council adopted the Northern Sea of Japan Sandfish Stock Management Agreement, which prohibited catching fish less than 15 cm long.

Stock enhancement

Stock enhancement is another aspect of fisheries management. Sandfish spawn on the stalks of gulfweed (*Sargassum* spp.) and the spawning areas are very limited (Sugiyama 1988). Recently, a reduction in seaweed beds caused the destruction of the spawning areas in response to, for instance, land reclamation. To enhance the sandfish stock, the Government of Akita Prefecture conducted surveys of the seaweed beds in the spawning areas from 1993 to 1996. On the basis of these surveys, it developed 1.3 ha of artificial seaweed beds. These newly developed seaweed beds were then used by spawning sandfish.

To further enhance the stocks, juveniles were also released from sandfish farms. The FPC initiated the production of sandfish juveniles in 1983 and has been producing sandfish ever since in collaboration with the Fisheries Research Agency of Japan.

The number of juveniles released up until 2004 is estimated to have been 3-5 million (Fig. 6). The rapid increase in 1994 resulted from technical advances, including the use of cage culture to grow juveniles to the appropriate size for release.

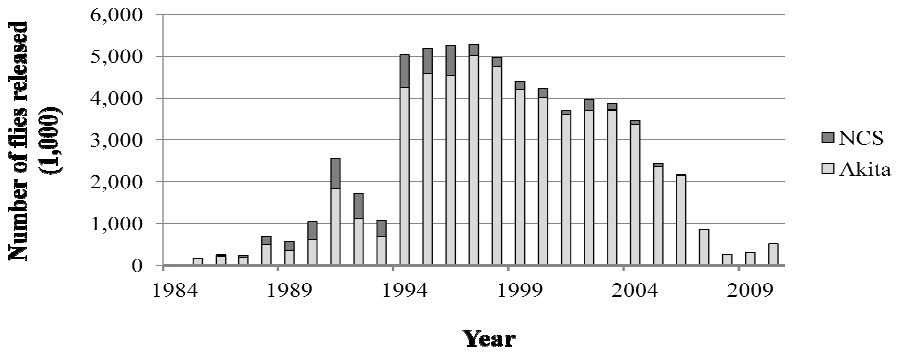


Fig. 6. The number of juveniles hatched in and released from sandfish farms (modified from Akita Prefecture 2011).

Effect of the fisheries closure

With these stock management and stock enhancement efforts, sandfish catches increased (Fig. 7). The catch in 2002 was about 30 times greater than that in 1991 (Sugiyama 2012). Although the catch exceeded the TAC in some years, there was no penalty because these excesses occurred in response to the biological characteristics of the fish. Essentially, large numbers of fish are now coming to spawn in the coastal shallow waters in a short period of time, which results in competition between the coastal and offshore fisheries.

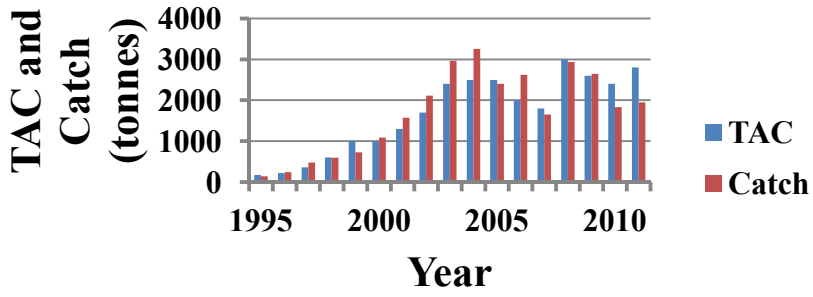


Fig. 7. TAC (tonnes) and the actual sandfish catch (tonnes) in Akita Prefecture (modified from Akita Prefecture, 2011)

Problems that emerged after the closure

Marketing was another important issue. Figure 8 shows the relationship between the unit price (Fig. 8a) and the total value (Fig. 8b) of the sandfish against the number of sandfish landings in Akita. The reduction in the unit price was very steep as the catches increased. The

unit price also changed greatly from year to year. For instance, the number of landings in 1965 and 1975 were almost the same, but the unit price was 1,300 yen·kg^{-1} (16.9 USD·kg^{-1}) in 1975 and 320 yen·kg^{-1} (4.2 USD·kg^{-1}) in 1965, so the values of the catches in those 2 years were quite different. Therefore, developing a marketing strategy that determines the price of the sandfish is also a very important issue from a socioeconomic point of view and to ensure equitable economic returns for the fishermen.

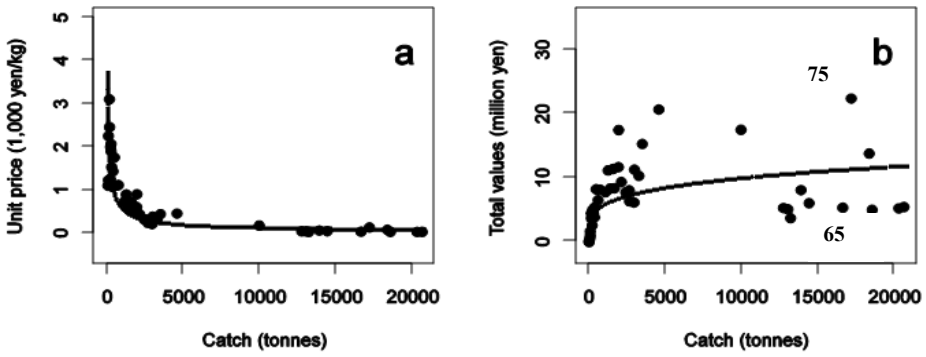


Fig. 8. Relationship between unit price (a) and total value (b) of sandfish against sandfish landings in Akita Prefecture (modified from Akita Prefecture 2011). Unit price = 3.807*catch$^{-0.755}$ (R^2=0.827).

Conclusion

The study indicated that the following factors played a vital role in the successful recovery of the collapsed sandfish fisheries: (1) a reliable leader was able to pull together all sandfish fishers into a collective entity; (2) opportunity costs to sandfish fishers were already low, and subsequently the closure had little impact on existing incomes from this fishery; (3) consensus amongst sandfish fishers; and (4) scientific advice based on available data used as indicators of the current status of sandfish stock and subsequent stock recovery.

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References

Akita Prefecture Division of Aquaculture, Forestry and Fisheries, Section Fishing port and ground. 2011. Outline of fisheries installations in Akita Prefecture in fiscal 2011. Akita, 111 pp.

Government of Japan. 2012. http://www.estat.go.jp/SG1/estat/List.do?lid=000001061498**.** **(**Accessed August 8, 2012).

Sugiyama, H. 1988. The study on reproductive characteristics of sailfin sandfish. Report of Sandfish Research Council 2:32-39 (in Japanese).

Sugiyama, H. 1990. Tendency of sandfish catch in the waters of northern Sea of Japan. Bulletin of the Japanese Society of Fisheries Oceanography 54:457-461.

Sugiyama, H. 1991. Construction of fishing ground for sandfish in the waters Northern Sea of Japan. Report of Experimental Research in the Sea of Japan 21:67-76 (in Japanese).

Sugiyama, H. 1992. Spawning ecology of sandfish in Oga Peninsula – time in hatching and amount of eggs. Report of the Section of bottom fish fisheries in Northern Japan. 25:11-25 (in Japanese).

Sugiyama, H. 1998. Fishery management for sandfish in Akita. Journal of North Japan Fisheries Economics Society 26:9-14 (in Japanese).

Sugiyama, H. 2012. Fishery management for sandfish in Akita. In: Fisheries handbook completely revised (eds. K. Shima, F. Seki, M. Maeda, S. Kimura, H. Saeki, K. Sakuramoto, Y. Suenaga, A. Nagano, T. Morinaga, N. Yagi and H. Yamanaka). Kohdansya, Tokyo, pp137-138 (in Japanese).

Watanabe, K. 2004. A study on dynamics and management of sandfish stocks *Arctoscopus japonicus* in the waters around Japan. PhD dissertation, Tokyo University of Fisheries, Tokyo. 128 pp.

Watanabe, K., H. Sugiyama, S. Sugishita, N. Suzuki and K. Sakuramoto. 2004. Estimation of distribution boundary between two sandfish *Arctoscopus japonicus* stocks in the Sea of Japan off Honshu, Japan using density indices. Bulletin of the Japanese Society of Fisheries Oceanography 68:27-35.

Watanabe, K., K. Sakuramoto, H. Sugiyama, S. Sugishita, and N. Suzuki. 2005. Estimating and monitoring the stock size of sandfish *Arctoscopus japonicus* in the northern Sea of Japan. Fisheries Science 71:776-783.

Watanabe, K., K. Sakuramoto, H. Sugiyama and N. Suzuki. 2011. Dynamics of two sailfin sandfish (*Arctoscopus japonicus*) stocks in the Sea of Japan, and their management. Canadian Journal of Fisheries and Aquatic Sciences 68:458-468.

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