Changes in Fishes Caught by Set Net Fishery Observed by Taxonomic Distinctness: Preliminary Study Using the Set Net Data on Futaoi Island, Simonoseki, Japan

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Abstract

This study examined the fishes caught by set net fishery on Futaoi Island, Shimonoseki, Japan in 2002, 2003, 2012 and 2013 and attempted to show the diversity of the fishes caught by the level of their taxonomic diversity. The number of fish species caught in the four years was 80.3±2.1 on average (Maximum in 2012 and 2013 with 82 species and minimum in 2003 with 79 species). The average landed quantity was 17857.3±1609.2 boxes (Maximum in 2013 with 19,249 boxes and were minimum in 2012 with 15,931 boxes). The distinctness index Δ* when the number of boxes was used instead of the number of individuals was 4.10±0.15 on average (Maximum in 2013 with 4.26 and minimum in 2012 with 3.93). If it is possible to calculate the number of individuals based on the number of boxes, it will be possible to show the distinctness index Δ* more precisely.

1 Introduction

Set net fishery is a passive fishing method where fishers form a cubic shape in the seawater with a set net for a certain period of time and wait fishes to visit and catch in the net, and the capacity of the fishing gear especially required in this fishery is the one to keep the shape of the net (net gear geometry) in the tide [1]. The set net has three parts, i.e., the bag net, the impounding net and the leader net in general. But some nets are composed of two parts only, the bag net serving as the impounding net, too, and the leader net, or four parts, that is, the bag net divided into the fish court and the slope net, the bag net and the leader net.

In the most of set net fishery, a long net known as leader net is set from the seashore toward the offing and shuts off the sea area from its surface to its bottom. Therefore, fishes that are migrating along the seashore hit this net and change their course; they are guided along the leader net in the direction of the offing and finally fall into the entrance to the impounding net or the entrance to the bag net located at the end of the leader net. This is the structure of the set net. Because the set net is laid at an appropriate place for a long period of time according to the migration of fishes, the net is securely fixed with anchors, sandbags, etc [2].

The mouth of the set net is always opened, and shoals have always the chance to enter the net. Hauling work is usually carried out once a day and at the fixed time. The time of hauling is determined depending on the opening time of the market or the collecting and shipping time of fishes caught and is mostly early morning before sunrise [1)]. Set net fishery is characterized by the fact that it is more passive than other fishing methods and that the fishing grounds are fixed. In addition, this fishing method has no feeding selectivity and is one of the fishing methods where it can be expected to catch a wide variety of fish species.

This study attempted to show the diversity of landed quantity by set net fishing on Futaoi Island, Shimonoseki, Yamaguchi Prefecture, by the taxonomic distinctness index. In addition, the author discussed the problems of using this index as a method of assessing the situation of fishing environments around the island.

2 Materials and methods

This study used the data recorded in the catch slips of set net fishery of the Futaoi Island Branch of the Yamaguchi Prefectural Fishers' Cooperative Association. Futaoi Island is located in the Sea of Nada in the western part of Shimonoseki, Yamaguchi Prefecture (lat. 34° 06'13.5 N. and long. 130° 47'12.5 E). The author read the fish species and the number of boxes for each day stated in the catch slips in 2002 and 2003 and in 2012 and 2013, ten years after, and prepared a database of landed quantity.

As an indicator showing the diversity of landed quantity, taxonomic distinctness was used [3]. Taxonomic distinctness defines the taxonomic distance ω_{ij} between the i th species and the j th species as follows: if the i th species and the j th species belong to the same species, the distance is 0, if they are different in species but belong to the same genus, the distance is 1, if they are different in genus but belong to the same family, the distance is 2, and so on. To sum up, the ωij (taxonomical distance) is 1 for the fishes belonging to different species but to the same genus, 2 for those belonging to different genera but to the same family, 3 for those belonging to different families but to the same order, 4 for those belonging to the different orders but to the same class, 5 for those belonging to different classes but to the same phylum and 6 for those belonging to different phyla but to different kingdom. This study used the method known as Δ^*, one of the taxonomic distinctness indexes. The equation is as shown below:

$$\Delta^* = \sum_{i=1}^{S}\sum_{j>i}^{S} \omega ij \cdot ni \cdot nj / \sum_{i=1}^{S}\sum_{j>i}^{S} ni \cdot nj \qquad (1)$$

$$i \geq j, \qquad 0 \leq \Delta^* \leq \mathrm{L}-1$$

Where S: total number of species;
ωij: taxonomic distance between the ith species and the jth species;
ni: no. of individuals of the ith species;
nj: no. of individuals of the jth species; and
L: no. of the taxonomic hierarches used

In this study, the number of boxes was used instead of the number of individuals.

3 Results

The average number of fish species caught in the four years, i.e., 2002, 2003, 2012 and 2013, was 80.3±2.1 (average ± standard deviation). The number of species caught was the largest in 2012 and 2013 with 82 species and was the smallest in 2003 with 79 species (Table 1). The landed quantity (in terms of the number of boxes) were 17,857.3±1,609.2 boxes on average; they were the largest in 2013 with 19,249 boxes and the smallest in 2012 with 15,931 boxes (Table 1). The composition of main fishes caught differed from year to year (Figs. 1- 4). The distinctness index of the fishes caught was 4.10±0.15; the index was the highest in 2013 with 4.26 and the lowest in 2012 with 3.93.

4 Discussion

This study paid attention to the characteristics of set net fishery where it can be expected to catch a great variety of fishes, instead of focusing on specified fish species, and attempted to show changes in catches by distinctness indexes. Distinctness indexes are the indexes for showing how many diverse species of life live in the area investigated. Main distinctness indexes include λ (Simpson) and H' (Shannon-Wiener), but the author adopted the taxonomic distinctness index where taxonomic information is incorporated into the assessment of distinctness. In the distinctness index, in Case A where Japanese jack mackerel (*Trachurus japonicus*) and Japanese amberjack (*Seriola quinqueradiata*) are caught and in Case B where Japanese jack mackerel and bastard halibut (Paralichthys olivaceus) are caught, it is considered that Case A and B have different taxonomic distances. Because the number of species is two and the same in both cases but Japanese jack mackerel and Japanese amberjack belong to different genera and to the same family in Case A and Japanese jack mackerel and bastard halibut belong to different orders but to the same class in Case B. While the methods of λ (Simpson), H' (Shannon-Wiener), etc. regard the distinctness in Cases A and B as the same, the taxonomic distinctness index estimates that Cases A and B have different distinctnesses and that Case B has more distinctness than Case A.

In the four years when the catches of set net fishery on Futaoi Island were examined in this study, the number of species was the most in 2012 and 2013. However, the value of taxonomic distinctness was the lowest in 2012 and the highest in 2013. This is partly because the total catches (number of boxes) were the largest in 2013 and the smallest in 2012, but it is supposed that there was also the influence of taxonomic distances. In 2013, the top three fishes caught (in terms of the number of boxes) were filefishes (Monacanthidae) and squids (Cephalopoda) whose taxonomic distance is great (Fig. 4). On the other hand, in 2012, the top two fishes caught (in the number of boxes) were those of Carangidae whose taxonomic distance is small, while the haul of Cephalopoda, whose taxonomic distance from the top two fishes is great, was poorer than that in 2013 (Fig. 3). In 2002, the number of species and total catches (in the number of boxes) of fishes both ranked third; the top species was Japanese jack mackerel, the second one was bigfin reef squid (*Sepioteuthis lessoniana*) and the third one was red barracuda (*Sphyraena pingiuis*) (Fig. 1), whose taxonomic distance is great. This is probably the reason why the taxonomic distance in 2002 was the second largest. In 2003, while the number of species caught was the smallest, the total haul (in the number of boxes) ranked second. Moreover, Japanese jack mackerel had the largest catches, followed by swordtip squid (*Uroteuthis edulis*) and skipjack (*Katsuwonus pelamis*) (Fig. 2), which have great taxonomic distances from one another. The reason that why the taxonomic distinctness in 2003 ranked third is probably due to that Japanese jack mackerel had a good catch in that year and that the number of boxes of this species accounted for nearly 40% of the total number of boxes affected the taxonomic distinctness.

In this study, no regular decrease or increase was observed in the distinctness of the hauls. From this fact it may be considered that the fishing grounds surveyed are stable. But to evaluate the stability of the fishing environment based on taxonomic distinctness, there will be the need to increase the number of the years for investigation and to use continuous data for calculation. It will also be necessary to refer to the information about such fishes as those smaller than the mesh size and those not caught because they have no market value. This study covered the set net fishery on Futaoi Island only, and there will be the need to increase the areas for investigation and to compare set net fishing with other fishing methods and to study if taxonomic distinctness indexes reflect the stability of fishing grounds considering the information on water temperatures, salinity and other ocean environmental factors and changes in the situation of plankton and other bait. In this study, it was difficult to convert the data of the number of boxes into that of the number of individuals and thus the calculation was made using the number of boxes as the minimum unit. The fact that the number of individual fishes caught in the box differs according to the fish species and changes according to the season, although the fish species contained in the box is the same one makes, it hard to estimate the number of individuals. If we are to use the taxonomic distinctness Δ^* in the future, one of the important problems will be to investigate the content of fish boxes in the market for each fish species and to make the number of individuals the minimum unit for calculation. If it is unable to do this, there will be the need to study the use of Δ^+, a simpler index of taxonomic distinctness for dealing with species presence data only[3].

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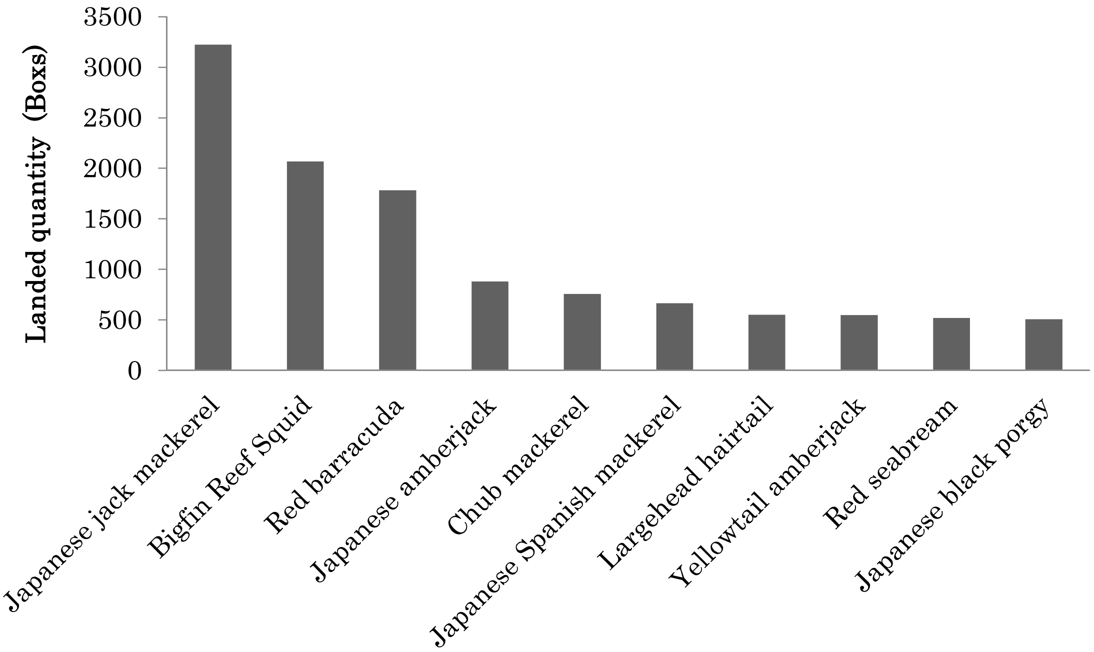

Fig. 1. Top ten fish species caught (the number of boxes) by set net fishery on Futaoi Island in 2002

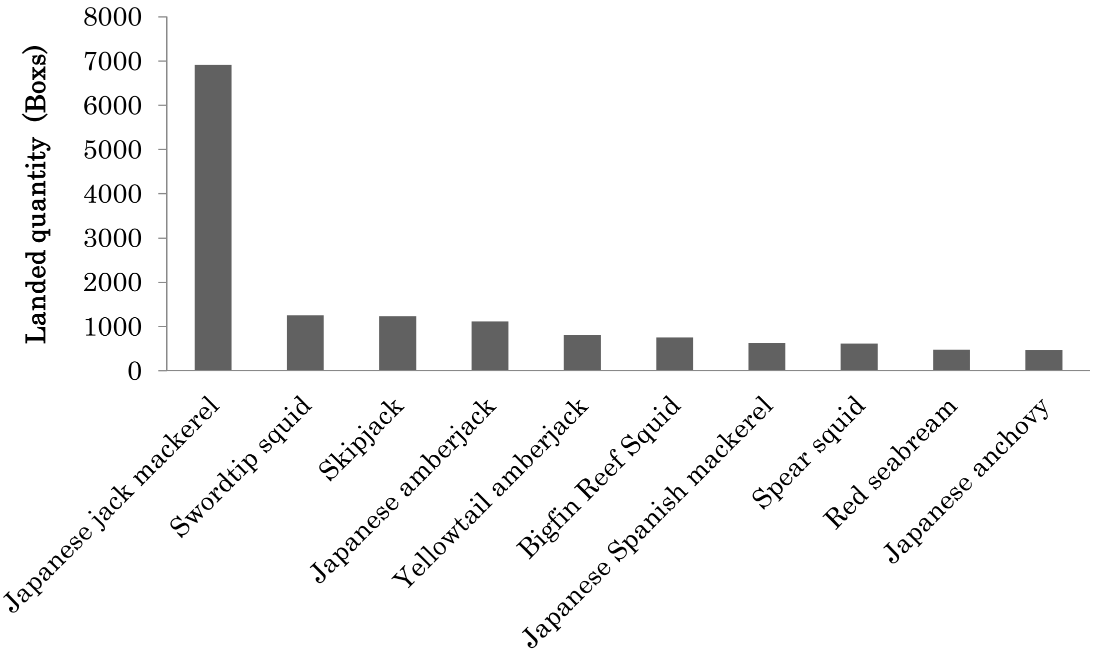

Fig. 2. Top ten fish species caught (the number of boxes) by set net fishery on Futaoi Island in 2003

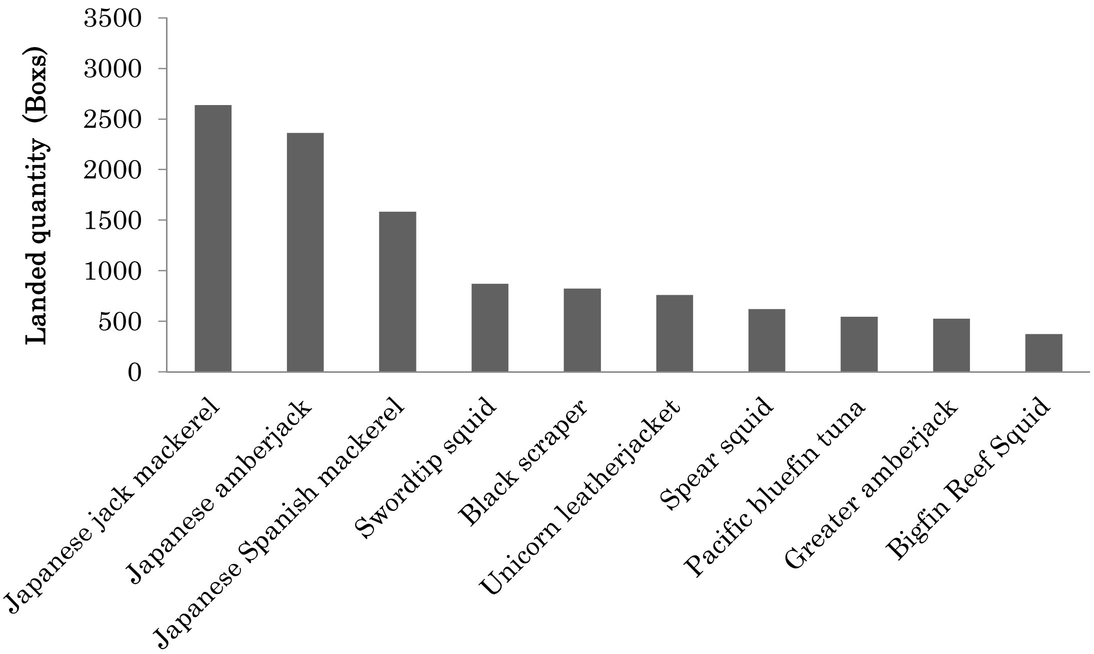

Fig. 3. Top ten fish species caught (the number of boxes) by set net fishery on Futaoi Island in 2012

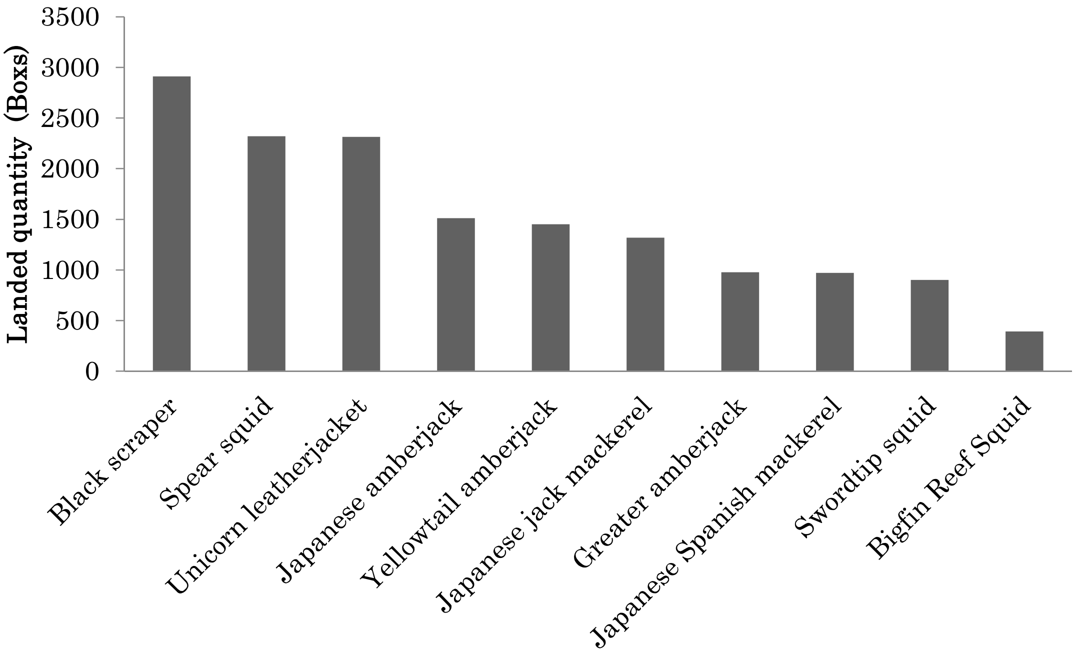

Fig. 4. Top ten fish species caught (the number of boxes) by set net fishery on Futaoi Island in 2013

Table 1. Taxonomic distinctness of catches by set net fishery on Futaoi Island

Year	No. of species	Catches (number of boxes)	No. of taxonomic hierarchies (L)	Δ^*
2002	79	17130	7	4.17
2003	78	19119	7	4.03
2012	82	15931	7	3.93
2013	82	19249	7	4.26