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Size Selectivity of Cod Hooks Used on a Longline for Walleye Pollock *Theragra chalcogramma*

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Abstract

Size selectivities of cod hooks used on an off-bottom longline for walleye pollock were estimated by simultaneously fishing with a small bottom trawl. Each unit of the longline consisted of 50 identical size cod hooks and 50 cm gangions attached to a 51 m main line at 1 m intervals. Three hook sizes were 5, 7 and 9 Gou. A total of 21 units (7 for each hook size) were used in a fishing trial. Rectangular pieces (1 by 3 cm) of Pacific saury were used as fishing bait. The fishing trial was carried out at Kojima Bank offshore of Matsumae, Hokkaido, on 5 December 1991. The trawl had a 2.9 m codend with a 43 mm inner net mesh size, and was towed parallel to the longline for 10 min. The maximum hooking rates of the 5 and 7 Gou hooks were both 0.047, and the maximum value of the 9 Gou hook was 0.020. The selectivity of the 5 Gou hook was unimodal and had a peak at about 435 mm total length (i.e., the optimum size). The selectivities of the 7 and 9 Gou hooks increased with increasing fish size and appear to peak at a size larger than 510 mm in total length.

Key words: Selectivity, Cod hook, Walleye pollock, Longline, Simultaneous fishing method, Trawl

Introduction

The longline fishery for walleye pollock (*Theragra chalcogramma*) is a major coastal fishery in Hiyama and Shiribeshi, Hokkaido. Fishermen use 7 Gou cod hooks on their longlines because they have concluded from their experiences that this is the most effective size. However, the size selectivity of cod hooks has not been examined in detail.

Size selectivities of hooks used on longlines have been investigated for several species, including cod (McCracken, 1963; Saetersdal, 1963), halibut (Myhre, 1969), and spiny goby (Takeuchi and Koike, 1969). A simultaneous fishing method, tagging experiment and Ishida's method were used in these studies to estimate size selectivity. When it is assumed that the size composition of the catch obtained by a trawl is representative of the stock, the size selectivity of a fishing gear can be directly estimated by simultaneously fishing with a trawl.

Shimizu (1998, 1999) estimated the size selectivities of cod hooks used on an off-bottom longline for walleye pollock by simultaneously fishing with a trawl and showed that the size selectivities increased with increasing fish size like the left part of a unimodal selectivity curve. The size selectivities of 5 and 7 Gou cod hooks were almost identical. In the same studies, the size selectivity curves of "sode"

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hooks for masu salmon were derived from a stochastic model of the hooking mechanism. These curves were unimodal. The results of these studies suggest that the size selectivity of 5 Gou cod hooks needs more consideration.

In the present paper, the size selectivities of cod hooks used on a longline for walleye pollock were re-estimated. Size selectivity of the cod hooks was discussed by comparing with the size selectivity of sode hooks derived from the stochastic model.

Methods

An off-bottom longline and a small otter trawl were used simultaneously to catch walleye pollock. The longline was composed of units called "hachi". Each hachi consisted of 50 identical size cod hooks and 50 cm gangions attached to a 51 m main line at 1 m intervals. The main line was made of vinylon (Japanese commercial name "kuremona") string (ϕ2.3 mm, 2×2). The gangion was made of vinylon thread (ϕ0.78 mm, 3×3). Three hook sizes were used : 5 Gou (11.3 mm in width), 7 Gou (12.7 mm in width) and 9 Gou (16.0 mm in width). The fishing bait consisted of 1 by 3 cm rectangular pieces of frozen Pacific saury fillet. The size and shape of the cod hooks and bait are shown in Fig. 1. Figure 2 shows that the off-bottom longline consisted of 21 hachis, which included seven 3-hachi sections each consisting of every different hook size. A small float and an 800 gw sinker with a 40 m sinker line were attached on every joint of the hachis. The fishing trial was carried out aboard the research vessel "USHIO MARU", Faculty of Fisheries, Hokkaido University at Kojima Bank offshore of Matsumae, Hokkaido, on 5 December 1991. The longline was set at 9 : 00 hours and retrieved at 14 : 00 hours on the same day.

The otter trawl had 7 m wing nets, a 14.1 m body net and a 2.9 m codend, with mesh sizes of 60 mm in the outer net and 43 mm in the inner net. The trawl was towed parallel to the longline on the bottom for 10 min. The total lengths and body weights of fish caught were measured.

Size selectivities were obtained as described below. The subscript i refers to hook size, and the subscript j refers to the size class of fish. Let R_{ij} be the size composition of size class j caught by hook i, C_{ij} be the number of fish of size class

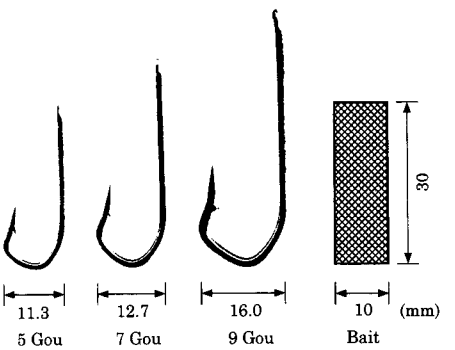

Fig. 1. Size and shape of each cod hook and the size of a piece of bait.

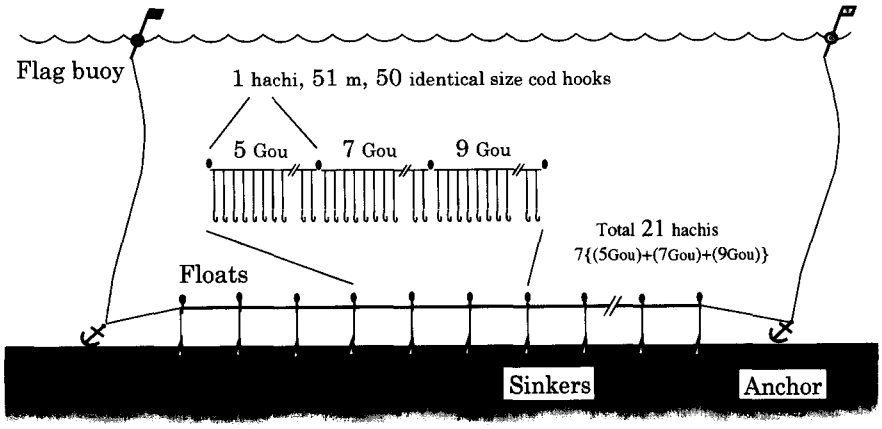

Fig. 2. Schematic drawing of the off-bottom longline.

j caught by hook i and $\max(C_{ij})$ be the maximum number of fish of size class in all of size classes caught by hook i. R_{ij} is expressed by the following equation:

$$R_{ij}=C_{ij}/\max(C_{ij}). \tag{1}$$

Hamley (1975) showed that C_{ij} can be calculated using the following equation:

$$C_{ij}=X_iS_{ij}N_j, \tag{2}$$

where X_i is fishing effort by hook i, S_{ij} is the selectivity of hook i to size class j, and N_j is the number of fish in the stock of size class j. Let $\max(N_j)$ be the maximum number of fish in the stock and R_{tj} be the size composition of size class j caught by the trawl. Dividing both sides of equation (2) by $\max(N_j)$ results in:

$$C_{ij}/\max(N_j)=X_iS_{ij}R_{tj}, \tag{3}$$

when it is assumed that the size composition of size class j of fish stock $N_j/\max(N_j)$ is equal to R_{tj}. Let $\max(N_j)$ be 1 to estimate the selectivity against a given unit of stock. By transforming equation (3), the selectivity can be obtained from the following expression:

$$S_{ij}=C_{ij}/X_i \cdot 1/R_{tj}. \tag{4}$$

Let H_{ij} be the hooking rate of hook i to size class j. When the total number of hooks i is adopted as the fishing effort X_i, H_{ij} is defined as:

$$H_{ij}=C_{ij}/X_i. \tag{5}$$

Results

A total of 97 walleye pollock were caught by the longline, and 270 were caught by the trawl. One hundred individuals were randomly sampled from the trawl catch for measurement. The size compositions of fish caught by each size hook and the trawl are shown by the 30 mm size class width in Fig. 3. Walleye pollock ranged in total length from 330 to 540 mm. The size compositions for each size hook and the trawl showed little difference, however more fish larger than 420 mm were

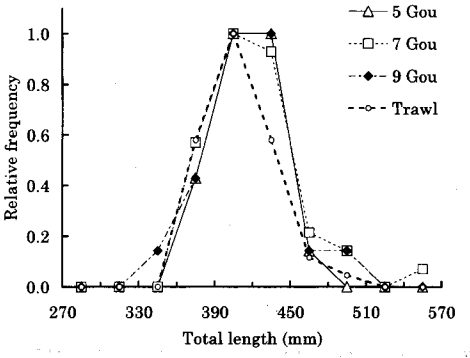

Fig. 3. Size composition of walleye pollock caught with each size of cod hook and trawl.

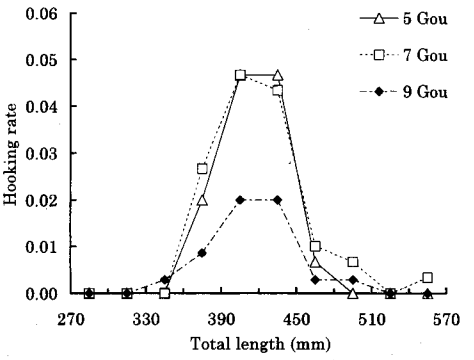

Fig. 4. Hooking rates of each size cod hook for each size class of fish.

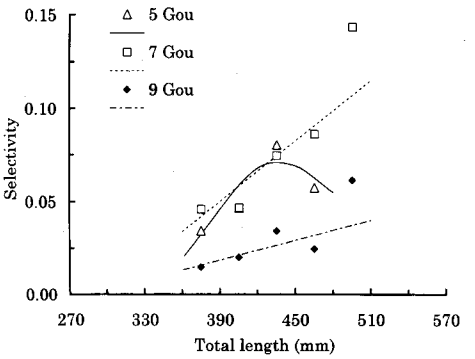

Fig. 5. Selectivities of each size cod hook for walleye pollock.
Marks, experimental values.

caught by the hooks than by the trawl. It appeared that the size composition caught by the trawl with codend mesh sizes of 60 mm in the outer net and 43 mm in the inner net was equal to that of the fish stock, because walleye pollock in total length from 330 to 540 mm was not able to pass through these sizes codend mesh.

The hooking rates of each size hook to size class of fish are shown in Fig. 4. The maximum hooking rates of the 5 and 7 Gou hooks were both 0.047, and the maximum value of the 9 Gou hook was 0.020. The selectivities for each hook size estimated from the above results are shown in Fig. 5. The selectivities were estimated within the total length range from 360 mm to 510 mm. The selectivities of the 5 and 7 Gou hooks to fish smaller than 450 mm in total length were similar, however, the selectivity of the 9 Gou hook was less than half of those of the 5 and 7 Gou hooks. The selectivity of the 5 Gou hook was unimodal and had a peak at about 435 mm total length (i.e., the optimum size). The selectivities of the 7 and 9 Gou hooks increased with increasing fish size. The optimum sizes for each of the hooks appear to be larger than 510 mm in total length.

Discussion

The size selectivity curves of hooks are unimodal, similar to those of the gillnets, but have wider selection ranges according to Pope et al. (1975). In previous papers (Shimizu, 1998 and 1999), the size selectivities of cod hooks increased with increasing fish size like the left part of a unimodal selectivity curve. And the selectivity of the 5 Gou hook appeared to be little lower than that of the 7 Gou hook. In the present paper, the size selectivities of the 7 and 9 Gou cod hooks appear to be the left part of the selectivity curve from the peak for each hook size, however the size selectivity of the 5 Gou hook appeared to be unimodal. In this case, the size selectivities of cod hooks are consistent with the property that optimum size increases as hook size increases. The selection ranges of cod hooks may be sufficiently wider spread than the total length range caught by each hook (330–540 mm).

Shimizu (1998, 1999) reported that the size selectivity curves of "sode" hooks for masu salmon derived from a stochastic model of the hooking mechanism were unimodal, and that as the hook size increased, the maximum value of the selectivity curve decreased and the fish size at which the selectivity curve peaked increased. If the selectivities of cod hooks have the same properties as the selectivities of sode hooks as above, the selectivity of the 5 Gou cod hook must become higher than that of the 7 Gou cod hook. But the selectivity of the 5 Gou cod hook was lower than that of the 7 Gou cod hook. It was assumed that the low selectivity of the 5 Gou cod hook was obtained to use the same bait size for all the hook sizes. As the bait was relatively large to the 5 Gou cod hook, as shown in Fig. 1, a baited 5 Gou cod hook might not easily enter the mouth. Further, if the hook point was easily covered by a large piece of bait, hooking could not occur easily. If a suitable size bait for the 5 Gou cod hook was used in the fishing trial, the selectivity of the 5 Gou cod hook became higher than that of the 7 Gou cod hook. Therefore, the peak of selectivities of cod hooks can become lower as the hook size increases.

In future studies, fishing trials will be carried out to catch a wide size range of walleye pollock and the effect of bait size will be examined to obtain more reliable selectivity curves. We will also try to estimate the selectivity by applying a stochastic model, such as was used for the sode hooks.

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