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White Patch on the Fore-Flipper of Common Minke Whale, as a Potential Morphological Index to Identify Stocks

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Abstract

Past studies have indicated that there are two different stocks (J and O stocks) in the North Pacific common minke whale *Balaenoptera acutorostrata* population. These two stocks differ from each other in certain characteristics, such as body size, conception dates, and genetics. However, till date, few studies have investigated differences in the external body appearance between the two stocks. Therefore, in the present study, we focused on the unique white patch on the flipper of this whale species to elucidate inter-stock differences. We used the animals collected from JARPNII research during 2012 and 2013; stock information was determined by microsatellite DNA analysis (n = 220). We focused on the morphological differences in the size and pattern of the white patch on the flipper of each whale. The length of the white patch along the anterior (ventral) margin of the flipper tends to be proportionally larger in O stock. The pattern of the boundary area of the white patch named as the "Grayish Accessary Layer (GAL)" was remarkably different between stocks. Within animals with "no GAL" type, 94% were J stock. Conversely, of animals with GAL expanding over the half the flipper width, 96% were O stock. We concluded from our study that there were clear morphological differences in the flipper color pattern between J and O stocks, which enable to apply widely to other individuals.

Keywords

Common Minke Whale, White Patch, External Morphology, Stock

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1. Introduction

The common minke whale *Balaenoptera acutorostrata* is the smallest species of the *Balaenoptera* whales. In the northern hemisphere, there are two distinguishable subspecies, one each in the North Pacific (*B. a. scammoni*) and North Atlantic (*B. a. acutorostrata*). In the southern hemisphere, there is another population, generally called as "dwarf" minke whales. They may provisionally be regarded as a racesubspecies of common minke whale, but their taxonomical status is not fixed yet due to the scanty data [1]. The notable feature of the common minke is the white patch in their flipper which is the unique character of this species. The size and the shape of the white patch differ between subspecies. Therefore, the white patch on the flipper may serve as a useful distinguishing characteristic for taxonomy classification purposes [2] [3].

Historically, this species have been regarded as an important resource worldwide. For the proper management of wild resources, stock-based management is important as well as species-based management. For the North Pacific common minke whales, the attempts to clarify the stock structure began in the 1950s. In the 1980s, it was suggested that there were two minke whale stocks in seas around Japan [4] comprising J stock which is mainly distributed from the Sea of Japan to the East China Sea, and O stock which is distributed from the Okhotsk Sea to the Western North Pacific. The two whale stocks share the same feeding ground and they are mixed in the Okhotsk Sea and Japanese coasts [5] [6].

Various aspects of the stock structure of the North Pacific minke whale population have been studied in-depth, including work on genetics [7]-[9], conception dates [10], and cookie cutter shark-induced scar marks [11]. Morphological studies comparing body length, body proportions, color patterns of the baleen plates, flippers and tail flukes have also been conducted [4] [10] [12] [13].

Among North Pacific common minke whales, it has been reported that the area ratio of the white patch on the flipper differs between J and O stocks [13]. Kanda *et al*. (2010) [13] suggested that the white patch length in proportion to the overall flipper length may differ; however, there was still no clear indicator to identify the two stocks. Therefore, we focused on the white patch of the flipper of the North Pacific minke whale in more detail. The aim of this study was to clarify the morphological differences between stocks so that a morphological index could be developed which would help to correctly identify whale stocks from their appearance.

2. Materials and Methods

2.1. Materials

The samples were collected during offshore and coastal (Sanriku and Kushiro) research of the Japanese Whale Research Program under Special Permit in the Western North Pacific-Phase II (commonly known as JARPNII) (**Figure 1**). The survey was conducted in accordance with the Article VIII of the International Convention for the

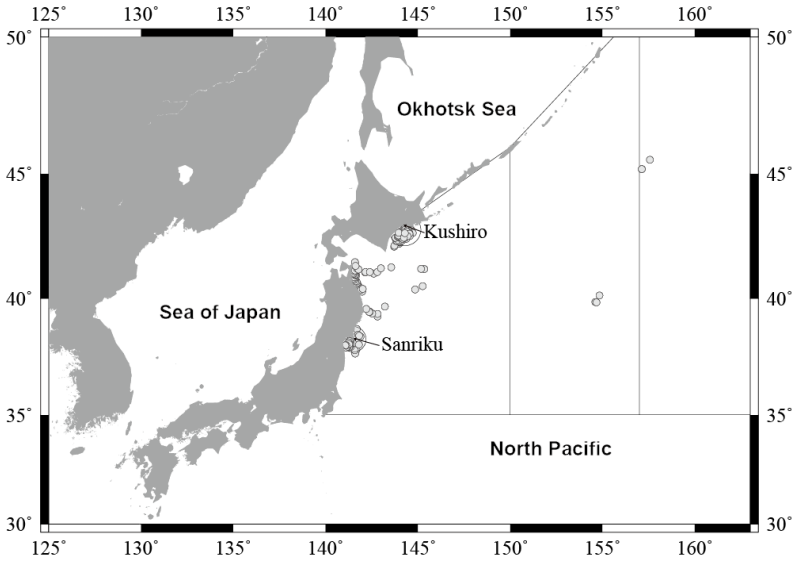

Figure 1. Research area (surrounded by line) and sampling location (circle).

Regulation of Whaling. The animals were identified and classified into either J or O stock using genetic analyses along with a combination of microsatellite and Bayesian clustering analyses following the methods of Kanda *et al*. (2009) [9]. We used the data collected from 2012 and 2013, because flipper measurements were taken in these two seasons. We conducted research on 220 animals (138 males, body length: 3.82 - 8.16 m; 82 females, body length: 4.06 - 8.68 m), which were assigned into the appropriate stock based on their high membership probability (>90%).

2.2. Measurement and Classification of the Flipper Types

In this study, we focused on the proportional size and boundary area pattern of the white patch on the flipper of each whale. We measured the following three flipper characteristics after the flipper was dissected from the ance from the tip of the flipper to the distal end of the white patch (Point A), and the tip to mesial end of the white patch (Point B) (**Figure 2**). These points were measured to millimeter scale accuracy using measuring tape or a stainless steel caliper. The boundary area pattern of the white patch named as "Grayish Accessary Layer (GAL)" were classified into groups, based on the criteria described below (**Figure 3**).

No GAL type: Animals with no grayish band near the boundary;
Type 1: With small GAL not fused to the other side;
Type 2: GAL is connected to the other side;
Type 3: GAL expands over the half-line of the flipper width.

2.3. Statistical Analysis

In the process of the statistical analysis, Mann-Whitney *U*-test was adopted to compare the proportional size of the white patch on the flipper and Pearson's chi-square test was adopted to compare the frequency of GAL types between two stocks. Each analysis were operated using the statistic software R 2.13.0.

3. Results

3.1. Proportional Size of the White Patch on the Flipper

The proportional length of Point A (distance from the tip of the flipper to the distal end of the white patch) to the

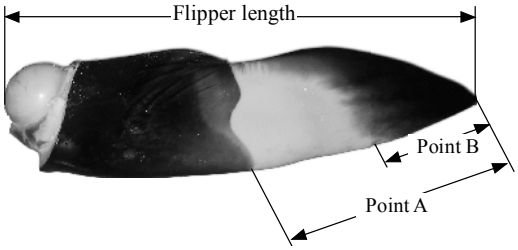

Figure 2. Measurement points on the flipper.

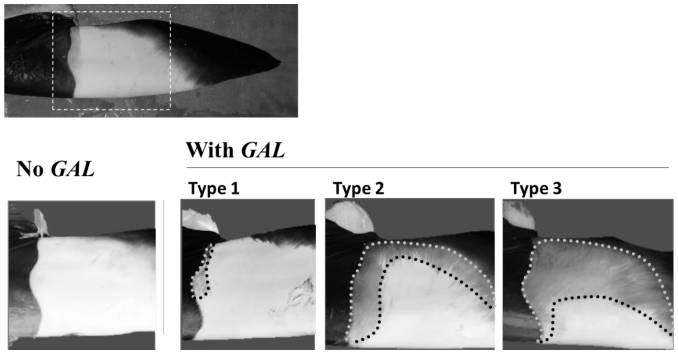

Figure 3. Basis for the classification based on the *GAL* types (*GAL*: surrounded by dotted line).

flipper length was 61.3% ± 4.7% (n = 47) and 63.8% ± 4.5% (n = 168) for J and O stocks, respectively. Although the values overlapped, the distal end of the white patch tends to be relatively far from the tip of flipper in O stocks compared with that in J stock whales (Mann-Whitney U-test, $p < 0.01$) (**Figure 4(a)**).

The proportional length of Point B (distance from the tip of the flipper to the mesial end of white patch) to the flipper length was 29.7 ± 4.5% (n = 49) and 30.3 ± 4.7% (n = 169) for J and O stocks, respectively. The values are quite similar between the two stocks, and therefore, no statistical differences were observed in this characteristic (Mann-Whitney U-test, $p > 0.05$) (**Figure 4(b)**).

3.2. Classification by GAL Type

The relationship between the type of stock and pattern of the boundary in the white patch (GAL) of individual whales was studied. More than 80% whales were categorized as Types 1 (n = 32) and 2 (n = 143) comprised both stocks. However, 94% of the "no GAL" type (n = 16) whales comprised J stock, and 96% of Type 3 (n = 27) whales comprised O stock (**Table 1**, **Figure 5**). The frequency of the J and O stocks was distinct among GAL types (Pearson's chi-square test, $p < 0.01$).

4. Discussion

The present study reported that the pattern of the white patch correlate well with genetics and this character would be help to identify stocks from external appearance. Previous studies mentioned the possibility that the pattern of the white patch on the flipper differs in these whales within as well as between particular oceans/seas, thus suggesting the possibility of inter-stock differences [3] [10] [14]. As indicated by these studies, definite morphological differences in the white patch of the flipper were observed between stocks.

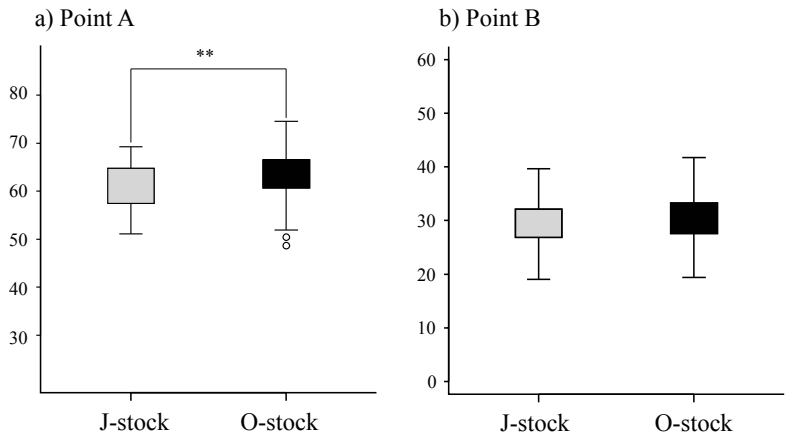

Figure 4. Proportional size of white patch in the flipper. a) The proportional length of Point A (the distance from the tip of the flipper to the distal end of white patch) to the flipper length; b) The proportional length of Point B (the distance from the tip of the flipper to the mesial end of white patch) to the flipper length. In Point A, proportional length was larger wain O stocks compared to J stock whales (Mann-Whitney U-test, $p < 0.01$).

Table 1. Number and proportion of each GAL types between J and O stocks.

	No GAL	With GAL			Total
		Type 1	Type 2	Type 3	
J stock	15 (93.8%)	7 (21.9%)	27 (18.9%)	1 (3.7%)	50
O stock	1 (6.3%)	25 (78.1%)	116 (81.1%)	26 (96.3%)	168
Total	16	32	143	27	218

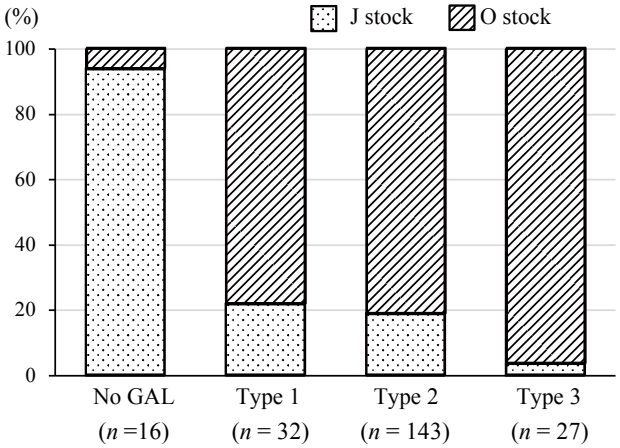

Figure 5. The relationships between stock and the pattern of the boundary in white patch (GAL).

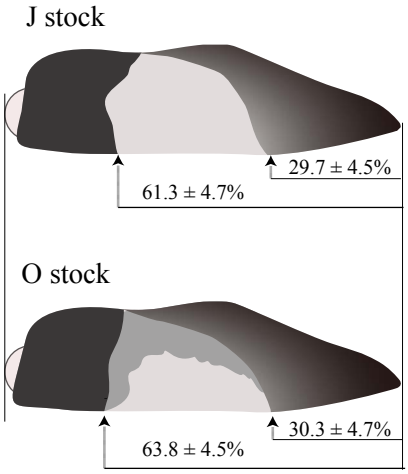

Figure 6. Typical diagram of the white patch of the flipper in J and O stocks.

The length of Point B was not significantly different between stocks, whereas the length of Point A was proportionally larger in O stock than in J stocks. This meant that the length of white patch along the anterior (ventral) margin of the flipper tends to be proportionally larger in O stocks. Statistical analyses also support these results. However, the range of the proportion are overlapped between stocks, and therefore, it would be difficult to classify whales into either stock with 100% accuracy based only on this characteristic. The GAL pattern was the clearest characteristic for stock identification. We were able to define separate stocks with high probability (>90%) when the target animal was "no GAL" type or "Type 3". These findings may help in the future development of a useful index to identify different North Pacific common minke whale stocks (**Figure 6**).

At present, the stock of each animals are identified by the combination method of microsatellite and Bayesian clustering analyses following the methods of Kanda *et al*. (2009) [9], as mentioned above. In this method, the database is required to identify stocks from the animals collected by stranding or biopsy sampling. However, if the flipper could be observed and its GAL type was "no GAL" or "Type 3", the stock is identified with high accuracy.

On the other hand, more than 80% of observed animals were classified into Type 1 (15%, n = 32) or 2 (66%, n = 143), and these were from both J and O stocks. For such animals, by combining other external characteristics, such as cookie cutter shark-induced scar marks and unsolved indicators that include body color pattern, the accuracy of whale stock identification in the ocean will be greatly improved and also would be able to clarify distribution areas of each stocks.

5. Conclusion

This study declared that white patch of the common minke whales was morphologically different between two stocks. The size of the white patch area relative to flipper area was not significantly different, however, the boundary area pattern of the white patch named as "Grayish Accessary Layer (GAL)" correlated highly with genetics. Using these characters, for the animal having typical character, it would be able to distinguish stocks only from its appearance.

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