 Discrimination of Morphological Differences of Walleye Pollock between Areas in the Bering Sea

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ABSTRACT

Discrimination by morphology was attempted for pollock samples on the continental shelf of the eastern Bering Sea, Aleutian Basin, and on the continental shelf of the western Bering Sea. For the discrimination, discriminant analysis used morphological values measured by the Truss Network Measurement method (Winans 1984) was introduced.

The analytical results showed discrimination at probabilities of 76% to 88% of pollock in the three areas, and that the samples from each area have different morphological characteristics. A comparison of similarities when judged by morphological differences using Maharlanobis' distance, showed that samples from the continental shelf of the eastern Bering Sea were close to samples from the Aleutian Basin, but the Aleutian Basin samples were separated from samples from the continental shelf of the western Bering Sea.
1. Introduction

There are some methods to discriminate fish stocks based on the morphological meristics, and biochemical differences. In the method based on morphological differences, an examination of statistical differences in relative growth was mainly used in the past. However, Winans (1984) showed that an effective method was one that treats by multivariate analysis measured values of morphological differences obtained by the Truss Network Measurement method (hereinafter referred to as TNM method), as used for determination of juvenile salmon origin. This method was applied to pollock and examined as to whether or not it can determine morphological differences by area, and its efficiency was demonstrated (Nitta and Sasaki 1990). Attempts were made to determine the morphological differences between pollock on the continental shelf of the eastern Bering Sea, in the Aleutian Basin and on the continental shelf of the western Bering Sea.

2. Materials and Methods

The TNM method grasps morphogenesis within consecutive cells from the head to the tail, treats four sides of each cell and a diagonal line as a statistic, and examines the morphological differences. As shown in Fig. 1, 19 points (8 cells and 43 distances in total) were set up for pollock (hereafter the distance between point 1 and point 2 is shown as point 1-2).

The samples used were from 3 areas:

<table>
<thead>
<tr>
<th>Area Caught</th>
<th>Date caught</th>
<th>Number in sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Bering Sea Continental Shelf</td>
<td>July to August, 1990</td>
<td>390 individuals</td>
</tr>
<tr>
<td>Aleutian Basin</td>
<td>August to September, 1990</td>
<td>292 individuals</td>
</tr>
<tr>
<td>Western Bering Sea Continental Shelf</td>
<td>June to July, 1990</td>
<td>398 individuals</td>
</tr>
</tbody>
</table>

Measurements were conducted by the following procedures

1. Thoroughly thawed samples were placed on measurement papers (Yupo paper 150µ).

2. Points for measurement were marked with a pin.

3. Coordinates of each point on the measurement paper were read by a digitizer.

4. The distances between points were calculated (43 in total).

Analyses were conducted by discriminant analysis.

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3. Results

The standard body lengths of individuals measured (points 2 - 19) indicated that they were small in the Aleutian Basin, and larger on the continental shelf of the western Bering Sea, as shown in Table 1.

They were not spawning season samples in all areas, and there were problems in assuming exactly indigenous groups in the three areas. Judging from past findings, there is a fair chance that fish from the Aleutian Basin are included in the small-sized fish samples collected on the continental shelf of the eastern Bering Sea. Therefore, for samples collected on the continental shelf of the eastern Bering Sea, only individuals more than 500mm in standard body length (106 individuals) were used, on the assumption that each area has an indigenous group, and proceeded with the following analyses.

Before the discriminant analyses were conducted, samples were examined to determine whether or not there were morphological differences in growth of body length in the samples in the same area. Frequency distributions of the ratio of 43 distances against standard body length (points 2-19) in each area were all unipeak-type, and variance was also small. From this it was estimated that there was no change in body shape in the body length range measured in each area and a discriminant analysis was made using the ratios of the standard body length.

The discriminant rates found for the continental shelf of the eastern Bering Sea and Aleutian Basin were 76%, for the continental shelf of the eastern Bering Sea and the continental shelf of western Bering Sea were 86%, and for the Aleutian Basin and the continental shelf of the western Bering Sea were 88%.

4. Consideration

Dawson (1989) applied the TNM method to juvenile pollock, in an attempt to discriminate samples from four areas on the continental shelf of the eastern Bering Sea and the Aleutian Basin, but the discriminant rates among the samples were low. As to reasons, he pointed out that some areas do not have any indigenous morphological characteristics, or if there are any characteristics, there are some possibilities that the samples from each are a mingled sample that originates from different areas.

However, in this study, it was shown that the discriminant rate was relatively high, and the samples from the three areas have respective indigenous characteristics. It is considered that as we analyzed only comparatively large-sized individuals which are regarded as participants in spawning, the possibility of mingling between different origin samples was low.

In addition, when the difference in similarity of morphogenesis was examined among the samples for each area based on the Maharlanobis' distance, it was greatest between samples from the Aleutian Basin and the continental
shelf of the western Bering Sea, followed by that between the continental shelf of the eastern Bering Sea and the continental shelf of the western Bering Sea, and there was most similarity between the continental shelf of the eastern Bering Sea and Aleutian Basin (Fig. 2).

From the above results, it was indicated that pollock in three areas of the Bering Sea have respective different morphological characteristics, and it is possible to discriminate between them with a high degree of probability. Morphological differences were small between samples from the continental shelf of the eastern Bering Sea and Aleutian Basin, and there is a possibility that samples from the continental shelf of the western Bering Sea were somewhat apart. Comprehensive analyses based on biochemical techniques etc. are required whether or not these results imply differences in stocks.

References, Tables 1, and Figs. 1 to 2 are in English in the Japanese document.
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この文書を引用する場合は下記による：
新田 朗・西村 明．1991．ペーリング海におけるスケトウダラの外部形態による海域識別について．7頁．(第38回 INPFC 定例年次会議提出文書．1991年10月．日本．東京)．水産庁．遠洋水産研究所．日本．〒424 清水市折戸5-7-1.
ベーリング海におけるスケトウダラの外部形態による海域識別について

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西村 明
（遠洋水産研究所）

要 旨

東部ベーリング海の大陵棚、アリューシャン海盆、及び西部ベーリング海の大陵棚で採集されたスケトウダラを用いて、外部形態による識別を試みた。識別方法としては、Truss Network Measurement法（Winans 1984）で測定した外部形態に関する測定値を判別分析で処理する方法を用いた。

解析の結果、3海域のスケトウダラは76〜88%の確率で識別でき、各海域の標本群がそれぞれ異なった形態的特徴を持っていることが示された。また、外部形態からみた類似性をマハラノビスの距離により比べたところ、東部ベーリング海の大陵棚とアリューシャン海盆の標本間が近く、アリューシャン海盆と西部ベーリング海の大陵棚が離れていた。

1. 緒 言

魚類の糸群を識別する方法は、これまで外部形態や計数形質の違いに基づく方法、及び生化学的方法等を用いて行われてきた。外部形態の違いに基づく方法では、従来主として相対成長の差を統計学的に検定する方法が用いられてきたが、Winans（1984）はオリジンの異なるさけの幼魚を識別する方法として、Truss Network Measurement法（以下T NM法と称）で測定した外部形態に関する測定値を多変量解析法で処理する方法が有効であることを示した。この手法をスケトウダラに適用して、水域による形態の違いを識別することが可能かどうかを検討した結果、その有効性が示された（新田・佐々木 1980）。そこで、本手法により東部ベーリング海大陵棚、アリューシャン海盆及び西部ベーリング海大陵棚から採集したサンプルを用いて、3海域のスケトウダラの外部形態による識別を試みた。

2. 材料及び方法

T NM法は、頭部から尾部にかけて連続した方形（Cell）で外部形態をとらえ、それぞれの方形の4辺と対角線を統計量として扱い、外部形態の差異を検討する手法である。スケトウダラでは図1に示す19ポインタ（8Cell、計43の距離）を設けた（以後、ポイント1とポイント2の距離をpoint 1-2のように示す）。

標本は、以下に示すように東部ベーリングリ海の大陵棚、アリューシャン海盆及び西部ベーリング海の大陵棚の3海域のものを用いた。
測定は以下の手順で行った。
① 充分に解凍したサンプルを測定紙（エポ紙 150μ）に無理のない姿勢で置く。
② 針により測定ポイントを穿孔する。
③ ディジタイザーにより測定紙の各点の座標を読み取る。
④ 座標よりポインタ間距離（合計 43）を計算する。
解析は判別分析により行った。

3. 結果

測定個体の標準体長（point 2 - 19）は、表 1 に示すように、アリューシャン海盆で小さく、西部ベーリング海の大陸棚で大きくなっていた。
各海域とも産卵期のサンプルではないため、厳密には 3 海域各々の固有群と仮定することには問題がある。既往の知見から考えて、東部ベーリング海大大陸棚サンプルの小型群にはアリューシャン海盆群が含まれている可能性が高い。そこで東部ベーリング海大大陸棚サンプルについては標準体長 500mm 以上の個体のみ（108 個体）を用い、各々の海域は固有群であると仮定して以下の解析を進めた。
判別分析を行う前に、同一海域内のサンプルにおいて成長に伴う外部形態の差異があるか否かを検討した。海域各の標準体長（point 2 - 19）に対する 43 の各距離の比の度数分布は、いずれも対称型であり分散も小さくなっていた。これにより、測定した体長範囲での体型の変化はないものと推定されたので、判別分析も標準体長に対する比を用いて行った。
判別分析の結果、東部ベーリング海大大陸棚とアリューシャン海盆の判別率が 76%、東部ベーリング海大大陸棚と西部ベーリング海大大陸棚の判別率 86%、アリューシャン海盆と西部ベーリング海大大陸棚の判別率 88% となった。

4. 考察

Dawson（1989）は、T N M 法をスケトウダラ幼魚に応用し、東部ベーリング海の大大陸棚上の 4 水域とアリューシャン海盆の標本群を識別できるか試みたが、標本群間におけ
識別率は低かった。その理由として、水域によって固有な外部形態の特徴を持たないか、あるいはあったとしても水域の標本がオリジンの異なる複数の水域からの混合群で

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った可能性を挙げている。
しかし、本研究では、判別率は比較的高く、3海域の標本はそれぞれ固有な外部形態の特徴をもっていることが示された。これは、本研究では産卵に関与すると考えられる比較的大型個体のみを分析したため、各水域の標本にオリジンの異なる水域からの標本が混合している可能性が低かったためと考えられる。
また、各海域のサンプル間の外部形態の類似性をマハラノビスの距離をもとにみると、アリューシャン海盆と西部ベーリング海大陸棚間で一番大きく、次いで、東部ベーリング海大陸棚と西部ベーリング海大陸棚間であり、一番類似していたのは東部ベーリング海大陸棚とアリューシャン海盆間であった（図2）。
以上の結果から、3海域のスケトウダラはそれぞれ異なった外部形態の特徴を持っており、高い確率で識別が可能なこと、及びその形態的差異は、東部ベーリング海の大陸棚とアリューシャン海盆で近く、西部ベーリング海の大陸棚の標本はこれらとはやや離れている可能性が示唆された。これらの結果が系統群の違いを意味するものかどうかは、今後生化学的手法等の情報に基づく総合的な解析が必要である。

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<table>
<thead>
<tr>
<th>Standard body</th>
<th>Eastern Bering Sea shelf</th>
<th>Aleutian Basin</th>
<th>Western Bering Sea shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>$\sigma^a$</td>
<td>$\varphi$</td>
<td>Total</td>
</tr>
<tr>
<td>$300 \sim 320mm$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$320 \sim 340$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$340 \sim 360$</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>$360 \sim 380$</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>$380 \sim 400$</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>$400 \sim 420$</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>$420 \sim 440$</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>$440 \sim 460$</td>
<td>18</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>$460 \sim 480$</td>
<td>24</td>
<td>43</td>
<td>67</td>
</tr>
<tr>
<td>$480 \sim 500$</td>
<td>19</td>
<td>96</td>
<td>115</td>
</tr>
<tr>
<td>$500 \sim 520$</td>
<td>11</td>
<td>54</td>
<td>65</td>
</tr>
<tr>
<td>$520 \sim 540$</td>
<td>4</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>$540 \sim 560$</td>
<td>0</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>$560 \sim 580$</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>$580 \sim 600$</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>$600 \sim 620$</td>
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<tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$660 \sim 680$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$680 \sim 700$</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Minimum | $340$ | $328$ | $328$ | $385$ | $372$ | $372$ | $340$ | $382$ | $340$ |
Maximum | $595$ | $610$ | $610$ | $507$ | $651$ | $651$ | $602$ | $655$ | $655$ |
Number of sample | $107$ | $270$ | $378$ | $190$ | $114$ | $304$ | $312$ | $86$ | $398$ |

**Table 1**: Length composition of walleye pollack by area used for morphometric study.
Fig. 1. Location of 19 landmarks for a truss network data set are illustrated as circles and morphometric distance measures between circles as broken lines. Landmarks refer to (1) posteriormost point of maxillary, (2) anterior tip of snout at upper jaw, (3) most posterior aspect of neurocranium, (4) origin of pelvic fin, (5) origin of first anal fin, (6) origin of first dorsal fin, (7) most posterior point of first dorsal fin, (8) origin of second dorsal fin, (9) most posterior point of second dorsal fin, (10) most posterior point of first anal fin, (11) origin of second anal fin, (12) origin of third dorsal fin, (13) most posterior point of third dorsal fin, (14) most posterior point of second anal fin, (15) anterior attachment of ventral membrane from caudal fin, (16) anterior attachment of dorsal membrane from caudal fin, (17) most posterior-dorsal point of naturally extended caudal fin, (18) most posterior-ventral point of naturally extended caudal fin, and (19) base of middle caudal rays. For landmarks 1 and 3, points are made at their respective positions at the closest point to the body on a line perpendicular to the horizontal axis of the specimen.
Figure 2. Results of discriminant analysis by TNM data

DR: discriminate rate