Age and Growth of Shotted Halibut, *Eopsetta grigorjewi* (Herzenstein, 1890), in the West Sea of Korea

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Abstract: To investigate the age and growth characteristics of shotted halibut, *Eopsetta grigorjewi*, in the West Sea of Korea, the samples were collected using Gill nets throughout 2019. A total of 861 specimens (693 females and 168 males) were analyzed. The BW-TL relations were BW = 0.0034TL^{3.3278} (R^2 = 0.8716) for females and BW = 0.0031TL^{3.3359} (R^2 = 0.8860) for males. This analysis revealed that males exhibited a larger growth rate than females (p < 0.05). Notably, the anterior and posterior sections of the otolith displayed an elongated oval shape, exceeding the radius of the dorsal and ventral regions.

By examining the correlation between radii in four directions and total length, the highest correlation was observed between the total length (TL) and the ventral radius (R). The evaluation of the relationship between the fish total length and the otolith ventral radius resulted in an equation of TL = 14.657R + 9.1601 (R^2 = 0.7081) for females and TL = 15.037R + 5.0265 (R^2 = 0.6992) for males (p < 0.05). The formation of annuli occurred annually, consistently in January each year, as discerned through monthly changes in marginal index (MI) values. The von Bertalanffy growth equations from the relationship between the otolith annuli radius and the total length were L_t = 83.6(1−exp^{−0.046(t+4.70)}) in females (n = 693, p < 0.05) and L_t = 56.8(1−exp^{−0.078(t+2.16)}) in males (n = 168, p < 0.05).

Keywords: shotted halibut; otolith; age; growth; West Sea of Korea; von Bertalanffy; ventral radius; age analysis

1. Introduction

The West Sea of Korea constitutes a region where multiple currents converge, including the warm Kuroshio Current from the south and the cold-water currents like the China Coastal Current and the Korean Coastal Current [1]. This area maintains turbid seawater year-round due to inflows from rivers and streams in China and Korea, resulting in consistently high productivity driven by nutrient-rich inflows [1]. The central area of the West Sea features a depth of less than 100 m and is predominantly composed of sandy and muddy substrates, creating a suitable habitat for benthic fishes except reef fishes. In summer, water temperatures exceed 10 °C, and low-layer water temperatures can reach 20 °C in the absence of wind. Conversely, winter may bring low-layer water temperatures below 5 °C due to the impact of the Yellow Sea Low-Layer Cold Water Stand (YSBCW) [2]. This environment fosters a habitat for Euphausiacea, a primary food source for smaller fish [3]. However, there are currently concerns about marine environmental pollution due to indiscriminate development and reclamation projects along the West Sea coast, and water temperatures are rising due to global warming. This raises concerns about the decline of fisheries’ resources in the West Sea, and ecological research on fish species with high commercial value must be conducted.

The *Eopsetta grigorjewi*, classified within Pleuronectiformes, Pleuronectidae, occupies diverse sea areas, including the South Korean littoral zone, the Japanese coast, Bohai Bay,
the East China Sea, and the Taiwanese coast. Typically found at 200 m or shallower depths, it predominantly resides on sandy or muddy seabeds [4]. As a flatfish species, *E. grigorjewi* is one of the predator in certain marine ecosystems, preying on small crustaceans (such as shrimp and crabs), cephalopods, and small fish [5–8]. However, its dietary preferences adapt to the specific marine environment. This species displays limited migratory behavior for spawning, breeding, and feeding, with variations in spawning seasons contingent on geographical locations [9,10].

Based on age-determination indicators, fish age, and growth studies are crucial in enhancing resource assessment precision and underpinning resource management strategies. While scales and vertebrae also aid in age determination and stock assessment, otoliths are often deemed the most suitable as they continue growing even after the cessation of body growth in older fish [11]. In most cases, the formation of annular rings post-spawning renders otoliths conducive to investigating early growth, including aspects such as spawning periods, metamorphosis duration, and daily growth rates [12,13]. Furthermore, otolith structure changes allow for probing environmental shifts [11]. Recently, as age data and images accumulate, technology to predict age through logical estimating technology is also being developed [14].

Studies on the age and growth of *E. grigorjewi* have been conducted mainly with fish samples collected in the East China Sea and the South Sea of Korea [15,16] and in the waters around Japan [17–19]. However, fishery resources are expected to change greatly due to changes in the marine environment, requiring periodic research on the ecological characteristics of fishery resources. Although *E. grigorjewi* is a highly commercially valuable fish species with more than 15,000 tons caught in Korea, ecological research is needed to manage flatfish fish stocks which are decreasing—from 14,496 ton in 2021 to 11,625 ton in 2022. However, in Korea, no close and no length limit for the *E. grigorjewi* season have been set. Ecological research on age, growth, and spawning is essential for the stock assessment, maintenance, and management of the maximum sustainable yield. Accordingly, this study investigated the age, growth and spawning season of *E. grigorjewi* inhabiting the West Sea of Korea to provide basic scientific data for fisheries’ resource management.

2. Materials and Methods

2.1. Specimens Collection

For the age analysis, we used 861 specimens (693 females and 168 males) of *E. grigorjewi* caught by offshore gill netting (mesh size = 450 mm) in the West Sea of Korea from January to December 2019 (Figure 1). After transporting the collected specimens to the laboratory, the total length (TL, cm) and body weight (BW, g) of each individual were measured, followed by sex and maturity stage determination and gonad weight (GW, g) measurement. The skulls of the measured *E. grigorjewi* were incised, and a pair of otoliths were extracted from the posterior part of the orbit, followed by washing with fresh water to remove foreign substances attached to the surface. Then the otoliths were stored in a 4% KOH solution for 24 h to completely clean their surfaces. Otoliths consist of 3 parts of sagitta, lapillus, and asteriscus. And the sagitta was used in this study. The right sagittal otolith (ocular side) from all samples was used to obtain consistent values in the otolith analysis.

2.2. Otolith Processing and Analysis

The clean otoliths were dried at room temperature, placed in a silicone mold for easy reading of annuli, and then molded with a solution of resin (EpoThinTM2 Epoxy Resin, BUEHLER Co., Lake Bluff, IL, USA) and hardener (EpoThinTM2 Epoxy Hardener, BUEHLER Co.) in a ratio of 6:4. After allowing the molded otoliths to solidify for more than 24 h in a dry environment, they were polished from the sides to the focus using sandpaper of increasing grade (CarbimetTM, p320, p400, p1600, BUEHLER Co.) on a polishing machine (ISOMET 1000, BUEHLER Co.). The polished surface, which was still rough, was further polished using Micron powder (Micropolish 0.05 micron, BUEHLER Co.) and glued to a slide glass for analysis. In this study, we analyzed the ages of *E. grigorjewi* specimens from
the West Sea of Korea using otoliths and read rings as age-determining traits by polishing their surfaces. There are two ways to analyze otoliths to determine age: surface grinding and sectioning. Among these two methods, the surface polishing method has the advantage of being easier to process than the sectioning method, and so one is able to process many otoliths in a short time. Additionally, since this method is already used in many fish, it was also used in this study [20]. The boundary where a translucent zone transitions to an opaque zone was used to read the annuli of otoliths. A stereoscopic microscope (SZX16, Olympus, Tokyo, Japan) and image analysis systems (i-works 2.0, i-works) were used to accurately image the otoliths and measure the otolith radius and the size of annuli (Figure 2). In the preliminary experiment, errors were reduced when reading the boundary where a translucent zone transitioned to an opaque zone. Moreover, the boundary between the zones was distinct, making the interpretation more straightforward and increasing ease of analysis. The same method was used in the study of E. grigorjewi collected in the South Sea of Korea [16], as well as for estimating the age of various fish, including flatfish [21,22]. And measurements from the focus of the otolith to the outer edges in four directions (anterior, posterior, ventral, and dorsal) revealed a proportional relationship between TL and the measured values in the focus-ventral axis. Because measuring the focus–ventral axis was easier than measuring other parts to identify false annuli and true annuli, age was estimated using this part in this study. The annulus of the otolith was read twice to confirm that there was no significant difference (p < 0.05) [23]. The index of average percent error (IAPE) analysis was performed to check the precision of the data measured twice. The formula is as follows [24]:

\[
IAPE = \frac{100}{N} \sum_{j=1}^{N} \left[ \frac{1}{R} \sum_{i=1}^{R} \frac{|Y_{ij} - \bar{Y}_j|}{\bar{Y}_j} \right]
\]

where \(N\) is the number of fish aged, \(R\) is the number of times the fish are aged, \(Y_{ij}\) is the \(i\)th determination for the \(j\)th fish, and \(\bar{Y}_j\) is the average estimated age of the \(j\)th fish. These IAPE results were compared with the generally accepted reference level of <5.5% [25]. Precision was confirmed using coefficient of variation (CV) along with IAPE:

\[
CV = \frac{100}{N} \sqrt{\frac{\sum_{j=1}^{N} (Y_{ij} - \bar{Y}_j)^2}{R-1}}
\]

where \(s\) is the standard deviation [24].

Figure 1. West Sea of Korea (Yellow Sea), where the Eopsetta grigorjewi specimens were collected, and ocean currents in the waters around Korea.
2.3. Spawning Season

The spawning period of the *E. grigorjewi* was analyzed to confirm the formation period of the first annulus. For the spawning period, the monthly gonadosomatic index (GSI) of females and monthly gonadal development stage data of females were used. To confirm the monthly gonadal development stage, macroscopic and histological methods were used in parallel, and if there was confusion in the development stage determination, the histological method was used. For gonad histological analysis, gonads were fixed in 95% formaldehyde, dehydrated, with a para block made, and Haematoxylin-eosin stained; specimens were prepared and examined and measured oocyte diameter under image analysis systems (i-works 2.0, i-works). At this time, the gonads were weighed to two decimal places. The following is the equation for calculating gonadosomatic Index (GSI):

\[
GSI = \frac{GW}{BW} \times 100
\]

Here, \(GW\) is the gonad weight (g), \(BW\) is the body weight (g).

2.4. Growth Equation

The number of months elapsed from the spawning season to the month in which the first ring was formed was applied to each group to calculate the age of each group. The growth equations of *E. grigorjewi* were estimated using the von Bertalanffy (1938) [27] growth equation using the total length at each individual. The FSA package (v. 0.9.4) [28], “nlstools” package [29], “tidyverse” package, and “car” package [30] in R program and R studio were used to determine the coefficients’ starting values \(L_\infty, K, t_0\) or \(I\), respectively. The von Bertalanffy (1938) growth equation is as follows:

\[
L_t = L_\infty (1 - e^{-k(t-t_0)})
\]
Here, \( L_t \) is the total length at age \( t \), \( L_\infty \) is the theoretical maximum total length, \( k \) is the growth coefficient, and \( l_0 \) is the theoretical age at a total length of 0 cm. As for the estimated growth coefficient in the growth equation, the growth rate index was employed to compare with that of a previous study [31]. The growth rate equation is as follows:

\[
\Phi = \log K + 2 \log L_\infty
\]

3. Results

3.1. Body Composition and Relative Growth

In this study 861 individuals of \( E. \) grigorjewi were analyzed in age and growth study, with 693 females and 168 males, and the female-to-male ratio was 4.1:1. The total length of females ranged from 22.3 to 50.3 cm, with an average of 34.3 cm, and about 60\% of them were in the range of 28–35 cm. In the case of males, the total length ranged from 22.5 to 38.4 cm, and the average was 29.7 cm, with about 60\% in the 25–30 cm total length range (Figure 3). The male specimens in the sample were in general smaller in length than the female specimens. The average total length of females was greater than that of males (one-way ANOVA, \( p < 0.05 \)), and there was significant difference in slope between the sexes in the relative growth between log total length and log body weight (ANCOVA, \( p < 0.05 \)). The isometry equations of male and female are as follows; samples smaller than 20 cm were not collected (Figure 4):

\[
\text{Female} : BW = 0.0034 TL^{3.3278} \quad (n = 693, \text{ } P < 0.05)
\]

\[
\text{Male} : BW = 0.0031 TL^{3.3359} \quad (n = 168, \text{ } P < 0.05)
\]

3.2. Annulus Reading and Annulus Formation Time

As a result of IAPE and CV analysis, IAPE was found to be 4.9\%, and CV was 9.8\%. CV was higher than 7.6\%, but IAPE was lower than 5.5\% [25]. We determined that the annulus reading was valid and performed an analysis of the annulus reading results. To investigate the validity of annuli as the growth indicator, we compared the relationship between ring radius and otolith radius for each ring group, and there were a minimum of 3 ring groups and a maximum of 10 ring groups (Figure 5). The annuli shown in the otoliths were separated from the adjacent ones, and even with the same number of annuli, the correspondence between the otoliths and the annuli was confirmed as the otolith radius, and the distance between annuli increased. Of the 861 otoliths, only 612, 499 females...
and 113 males, were used for age determination, excluding samples that were lost during polishing or those that presented difficulty in reading.

![Graph showing relationship between total length and body weight of Eopsetta grigorjewi in the West Sea of Korea](image)

**Figure 4.** Relationship between total length and body weight of *Eopsetta grigorjewi* in the West Sea of Korea (*up*; Female, *down*; Male).

![Graph showing relationships between otolith radius (OR) and ring radius (r_n) for each ring group of female and male *Eopsetta grigorjewi* at the West Sea of Korea](image)

**Figure 5.** Relationships between otolith radius (OR) and ring radius (r_n) for each ring group of female and male *Eopsetta grigorjewi* at the West Sea of Korea: (*A*) Female; (*B*) Male.

Monthly changes in marginal index (MI) were analyzed to determine annulus formation time (Figure 6). The mean MI of *E. grigorjewi* was the lowest in January at 0.3. It remained between 0.4 and 0.5 from February to November and was the highest in December.
at 0.58. Therefore, January was confirmed as the time of annulus formation in *E. grigorjewi* in the West Sea of Korea.

![Figure 6. Monthly changes in the mean marginal index (MI) of *Eopsetta grigorjewi* at the West Sea of Korea. Vertical line (whiskers), the upper and lower whiskers represent scores outside the middle 50%; the top of the box (upper quartile), seventy-five percent of the scores fall below the upper quartile; the bottom of the box (lower quartile), twenty-five percent of scores fall below the lower quartile; bold line (the median), the median marks the mid-point of the data and is shown by the line that divides the box into two parts.

3.3. Spawning Season

To determine the duration of annulus formation, the exact spawning period was analyzed through histological observations of the gonad and gonadosomatic index (GSI) in females (Figure 7). As a result of analyzing the GSI, the value was maintained from May to September, but the figure gradually increased from October; it was the highest in March of the following year. The GSI in the specimens began to fall in April, and showed a low value in May.

![Figure 7. (A) Monthly change in gonadosomatic index (GSI) in female *Eopsetta grigorjewi*. (B) Monthly changes in maturity stages of female *Eopsetta grigorjewi* at the west Sea of Korea.](image-url)
The histological analysis of the gonads was as follows (Figure 8). The immature stage has appeared since June. At this stage, the cytoplasm was scanty, peri-nucleolus and oil droplet were observed, and the nucleus occupied most of the cells; the oocytes diameter was about 80–140 µm. Most of the time from June to November the status of gonad was in immature stage, and the maturing stage appeared in December. At this stage, oocytes developed to 150–200 µm, yolk vesicles appeared in the cytoplasm, and oocytes with yolk sac and yolk granule appeared. In March, when GSI was the highest, mature stage and spent stage appeared. In the mature stage, the oocytes diameter was 220–400 µm, the nuclear membrane was irregular oval, yolk globules were observed, and the cytoplasm was filled with a number of yolks. The ripe and spawning stage takes place in a fairly short time and is assumed to have occurred in some objects. At this stage, it is filled with fully ripened eggs of size 450 to 600 µm, and hydrated oocyte were observed. In the spent stage, the ovarian epithelium was relocated, and oocytes with diameters of 20–50 µm were distributed; degenerating oocytes and follicular cell layer indicating some traces of spawning were observed. In April, spawning stage and spent stage account for 50% of the total population, which is estimated to be the main spawning season. As a result, the spawning season for *E. grigorjewi* was estimated to be from March to May, and since an annulus is periodically formed once a year, the period from the time of spawning to the formation of the first annulus was estimated to be 0.7 years.

![Figure 8](image.png)

**Figure 8.** Developmental stages in the ovary, which were stained with Hematoxylin-eosin, of *Eopsetta grigorjewi*. (A) Ovary of the growing stage. (B) Ovary of the early mature stage. (C) Ovary of the mature stage. (D) Ovary of the ripe and spawning stage. (E) Ovary of the recovery stage. Ho, hydrated oocyte; N, Nucleus; Oc, Ovarian cavity; Od, Oil droplet; Pn, peri-nucleolus, Pof, postovulatory follicle; Yg, Yolk globule; Yv, Yolk vesicle.

### 3.4. Estimation by Growth Equation

It takes 0.7 years from June of the spawning season to January when the first ring is formed, so in January, the age of individuals with 3 rings is 3.7 years (the elapse between the capture month and January), the age of individuals with 4 rings is 4.7 years, and the age of individuals with 11 rings is 3.7 years. The oldest age was 10.7 years, and in February, the age of individuals with 3 rings was calculated to be 3.7 + 1/12 years, and the age of individuals with 4 rings was calculated to be 4.7 + 1/12 years. In this way, the age of each individual was calculated, and the growth formula was estimated. The average diameter of first annulus in female otoliths was 0.37 mm, and the width between the annuli decreased with age. In males, the average diameter of first annulus was 0.32 mm, shorter than in females, and also showed a decreasing trend in width between the annuli, in terms of age. The equations are as follows (Figure 9):

**Female**: 

\[ TL = 14.657R + 9.1601 \]  \( (r^2 = 0.7081) \)
\[ Male : TL = 15.037R + 5.0265 \quad (r^2 = 0.6992) \]

*Figure 9.* Relationship between total length and otolith radius of *Eopsetta grigorjewi* at the West Sea of Korea.

By analyzing the mean length for each age by calculating the mean size of annuli for each age from the relationship between the otolith radius and the length, we found that, for females, the minimum \( L_{0.7} \) was 14.64 cm and the maximum \( L_{10.7} \) was 43.08 cm. In contrast, for males, the minimum \( L_{0.7} \) was 9.87 cm and the maximum \( L_{8.7} \) was 33.44 cm. The equations are as follows (Figure 10):

\[
Female : L_t = 83.6 \left( 1 - e^{-0.046(t+4.70)} \right)
\]

\[
Male : L_t = 56.8 \left( 1 - e^{-0.078(t+2.16)} \right)
\]

*Figure 10.* Von Bertalanffy growth curves in total length estimated using a nonlinear regression method of *Eopsetta grigorjewi* at the West Sea of Korea (gray area is 95% confidence interval).
As a result, the theoretical maximum body length \( (L_\infty) \) of the female \( E. \) grigorjewi was estimated to be 83.6 cm (confidence interval: 62.9–170.6 cm), the growth coefficient was 0.046/year (confidence interval: 0.017–0.083), and the theoretical age \( (t_0) \) at the length of 0 was estimated to be −4.70 years (confidence interval: −7.15–−2.46). The theoretical maximum length \( (L_\infty) \) of males was estimated to be 56.8 cm (confidence interval: 44.5–127.7 cm), the growth coefficient was 0.078/year (confidence interval: 0.018–0.163), and the theoretical age \( (t_0) \) at the length of 0 was estimated to be −2.16 years (confidence interval: −7.51–0.29, Figure 11).

**Figure 11.** Comparison of von Bertalanffy growth curves for male and female of *Eopsetta grigorjewi* of the West Sea of Korea using nonlinear regression analysis.

### 4. Discussion

The otolith reflects biological and environmental factors during the entire life cycle of the individual, and the cause of the formation of the annulus may vary from individual to individual and across each species of fish. Fish species that are greatly affected by the environment include ocellate spot skate (*Okamejei kenojei*) that live in the West Sea, and in this species, as the water temperature decreases, annuli are formed [26]. Species whose spawning period and formation of the annulus are close to each other include brown sole (*Pleuronectes herzensteini*) and marbled flounder (*Pseudopleuronectes yokohamae*), and *E. grigorjewi* in the West Sea in Korea also falls in this category [32,33]. It has been reported that the otolith of ordinary fish forms a transparent band at a time when growth is rapidly accelerated, and an opaque band at a time when growth is slowed [34]. The annulus of the *E. grigorjewi* is formed in January, which interferes with feeding habits due to low water temperature, and it is adjudged that the growth was low due to reduced feeding habit due to abdominal distension caused by gonadosomatic effects ahead of the spawning season [33]. In addition, the low metabolic rate of fish in cold season is another possible reason for opaque zone formation on otolith. The brown croaker (*Miichthys miyu*) in the southwestern sea of Korea has a similar annulus formation time as *E. grigorjewi*, when the water temperature is low before spawning season, when the water temperature is low and an annulus is formed before spawning [35].

Based on our results, the estimated growth equation of the *E. grigorjewi* collected from the West Sea of Korea was compared with that from previous studies conducted using samples from other sea areas (Figure 12; Table 1). In all three studies, female *E. grigorjewi* exhibited increasing growth trends with an increase in latitude of collection area. This finding is consistent with the observations in a previous study for another species in the family Pleuronectidae, *Pseudopleuronectes yokohamae*, in which greater growth was observed at higher latitudes [36]. In the case of the male *E. grigorjewi*, the growth rate tended to increase for the samples collected in higher latitude areas, and these results were similar to those of other flatfish species [36]. However, the growth rate of the male *E. grigorjewi* from the West Sea of Korea was lower than those from other regions, presumably due to the small number of samples and the narrow range of their length, meaning a greater number of fish samples is needed for accurate age determination. It is possible that the maximum length of both female and male specimens collected in this study was larger than those
from other regions. Owing to the nature of the model, the greater the size of the collected individuals, the greater the maximum length [37]. Accordingly, it is necessary to collect fish samples in the same manner to analyze the growth differences accurately in each sea area.

![Figure 12. Comparison of von Bertalanffy growth curves of Eopsetta grigorjewi by different authors [16,19].](image)

Table 1. Comparison of growth parameters and growth performance index of Eopsetta grigorjewi reported by different authors.

<table>
<thead>
<tr>
<th>Study</th>
<th>Female</th>
<th>Male</th>
<th>Survey Area (Coordinate)</th>
<th>Analysis Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L_∞</td>
<td>k/Year</td>
<td>t_o</td>
<td>Range of TL</td>
</tr>
<tr>
<td>This study</td>
<td>83.6</td>
<td>0.046</td>
<td>-4.7</td>
<td>22.3–50.3</td>
</tr>
<tr>
<td>Kim et al. (2011) [16]</td>
<td>46.6</td>
<td>0.14</td>
<td>-1.3</td>
<td>22.3–40.5</td>
</tr>
<tr>
<td>Imai and Miyazaki (2005) [19]</td>
<td>48.7</td>
<td>0.16</td>
<td>-0.6</td>
<td>15.0–38.0</td>
</tr>
</tbody>
</table>

L_∞: the theoretical maximum total length; k (/year) is the growth coefficient. φ: growth rate.

Using the growth equation, one can infer the resource status in several directions. It has been reported that maximum fish length can differ between habitats when the appearance frequency of older fish decreases due to changes in fishery resources because of overfishing [38,39]. In general, overfishing of fishery resources leads to faster sexual maturity, increasing the TL at the age or decreasing maturity at the age [40]. The status of fish stock can be determined indirectly via the growth coefficient [41]. The growth rate of fish increases with relatively higher consumption of food due to a decrease in the number of fish, suggesting that a higher growth rate is indicative of poor fishery resources. There is a possibility that if the growth coefficient (k) is high, the resource density is low, and if the growth coefficient (k) is low, the resource density is high, but More research will be needed to infer resources from these coefficients.

Since male individuals larger than 40 cm were not collected in this study, the L_∞ value may be considered biased. However, given that there was a difference between the sexes in the research results of Imai and Miyazaki (2005) [19], it is unclear whether this is an inherent characteristic of this species or an influence of the habitat environment. The growth rate of young individuals is high, but the growth rate decreases as age increases. However, in this study, due to the lack of individuals under 3 years of age, the growth rate was estimated by analyzing older individuals, and the growth coefficient was lower than the results of other studies. Also, because the mesh size of the gillnet is 450 mm and individuals smaller than 20 cm are not caught, additional sampling through direct catch surveys, which can take a lot of time and effort, is considered necessary to increase the accuracy of the results of this study.
A stock assessment based solely on growth is insufficient; the inclusion of catch data and further investigations on feeding habits through dietary studies and ecological research on spawning and maturation in different regions are required. Particularly for *E. grigorjewi*, known for their low productivity and reported as a species with limited recovery potential under deteriorating resource conditions [42]; such additional research is highly warranted. Furthermore, continuous monitoring and ecological studies are imperative to prevent resource depletion. Reports have indicated severe overexploitation of *E. grigorjewi* in Japanese waters [43], highlighting the necessity for research on fishing pressure on *E. grigorjewi* in Korean waters. Understanding the status of fishery resources is crucial not only for *E. grigorjewi* but also for other species in the family *Pleuronectidae*.


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**Institutional Review Board Statement:** The study was conducted in accordance with the regulations on research ethics of the National Institute of Fisheries Science. We only used specimens from the fish market which were already dead.

**Informed Consent Statement:** Written informed consent has been obtained from the patient(s) to publish this paper.

**Data Availability Statement:** Data are contained within the article.

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