Data-limited stock assessment of yellow striped flounder (*Pseudopleuronectes herzensteini*) in Korea using the CMSY++ approach

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https://doi.org/10.67784/4003

Abstract. Yellow striped flounder (*Pseudopleuronectes herzensteini*) is a commercially important demersal species that supports coastal fisheries in South Korea, particularly in the East Sea. However, increasing fishing pressure and the lack of fishery-independent data have raised concerns regarding the long-term sustainability of this stock. In this study, the stock status of yellow striped flounder was assessed using the Catch–Maximum Sustainable Yield approach with recent improvements (CMSY++), a catch-only method suitable for data-limited fisheries. Annual catch data from 1950 to 2023 were analysed, showing catches ranging from 6,000 t to 29,466 t, with an overall increasing trend followed by fluctuations in recent decades. The intrinsic growth rate (r) was estimated at 0.288 yr^{-1} (95 % CI: 0.164 – 0.504), while the carrying capacity (k) was estimated at 278,000 t (179,000 – 431,000 t). The maximum sustainable yield (MSY) was estimated at 19,200 t (16,100 – 24,000 t), with a corresponding biomass at MSY (B_{MSY}) of 139,000 t (89,500 – 215,000 t). Biomass in the terminal year was estimated at 138,000 t (62,700 – 166,000 t), resulting in a relative biomass (B/B_{MSY}) of 0.991, indicating that the stock is close to sustainable levels. Fishing mortality in the final year (F = 0.155 yr^{-1}) slightly exceeded the fishing mortality at MSY (F_{MSY} = 0.144 yr^{-1}), yielding an exploitation rate (F/F_{MSY}) of 1.08. Historical catches exceeding MSY suggest periods of elevated fishing pressure.
Keywords: maximum sustainable yield (MSY), data-limited fisheries, fishing mortality.

Introduction. The sustainable management and long-term conservation of fisheries depend on accurate evaluation of fish stock dynamics. Stock assessments play a pivotal role in providing managers with the information required to determine appropriate fishing intensity and timing to ensure sustainable populations (Kell & Sharma, 2025). These evaluations often combine quantitative and qualitative data to assess key factors influencing population dynamics, including growth rate, maturation, fertility, and natural and fishing mortality (Cortés et al., 2012).

Marine fisheries are a critical source of food for coastal and inland communities, supporting livelihoods and contributing to export revenues. While commercial fisheries have been extensively studied, resulting in comprehensive datasets on catch time series, age and length structures, fishing effort, and catch-per-unit-effort (CPUE) among other life-history parameters (Methot & Wetzel, 2013), many non-commercial or by-catch species particularly in tropical regions remain poorly understood and are often classified as data-limited or "data-poor" fisheries (Costello et al., 2012). Assessing these stocks is essential for implementing science-based management strategies, yet the lack of reliable data poses substantial challenges for determining population dynamics and establishing biological reference points (Chrysafi & Kuparinen, 2016; Dowling et al., 2015; Wetzel & Punt, 2011). Globally, the proportion of biologically sustainable fish stocks has decreased from 90% in 1974 to 65.8% in 2017, reflecting widespread overexploitation and depletion of marine resources (FAO, 2022). In many developing countries and data-poor fisheries, the scarcity of comprehensive biological and fishery information further complicates management, leaving the exploitation levels and condition of numerous commercial stocks uncertain (Lorenzen et al., 2016; Nielsen et al., 2018). Maintaining fish stock biomass at sustainable levels is essential to achieve the maximum sustainable yield (MSY), which

provides both a biological reference point (BRP) and an indicator of fishery status within a given area (Kumar et al., 2017; Martell & Froese, 2013). Traditional stock assessment methods, which rely heavily on survey and fishery data, are often impractical under data-limited conditions (Fujita, 2021). To overcome these challenges, the catch maximum sustainable yield (CMSY) method has been developed as a practical approach for estimating stock status using only catch data and Monte Carlo simulations (Froese et al., 2017, 2023). CMSY provides estimates of key population parameters, including MSY, carrying capacity (K), intrinsic population growth rate (r), fishing pressure, and overall stock condition. The method can also integrate supplementary qualitative information, such as expert knowledge or relative abundance indices, to improve estimation accuracy (Froese et al., 2017, 2023). The Monte Carlo catch–maximum sustainable yield (CMSY) method provides essential management reference points that are crucial for evaluating stock status and guiding sustainable fisheries exploitation. In particular, the ratios of current biomass to biomass at maximum sustainable yield (B_{END}/B_{MSY}) and current fishing mortality relative to fishing mortality at maximum sustainable yield (F_{END}/F_{MSY}) offer valuable insights into whether a stock is underexploited, fully exploited, or overexploited. These indicators support science-based decision-making and contribute to the development of effective fisheries management strategies (Froese et al., 2017). Widely regarded as a cost-effective and data-limited stock assessment approach, CMSY is especially useful in situations where detailed biological data are lacking. The method relies on minimal input data, including time-series catch records, estimates of the maximum intrinsic rate of population increase (r), and prior knowledge of biomass relative to carrying capacity (B/k) at the beginning and end of the time series. By utilizing these parameters, CMSY reconstructs stock dynamics and serves as a practical alternative to more complex, data-intensive models, such outputs are fundamental for ensuring long-term sustainability and enabling the recovery of overexploited fish stocks (Froese et al., 2017). By generating reliable reference points and insights into stock status, CMSY enables sustainable management and supports decision-making even in fisheries where conventional data are unavailable (Bouch et al., 2021).

The yellow striped flounder, *Pseudopleuronectes herzensteini* (Jordan & Snyder, 1901), is a demersal flatfish belonging to the family Pleuronectidae, widely distributed across the northwestern Pacific, including the waters of Korea, Japan, China, and Russia (Orlov et al., 2021). This species inhabits primarily shallow, sandy coastal environments, though it can occur at depths ranging from 5 to over 700 m (Orlov et al., 2021). It plays an important role in regional fisheries, being commonly caught in gillnet, trawl, and bottom seine fisheries. Despite its broad distribution and current classification as Least Concern by the International Union for Conservation of Nature, populations show region-specific declines, largely attributed to overfishing and environmental pressures (Orlov et al., 2021).

With a generation length of approximately six years and varying stock trends across its distribution range, yellow-striped flounder requires effective fisheries management and continuous monitoring to ensure long-term sustainability (Orlov et al., 2021). Catch-only stock assessment methods have been widely applied to evaluate the status of data-limited fish stocks in different regions of the world (Hashemi et al., 2025; Konoyima, 2026; Suresh et al., 2023). In Korean waters, the CMSY framework has been successfully used to assess the stock status of several fish and squid species (Hong & Kim 2021; Lim & Jung, 2025). Existing research on yellow-striped flounder has primarily focused on aspects of its biology and genetics, including mitochondrial genome structure (Chae et al., 2022), while information on stock status, exploitation level, and population sustainability remains limited. Given the commercial importance of yellow-striped flounder and the absence of formal stock assessments in Korean waters, evaluating its population status is essential for sustainable fisheries management. Therefore, this study applies the CMSY++ framework to estimate key population parameters, including biomass, fishing mortality, maximum sustainable yield, and stock depletion status. Beyond generating parameter estimates, the study provides the first quantitative evaluation of the species' exploitation status in the Northwest Pacific region of Korea, identifies potential risks associated with current fishing pressure, and establishes biological reference points that can support evidence-based management decisions. The findings contribute to a better understanding of the

sustainability of fishery and provide a scientific foundation for future monitoring, conservation, and stock recovery strategies.

Material and Method

Data acquisition. Annual catch data for yellow striped flounder in Korean waters of the Northwest Pacific were compiled using the FAO Fisheries & Aquaculture resources software (FishStatJ), which provide comprehensive global fishery statistics and analyses for monitoring national and regional trends. The FishStatJ database, a component of the FAO data system, was employed to extract fishery-dependent time-series records from 1950 to 2023 (FAO, 2025). These data served as the foundation for assessing historical catch trends and evaluating stock status using catch-based assessment approaches. Data were compiled in June 2026.

Catch-based maximum sustainable yield (CMSY++) approach. CMSY++ is an advanced Bayesian state-space model developed for assessing fish stock status using catch data and, optionally, abundance indices (Froese et al., 2017, 2023; Martell & Froese, 2013). It extends the CMSY frameworks by enabling estimation of key fisheries reference points, including maximum sustainable yield (MSY), fishing mortality at MSY (F_{MSY}), and biomass at MSY (B_{MSY}). Additionally, CMSY++ provides estimates of relative stock size (B/B_{MSY}) and exploitation rates (F/F_{MSY}), integrating prior information on species-specific productivity (intrinsic growth rate, r) and broad priors for the ratio of biomass to unfished levels (B/k) at the start, mid, and end of the time series. This approach accommodates uncertainty in initial biomass and unexploited stock size, enhancing the robustness of assessment outcomes.
The model is grounded in a modified Schaefer surplus production framework. CMSY++ replaces the uniform priors used in earlier implementations with multivariate lognormal (MVLN) priors for r and the carrying capacity (k), which improves the identification of probable r–k combinations and increases computational efficiency (Froese et al., 2017). The basic biomass dynamics are expressed as:

$$B_{t+1} = \left[B_t + r * B_t * \left(1 - \frac{B_t}{k}\right) - C_t * e^{\varepsilon_t} \right] * e^{\eta_t}$$

Where B_t is the biomass in year t, C_t is the catch in metric tons, r is the intrinsic growth rate, k is the environmental carrying capacity, and ε_t and η_t represent lognormal observation and process errors, respectively. For simplicity, these errors can be omitted in basic formulations (Martell & Froese, 2013). CMSY++ also accounts for reduced recruitment at low stock sizes. When biomass falls below 25% of the carrying capacity ($B < 0.25k$), the intrinsic growth rate is assumed to decline linearly, reflecting density-dependent limitations on population growth.

$$B_{t+1} = B_t + \left[\left(4 * \frac{B_t}{k}\right) * r \right] * \left(1 - \frac{B_t}{k}\right) * (B_t - C_t), \qquad \frac{B_t}{k} < 0.25$$

This formulation ensures that severely depleted stocks exhibit lower productivity, consistent with empirical observations (Froese et al., 2017, 2023). The CMSY++ model can estimate relative equilibrium biomass (B/k) from catch data using a feed-forward artificial neural network, which guarantees meaningful solutions when catches remain below near-MSY thresholds ($C_t < 0.99\ MSY_{prior}$). The relationship between relative catch and biomass is expressed as:

$$\frac{C}{MSY} = \left(4 * \frac{B}{k} - \left(2 * \frac{B}{k}\right)^2\right) * RC$$

Where the recruitment correction factor (RC) adjusts for reduced recruitment at low biomass. Alternative production models, such as the Fox model, may be applied depending on species-specific biology.

Priors for r are derived from life-history traits and species resilience information from FishBase (Froese & Pauly, 2026), while k priors are based on maximum observed catch using:

$$k_{low} = \frac{\max(C)}{r_{high}}$$

$$\frac{k_{high} = 4 * \max(C)}{r_{low}}$$

Where r_{low} and r_{high} are the lower and upper bounds of intrinsic growth, and max(C) is the maximum recorded catch (Froese et al., 2017, 2023). These priors are incorporated into the multivariate lognormal (MVLN) distribution to account for correlations between r and k, improving parameter reliability.

The CMSY++ approach identifies viable r–k combinations consistent with the observed catch trends through Monte Carlo simulations. From these combinations, key stock parameters are estimated, including:

$$MSY = r\,\frac{k}{4}$$

$$B_{MSY} = \frac{k}{2}$$

$$F_{MSY} = \frac{r}{2}$$

Stock status categories are defined as follows: $B/B_{MSY} \geq 1 \rightarrow$ healthy stock, 0.5 – 1 → overfishing, 0.2 –0.5 → high overfishing, < 0.2 → collapsed stock (Palomares et al., 2018). Prior information on the intrinsic growth rate (r) and carrying capacity (k) is required for CMSY++ analysis.

The prior range for k was estimated from the maximum observed catch following the procedures described by Froese et al., (2017). The prior range for r was determined according to the resilience classification available in FishBase. According to Froese et al. (2017), prior r ranges of 0.6 – 1.5, 0.2 – 0.8, 0.05 – 0.5, and 0.015 – 0.1 correspond to high, medium, low, and very low resilience species, respectively. Yellow-striped flounder (*Pseudopleuronectes herzensteini*) is classified as a low-resilience species in FishBase, therefore, a prior r range of 0.05 – 0.50 was used in the present study. The prior relative biomass (B/k) ranges for the beginning, intermediate, and final years of the assessment were assigned following the guidelines of Froese et al. (2017) and based on the historical catch trajectory of the fishery. The initial biomass prior was set at 0.8 – 1.0 in 1950. The intermediate prior biomass was set at 0.5 – 0.9 in 1979 and the final biomass prior was set at 0.226 – 0.596 in 2023. All priors used in the CMSY++ analysis are summarized in Table 1.

Table 1

Prior parameter values used in the CMSY++ assessment of *Pseudopleuronectes herzensteini* in Korean waters

Parameter	*Prior range*
Resilience category	Low
r	0.05 – 0.50
Initial B/k (1950)	0.8 – 1.0
Intermediate B/k (1979)	0.5 – 0.9
Final B/k (2023)	0.226 – 0.596
k	192,000 – 577,000

Results

Catch trends yellow striped flounder (1950–2023). The catch time series for yellow striped flounder from 1950 to 2023 shows pronounced temporal variability. During the early period (1950s – early 1960s), catches remained relatively low and stable, ranging between approximately 6,000 and 13,000 t (Figure 1). A substantial increase was observed from the mid-1960s to late 1970s, with catches exceeding 20,000 t and with a peak of 28,022 t in 1976. The highest catch in the entire time series occurred in 1980 (29,466 t), indicating a period of intense exploitation. Following this peak, catches generally declined throughout the 1980s and early 1990s, dropping to nearly 13,000 t by 1990. A moderate recovery was observed in the late 1990s and mid-2000s, with catches again exceeding 20,000 t in some years. However, fluctuations persisted, and catches declined again during the mid-2010s, reaching around 14,000–15,000 t. In recent years (2020–2023), catches have increased slightly, ranging between approximately 19,000 and 22,700 t. Overall, the catch trajectory reflects an initial expansion phase, followed by decline and subsequent fluctuations, suggesting changes in stock abundance and fishing pressure over time.

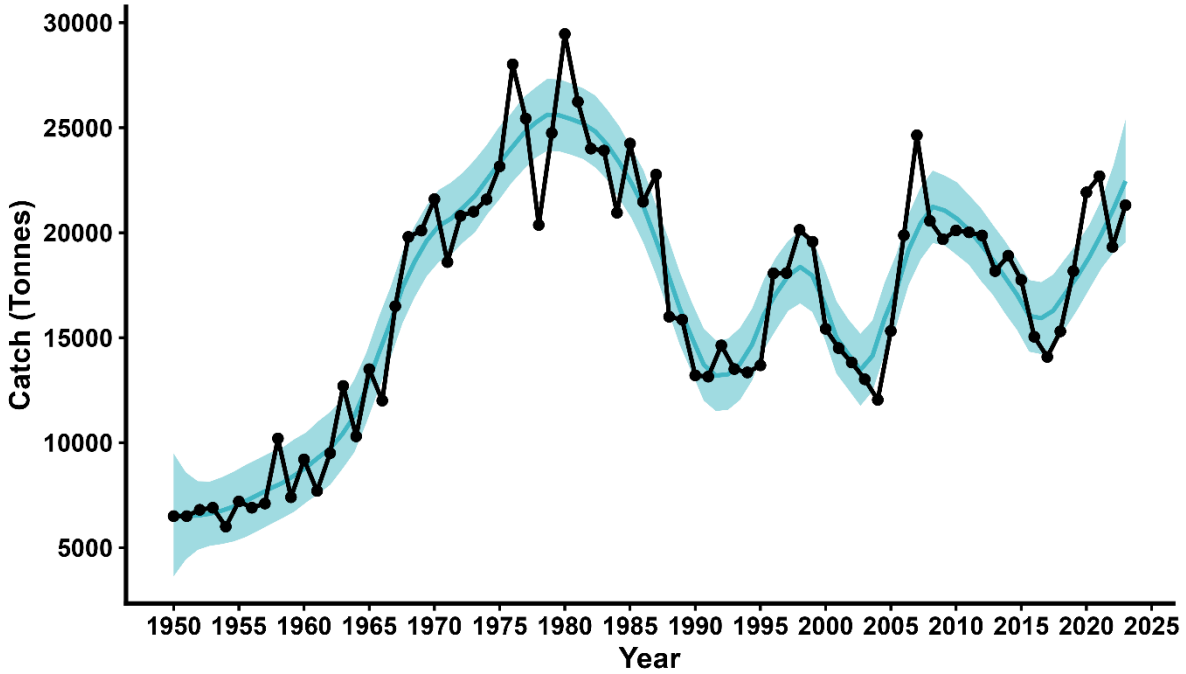


Figure 1. Annual catch of yellow-striped flounder in the Korean waters (Northwest Pacific), 1950 – 2023. Points show observed catches (tonnes), and the LOESS curve with shaded 95% confidence interval illustrates the overall temporal trend.

CMSY++ outcomes for yellow striped flounder in Korea. The CMSY++ analysis estimated an intrinsic growth rate (r) of 0.288 yr^{-1} (95% CI: 0.164 – 0.504) and a carrying capacity (K) of 278,000 t (95% CI: 179,000 – 431,000 t (Figure 2; Figure 3; Table 2). The maximum sustainable yield (MSY) was estimated at 19,200 $t \cdot yr^{-1}$ (95% CI: 16,100 – 24,000 $t \cdot yr^{-1}$), with the corresponding biomass at MSY (B_{MSY}) of 139,000 t (95% CI: 89,500 – 215,000 t) (Figure 2; Table 2).

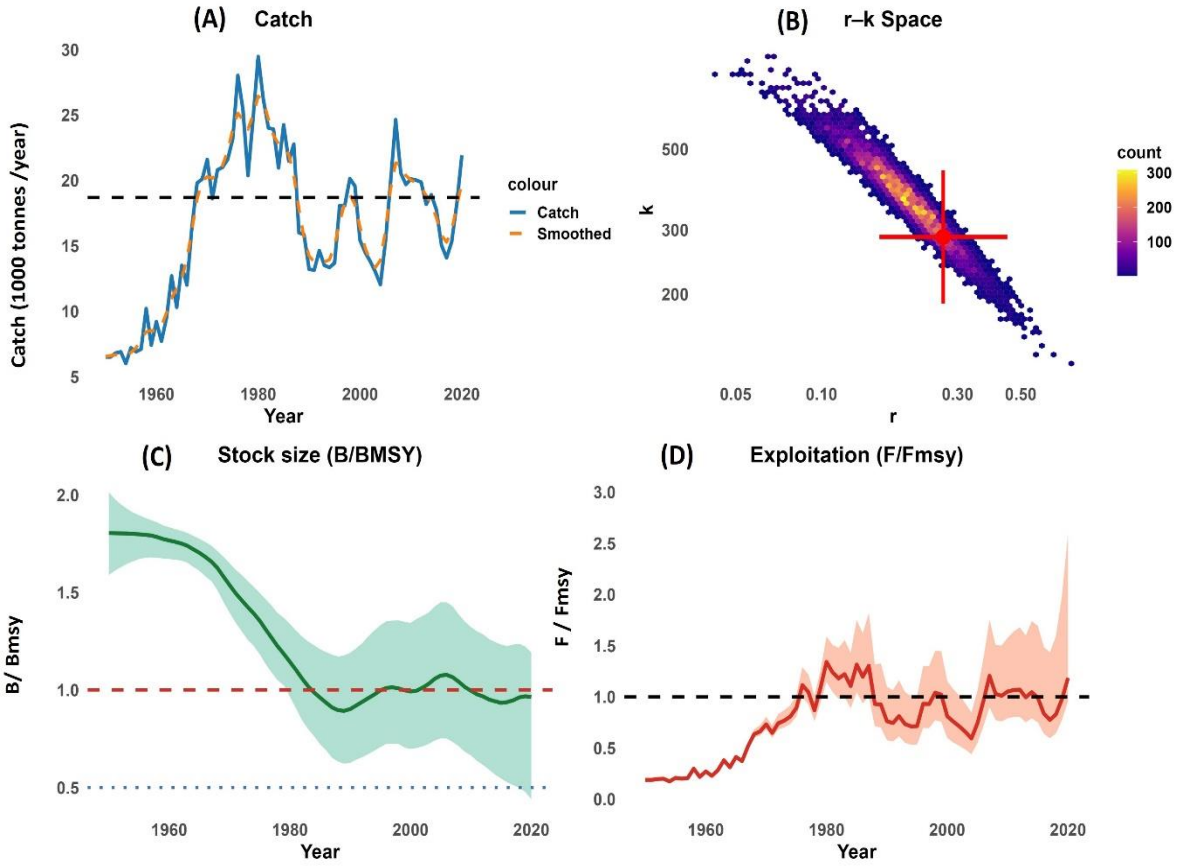


Figure 2. CMSY results showing (A) annual catch (solid line) and smoothed catch (dashed line) with the MSY indicated by a horizontal dashed line, (B) viable r–k parameter space with the estimated r and k (point) and confidence intervals (cross lines), (C) stock size (B/B_{MSY}) with median trajectory (solid line), confidence intervals (shaded area), and reference lines at B/B_{MSY} = 1 (dashed) and 0.5 (dotted), and (D) exploitation rate (F/F_{MSY}) with median trend (solid line), confidence intervals (shaded area), and a reference line at F/F_{MSY} = 1 (dashed).

Time-series trends indicate that catches increased until the late 1970s and fluctuated thereafter (Figure 2), while stock biomass declined from high initial levels and stabilized near B_{MSY} in recent years (Figure 2). Fishing pressure increased markedly during the 1970s – 1980s and has remained variable but close to F_{MSY} since then (Figure 2). In 2023, the estimated stock biomass was 138,000 t (95% CI: 62,700 – 166,000 t), yielding a B/B_{MSY} ratio of 0.991 (95% CI: 0.451 – 1.19), which is close to the sustainability threshold of 1 (Figure 2; Table 2).

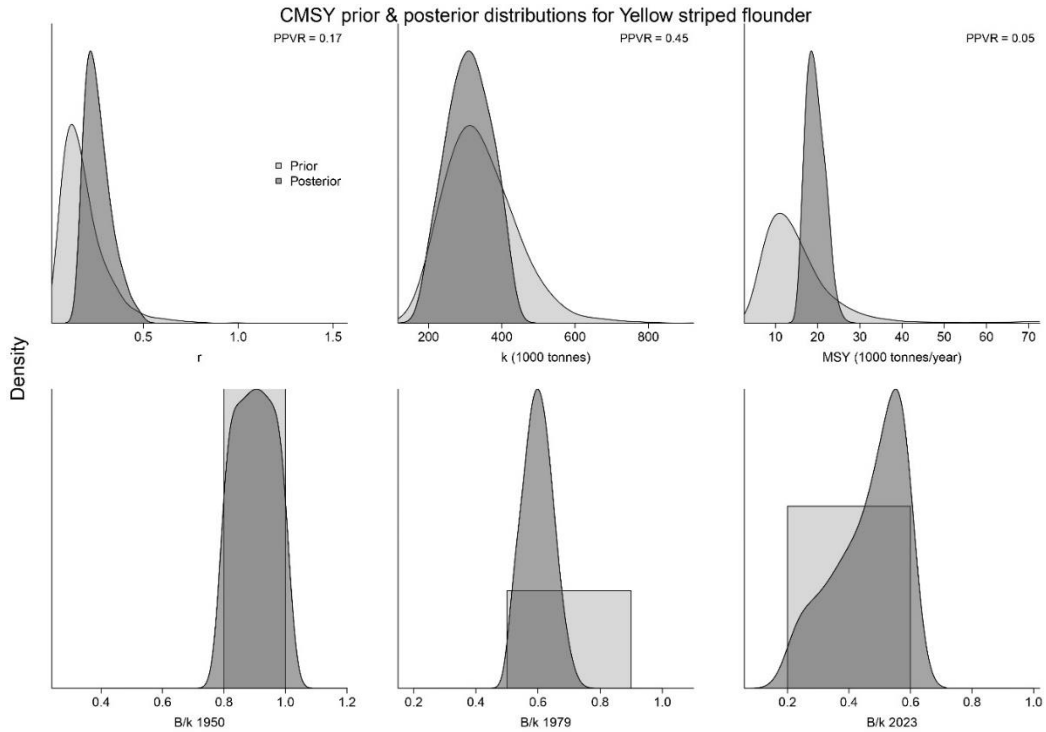


Figure 3. Prior (light) and posterior (dark) CMSY++ distributions for yellow striped flounder in the Korean waters (Northwest Pacific), 1950–2023, showing r, k, MSY, and B/k. PPVR (Prior–Posterior Variance Ratio) values are indicated for each panel.

The B/K ratio was 0.495 (95% CI: 0.226 – 0.596), indicating that the stock is at approximately half of its carrying capacity (Figure 4).

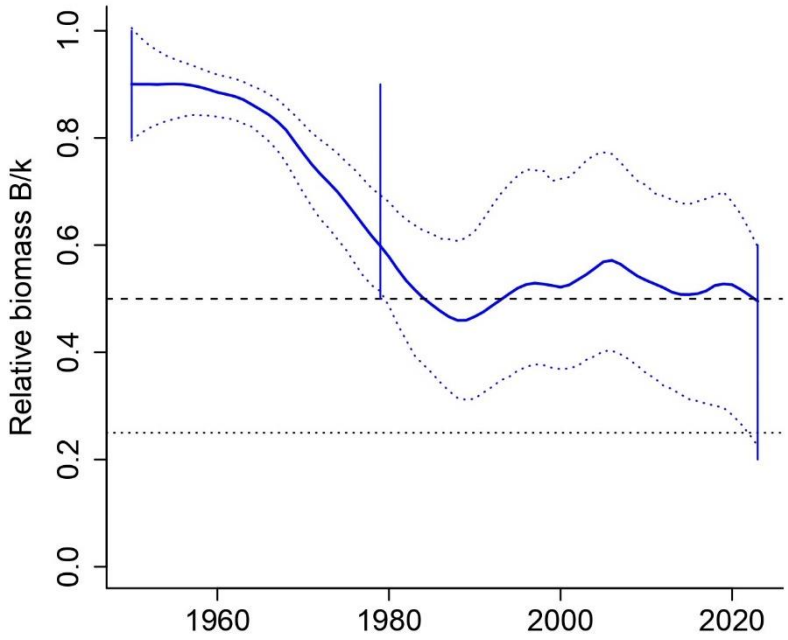


Figure 4. Time series of relative biomass (B/K) estimated by the CMSY model from 1950 to 2023. The solid blue line represents the median biomass trajectory, while the dotted blue lines indicate the 95% confidence intervals. The horizontal dashed line denotes the biomass level corresponding to B_{MSY}/K (0.5), and the horizontal dotted line shows the limit reference point (0.25).

Fishing mortality in 2023 was estimated at 0.155 yr^{-1} (95% CI: 0.129 – 0.34), slightly exceeding the fishing mortality at MSY (F_{MSY} = 0.144 yr^{-1}; 95% CI: 0.0821 – 0.252), resulting in an exploitation rate (F/F_{MSY}) of 1.08 (95% CI: 0.895 – 2.36) (Figure 2; Figure 5). The Kobe plot indicates that the stock is located near the boundary between the red and orange regions, with biomass close to B_{MSY} and fishing mortality slightly exceeding F_{MSY} (Figure 5).

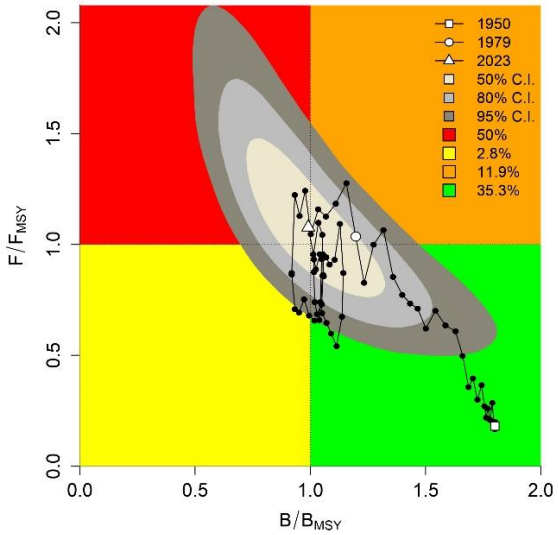


Figure 5. Kobe plot showing the stock status of yellow-striped flounder in Korea (1950–2023). Black dots indicate years; green, yellow, orange, and red areas represent safe, recovery, overfished, and depleted biomass zones, respectively. Grey shades show 50%, 80%, and 95% credibility intervals for the most recent assessment.

Overall, these results suggest that the stock is experiencing slight overfishing, with biomass close to sustainable levels but fishing mortality exceeding the recommended threshold.

Table 2

CMSY++ estimates yellow striped flounder in Korea

Parameter	*Unit*	*Estimate (95% confidence interval)*
Intrinsic growth rate, r	yr^{-1}	0.288 (0.164 – 0.504)
Carrying capacity, K	t	278,000 (179,000 – 431,000)
Maximum sustainable yield, MSY	$t \cdot yr^{-1}$	19,200 (16,100 – 24,000)
Biomass at MSY, B_{MSY}	t	139,000 (89,500 – 215,000)
Biomass in last year, B	t	138,000 (62,700 – 166,000)
Stock biomass relative to B_{MSY}, B/B_{MSY}	–	0.991 (0.451 – 1.19)
Stock biomass relative to carrying capacity, B/K	–	0.495 (0.226 – 0.596)
Fishing mortality, F	yr^{-1}	0.155 (0.129 – 0.34)
Fishing mortality at MSY, F_{MSY}	yr^{-1}	0.144 (0.0821 – 0.252)
Exploitation rate, F/F_{MSY}	–	1.08 (0.895 – 2.36)
Exploitation F/(r/2)	–	1.08 (0.895 – 2.36)
Stock status	–	Slightly overfished

Discussion. Fisheries scientists and managers commonly incorporate key population parameters such as intrinsic growth rate (r), carrying capacity (k), catchability coefficient (q), and maximum sustainable yield (MSY) when aiming to achieve sustainable resource utilization (Froese et al., 2017). Among these, MSY remains one of the most widely used biological reference points (BRPs), while the ratio B/B_{MSY} is frequently applied to evaluate stock status and determine whether a fish population is overexploited or sustainably managed (Yin et al., 2023). Stock assessment plays a central role in sustainable fisheries management because it generates the scientific information needed for policy formulation and resource conservation (Gebremedhin et al., 2021). In this context, biological reference

points derived from various statistical and analytical methods are used to assess the condition of fish stocks and guide management decisions (Mangel et al., 2013). However, many stock assessment models require large amounts of high-quality data, which limits their application mainly to commercially important or well-studied species (Mangel et al., 2013). As a result, a considerable number of lesser-known or non-target species remain insufficiently assessed, creating important gaps in fisheries management and stock evaluation (Fujita, 2021). This study provides a comprehensive catch-based assessment of yellow striped flounder (*Pseudopleuronectes herzensteini*) in Korean waters of the Northwest Pacific using the CMSY++ framework.

In Korean waters, the stock is currently in a relatively stable condition close to biological reference points. The intrinsic growth rate is estimated at r = 0.288 yr^{-1}. The carrying capacity is K = 278,000 t, while the maximum sustainable yield is MSY = 19,200 $t \cdot yr^{-1}$, reflecting a highly productive demersal fishery system. Current biomass (B = 138,000 t) is nearly identical to biomass at MSY (B_{MSY} = 139,000 t), resulting in B/B_{MSY} = 0.991 (0.451 – 1.19). This suggests that the stock is operating very close to its optimal biological level. However, fishing mortality is slightly above sustainable limits (F/F_{MSY} = 1.08), indicating mild overfishing and placing the stock within a precautionary management zone. In contrast, Japanese waters exhibit a markedly different stock condition characterized by severe depletion. Biomass is substantially below the level required to support maximum sustainable yield (B/B_{MSY} = 0.182), while fishing mortality greatly exceeds sustainable limits ($F/_{FMSY}$ = 3.10), indicating prolonged overexploitation and a heavily depleted stock (Zhang et al., 2020). These results contrast sharply with those observed in Korean waters, where biomass remains close to B_{MSY} and fishing pressure is only slightly above F_{MSY}. Comparison of population parameters further highlights these regional differences. Although the intrinsic growth rate (r) is slightly higher in Japanese waters, this apparent productivity advantage has not translated into improved stock status because of sustained high fishing pressure and reduced biomass. The carrying capacity estimated for Korean waters (K = 278,000 t) is substantially greater than that reported for Japanese waters (K = 7,190 t), suggesting considerable differences in stock productivity, population size, and habitat support capacity between the two regions. Likewise, the estimated MSY in Korean waters (19,200 $t \cdot yr^{-1}$) is considerably higher than that in Japanese waters (713 $t \cdot yr^{-1}$), indicating a greater potential for sustainable harvest. These contrasting stock conditions are likely influenced by differences in fishing intensity, management practices, recruitment dynamics, habitat quality, and environmental conditions, all of which can affect population productivity and recovery potential. Collectively, the results suggest that long-term fishing pressure has played a major role in shaping the divergent stock trajectories observed between Korean and Japanese waters. Historically, the Korean stock has experienced periods of high exploitation, particularly during the late 1970s and early 1980s, when catches exceeded estimated MSY. These episodes likely contributed to past biomass declines; however, partial recovery is evident in recent years. Despite this recovery, the current condition still reflects the combined effects of historical fishing pressure and ongoing moderate exploitation.

CMSY-based assessments of other flatfish species in the Japan Sea further confirm widespread overexploitation. Species such as *Cleisthenes pinetorum*, *Eopsetta grigorjewi*, *Hippoglossoides dubius*, and *Paralichthys olivaceus* are all classified as overfished with varying levels of depletion (Zhang et al., 2020). Within this context, *P. herzensteini* in Japanese waters represents one of the most severely depleted demersal stocks, highlighting its high vulnerability compared to other flatfish species (Zhang et al., 2020). However, length-based stock assessments of two other commercially important flounder species, *Cleisthenes pinetorum* and *Glyptocephalus stelleri* in the East Sea of Korea, also indicate low biomass (B/B_{MSY}), suggesting that these species are similarly experiencing overfishing in the region (Majeed et al., 2025).

Overall, the CMSY++ results indicate that yellow striped flounder exhibits strong spatial variability in stock status between Korea and Japan waters. Korean waters currently support a near-sustainable but slightly overfished stock, while Japanese waters show severe depletion driven by prolonged and intense fishing pressure (Zhang et al., 2020). From a management perspective, maintaining fishing mortality at or below F_{MSY} in Korean

waters is essential to prevent future stock decline and promote long-term sustainability. Given that the current fishing mortality slightly exceeds the sustainable threshold (F/F_{MSY} = 1.08), a modest reduction in fishing effort may be necessary to allow biomass to remain above B_{MSY}. Management measures could include periodic adjustment of total allowable catches (TACs) based on updated stock assessments, implementation of seasonal closures during peak spawning periods to protect reproductive individuals, and gear regulations such as increased mesh sizes to reduce the capture of juveniles. In addition, continued fishery-independent monitoring and regular stock assessments are recommended to track changes in stock status and evaluate the effectiveness of management actions. Collectively, these measures would help maintain sustainable exploitation and reduce the risk of future overfishing of this economically important demersal species.

Conclusions. This study assessed the stock status of yellow striped flounder (*Pseudopleuronectes herzensteini*) in Korean waters using the CMSY++ approach. The results indicate that the stock is close to sustainable levels ($B/B_{MSY} \approx 0.99$), although fishing pressure slightly exceeds the optimal level (F/F_{MSY} = 1.08), suggesting mild overfishing. Historical catches exceeding MSY highlight periods of elevated exploitation. A precautionary reduction in fishing effort is recommended to ensure the stock remains above sustainable levels and it can support long-term stability. A key limitation of this study is that the assessment relied only on catch data, without incorporating fishing effort information. Future studies should integrate catch and effort data, along with length-based assessment approaches, to improve the accuracy and strength of stock status estimates. Overall, continued monitoring and cautious management are essential to prevent future depletion of this resource.

Author Contributions. Conceptualization and study design: SM.; Methodology: SM.; Software: SM.; Data curation: SM.; Formal analysis: SM.; Visualization: SM.; Writing—original draft: SM.; Writing—review and editing: SM, KCH.

Conflict of Interest. The authors declare no conflicts of interest.

Data Availability. The datasets generated during this study are available from the corresponding author upon reasonable request.

Funding. This research received no external funding.

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Received: 15 August 2026. Accepted: 28 September 2026. Published online: 30 October 2026.
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How to cite this article:
Majeed, S., & Hwan, K. C. (2026). Data-limited stock assessment of yellow striped flounder (*Pseudopleuronectes herzensteini*) in Korea using the CMSY++ approach. *Aquaculture, Aquarium, Conservation & Legislation*, *19*(5), 2618-2629. https://doi.org/10.67784/4003