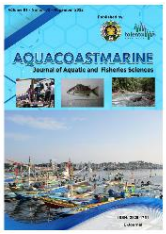
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Hidden Harvest Estimation in Small-Scale Fisheries Landed at Dumai Fish Landing Port, Indonesia

Estimasi Tangkapan Tersembunyi pada Perikanan Skala Kecil yang Didaratkan di Pelabuhan Pendaratan Ikan Dumai, Indonesia

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ABSTRACT

The Fisheries production in Dumai City is predominantly derived from marine fisheries. This substantial marine fisheries potential is largely categorized under small-scale fisheries (SSF). By quantifying hidden harvests and examining their relationship with small-scale fisheries activities, policymakers can obtain a more comprehensive understanding of fisheries production, fisher livelihoods, and resource utilization patterns. Therefore, this study aims to estimate the hidden harvest generated by SSF in Dumai Waters, that land their catches at the Dumai Fish Landing Port. The study was conducted at the Fish Landing Port in Dumai, Indonesia (1° 41′ 42.14″ N, 101° 24′ 39.00″ E) during May-June 2026. Primary data on the catch volume of target species were collected through direct, structured interviews with SSF during their landing activities at the Dumai Fish Landing Port. Data Analysis including fishing productivity analiysis and hidden harvest estimassion. All data processing, statistical analyses, and graphical visualizations were performed using R software. The result showed hidden harvests estimated for SSF in Dumai waters, culminate at 18.59 tons month^{-1} or 223.08 tons year^{-1}, actual fisheries production in the region is roughly 130.7% higher than official statistics indicate. This stark discrepancy underscores an urgent need for local marine and fisheries authorities to shift from generalized macro data collection toward localized, gear specific monitoring frameworks. To ensure sustainable management in Dumai waters.

Keyword: Fishing productivity, Hidden harvest, Push nets, Shrimps, SSF

ABSTRAK

Produksi perikanan di Kota Dumai sebagian besar berasal dari perikanan laut. Potensi perikanan laut yang besar ini sebagian besar termasuk dalam kategori perikanan skala kecil. Dengan mengukur hasil tangkapan tersembunyi dan menganalisis hubungannya dengan kegiatan perikanan skala kecil, para pembuat kebijakan dapat memperoleh pemahaman yang lebih komprehensif mengenai produksi perikanan, mata pencaharian nelayan, dan pola pemanfaatan sumber daya. Oleh karena itu, penelitian ini bertujuan untuk memperkirakan hasil tangkapan tersembunyi yang dihasilkan oleh SSF di Perairan Dumai, yang mendaratkan hasil tangkapannya di Pelabuhan Pendaratan Ikan Dumai. Penelitian ini dilakukan di Pelabuhan Pendaratan Ikan Dumai, Indonesia (1° 41′ 42.14″ N, 101° 24′ 39.00″ E) selama Mei-Juni 2026. Data primer mengenai volume tangkapan spesies target dikumpulkan melalui wawancara langsung dan terstruktur

dengan nelayan skala kecil selama aktivitas pendaratan mereka di Pelabuhan Pendaratan Ikan Dumai. Analisis data mencakup analisis produktivitas perikanan dan estimasi hasil tangkapan tersembunyi. Seluruh pengolahan data, analisis statistik, dan visualisasi grafis dilakukan menggunakan perangkat lunak R. Hasil menunjukkan bahwa panen tersembunyi yang diperkirakan untuk nelayan skala kecil di perairan Dumai mencapai 18,59 ton per bulan atau 223,08 ton per tahun. Produksi perikanan aktual di wilayah tersebut sekitar 130,7% lebih tinggi daripada yang ditunjukkan oleh statistik resmi. Perbedaan yang mencolok ini menegaskan kebutuhan mendesak bagi otoritas kelautan dan perikanan setempat untuk beralih dari pengumpulan data makro yang bersifat umum ke kerangka pemantauan yang lebih terfokus pada lokasi dan jenis alat tangkap tertentu.untuk memastikan pengelolaan yang berkelanjutan di perairan Dumai,

Keyword: Perikanan skala kecil, Produktivitas perikanan, Sondong, Tangkapan tersembunyi, Udang

1. Introduction

Fisheries production in Dumai City is predominantly derived from marine fisheries. According to data from the Dumai City Fisheries Service, marine fisheries accounted for 76.25% of the total 1,630.7 tons of fish production in 2025 (BPS - Statistics Dumai Municipality, 2026). This substantial marine fisheries potential is largely categorized under small-scale fisheries, which play a pivotal role in sustainable development. Specifically, small-scale fisheries contribute significantly to food security, nutrition, local economies, livelihoods, fishing rights, and gender equality, thereby aligning with the United Nations Sustainable Development Goals (SDGs) and global capture fisheries management (FAO et al., 2023).

Small-scale fisheries (SSF) is one of the most important livelihoods in Indonesia (Saksono et al., 2023). SSF often operate informally, leading to significant gaps in official documentation. Due to their highly diverse and dispersed nature, quantifying the comprehensive contributions of these fisheries remains a methodological challenge. Consequently, critical parameters including total catch, employment rates, nutritional impacts, and governance structures are frequently omitted or aggregated indistinctly within national statistics. This data exclusion prevents small-scale fisheries from being explicitly integrated into national, regional, and global policy frameworks. So long as these sectors remain data-deficient or 'hidden,' they will inevitably face continued marginalization in political, decision-making, and resource management arenas (FAO et al., 2023).

Although the importance of small-scale fisheries and hidden harvests has been widely recognized, empirical assessments remain limited at the local level. Previous studies have highlighted the substantial contribution of small-scale fisheries to food security, livelihoods, and fisheries production, while also demonstrating that official statistics often underestimate actual catches due to unreported and informal fishing activities (Basurto et al., 2025; Fluet-Chouinard et al., 2018; Pita et al., 2019). However, most studies have focused on global or national scales, leaving significant knowledge gaps in many coastal regions. In Dumai Waters, despite the economic importance of marine fisheries, no study has quantified hidden harvests generated by small-scale fisheries or assessed their contribution to total fisheries production. As a result, the extent of unreported catches and their implications for fisheries statistics and management remain poorly understood. This study addresses this gap by estimating hidden harvests and evaluating their contribution to fisheries production and local livelihoods in Dumai Waters, focusing on small-scale fisheries that land their catches at the Dumai Fish Landing Base, Riau Province, Indonesia. Fisheries production in this region is generally dominated by small pelagic fish and coastal demersal fish, which are the primary targets of small-scale fishermen, in line with the characteristics of the small-scale fleet and daily fishing operations (Mardiah et al., 2021; Pramesthy & Hutapea, 2020).

Hidden harvest refers to the relative contributions of various fisheries subsectors, both at the harvest and post-harvest stages, which have not yet been systematically assessed to inform fisheries policy formulation and management (World Bank, 2012). Understanding the magnitude of hidden harvests is essential for improving fisheries management and ensuring sustainable utilization of fishery resources. By quantifying hidden harvests and examining their relationship with small-scale fisheries activities, policymakers can obtain a more comprehensive understanding of fisheries production, fisher livelihoods, and resource utilization patterns. Therefore, this study aims to estimate the hidden harvest generated by small-scale fisheries in Dumai focusing on small-scale fisheries that land their catches at the Dumai Fish Landing Base. The findings are expected to provide valuable information for strengthening fisheries statistics, supporting evidence-based management, and enhancing the recognition of small-scale fisheries in regional development planning used.

2. Method

2.1 Study Site and Data Collection

The study was conducted at the Fish Landing Port in Dumai, Indonesia (1° 41′ 42.14″ N, 101° 24′ 39.00″ E). Primary data on the catch volume of target species were collected through direct, structured interviews with small-scale fishers during their landing activities at the Dumai Fish Landing Port. The fishers self-reported their actual daily catches, which were formally documented during the survey period. This interview-based approach was employed to precisely quantify the monthly production originating strictly from the small-scale fishing sector, aligned with the 'hidden harvest' conceptual framework that emphasizes the documented contribution of artisanal fisheries.

Fisher surveys, including household and recall surveys, were conducted using structured questionnaires administered to active fishers. The surveys collected information on fishing activities during the previous three months, including the number of fishing trips, average catch per trip, total catch, trip duration, number of active fishing days per month, fishing gear used, target fish species, and catch utilization patterns for household consumption and sale. These data were used to estimate actual catch production and fishing effort.

2.2 Framework

Based on the stated research objectives and methodological approach, the overall research framework is illustrated in **Figure. 1**.

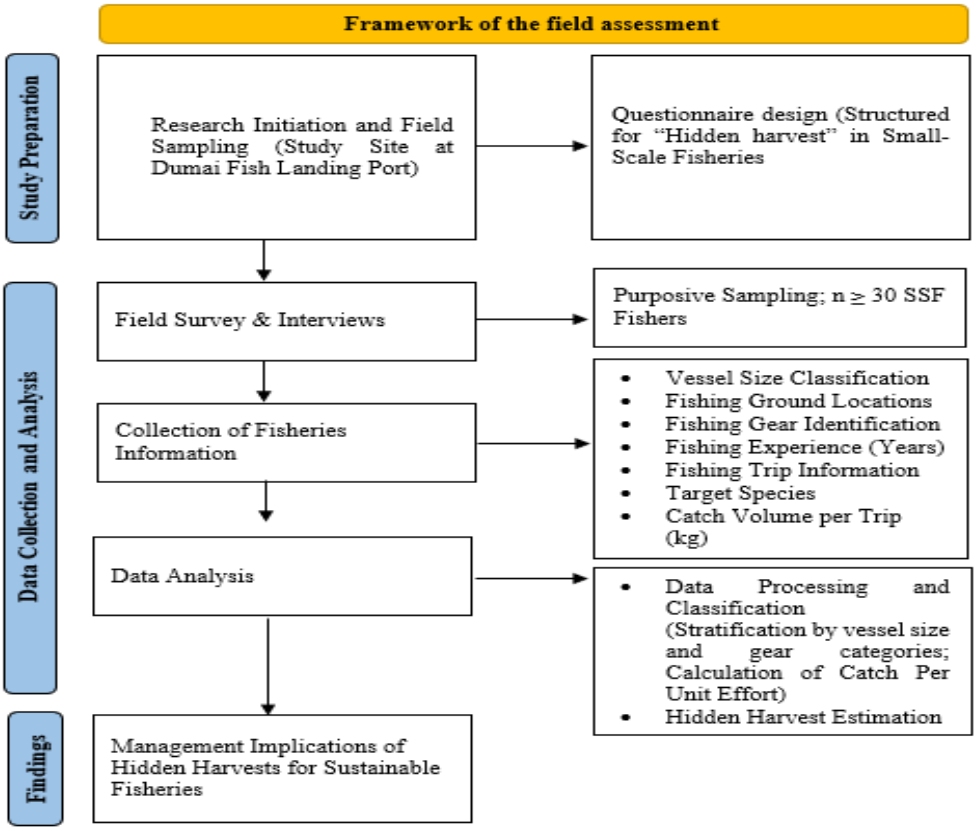


Figure 1. Framework of the field assessment

2.3 Data Analysis

2.3.1 Fishing Productivity Analiysis

Catch per unit effort (CPUE) was used as an index of fishing productivity and was calculated separately for each fishing gear type. CPUE was estimated by dividing the catch obtained in each fishing trip (kg) by the corresponding fishing operation time (hours), as follows:

$$CPUE_i = \frac{C_i}{E_i}$$

Where $CPUE_i$ is catch per unit effort for trip i (kg h^{-1}), C_i is catch obtained in trip i (kg), and E_i is fishing operation time during trip i (h). The CPUE values were subsequently grouped and analyzed according to fishing gear type to compare fishing productivity among gears.

2.3.1 Hidden Harvest Assessment

Hidden harvest was estimated using a raising factor approach, in which all catches reported through fisher surveys were considered part of the hidden harvest. Total catch production was estimated by expanding the average catch and fishing effort data obtained from sampled fishers to the active fishing population. The total catch was calculated as:

$$C_{total} = N \; x \; \bar{f} \; x \; \bar{c} \; x \; 4$$

where N is the number of respondent fishers, $\bar{f}$ mean number of fishing trips undertaken by a fisher each week, and $\bar{c}$ is average catch obtained from a single fishing trip (kg). When multiple fishing gears were involved, the estimation was conducted separately for each gear category and subsequently aggregated to obtain the total hidden harvest. All data processing, statistical analyses, and graphical visualizations were performed using R software (R Core Team, 2024).

3. Result and Discussion

Fishers in the study area predominantly operated vessels within the 3–5 GT size class, while only a few vessels exceeded 5 GT, with the largest vessel reaching 6 GT. The vessel size distribution of the fishing fleet operating in Dumai Waters and utilizing the Dumai Fish Landing Port as their primary landing site is presented in Fig. 2a. This finding indicates that fishing activities in the study area are primarily conducted by small-scale fishing vessels. An example of a typical fishing vessel operating in the area is presented in Fig. 2b. The composition of fishing gears used by small-scale fishers in Dumai Waters is presented in Fig. 3.

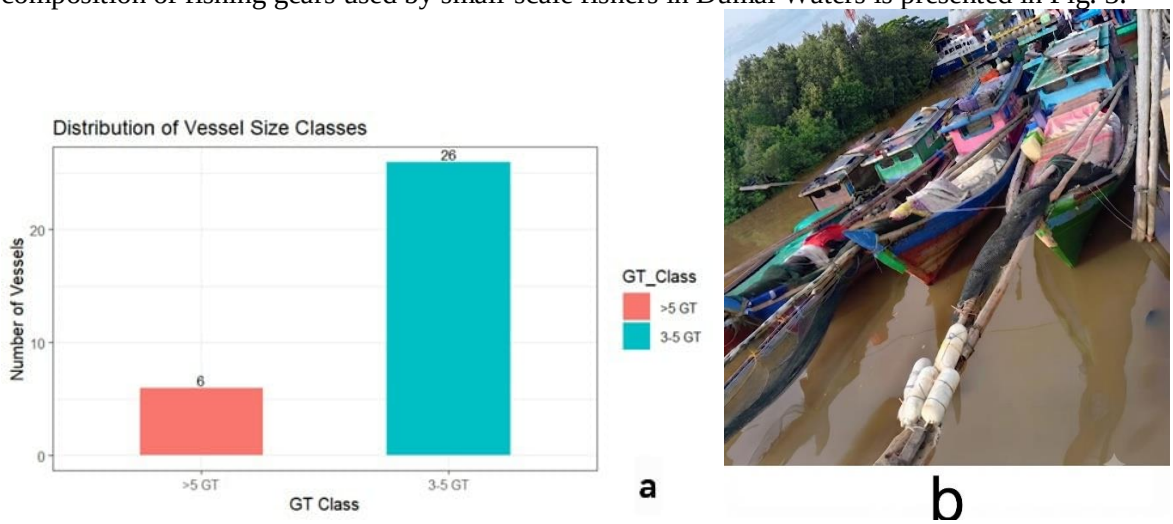


Figure 2. Characteristics of the small-scale fishing fleet in Dumai Waters: (a) vessel size class distribution; and (b) a typical fishing vessel operating in the study area

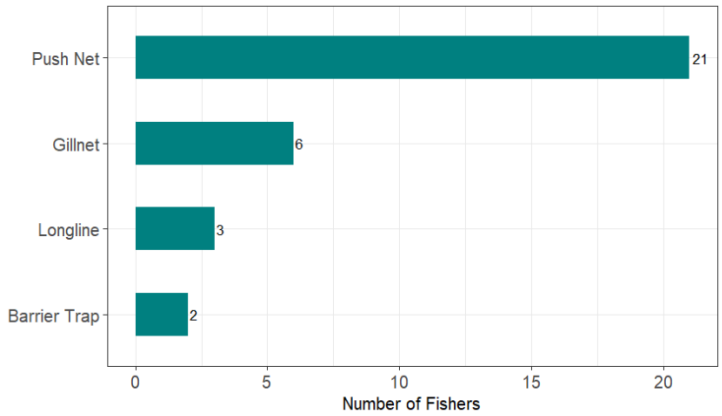


Figure 3. Composition of fishing gears used by small-scale fishers in Dumai Waters

As shown in **Figure 3**, Push net was the dominant fishing gear, accounting for 75.7% of the total gears used. Consequently, this high prevalence made it the primary contributor to hidden harvests, while other fishing gears contributed only a small proportion. The distribution of fishing productivity, expressed as catch

per unit effort (CPUE), is presented in **Figure 4**. The estimated hidden harvest production across various fishing gear categories in Dumai Waters is depicted in Fig. 5. As illustrated in Fig. 6, the allocation of hidden harvest across gear categories exhibits an extreme asymmetry.

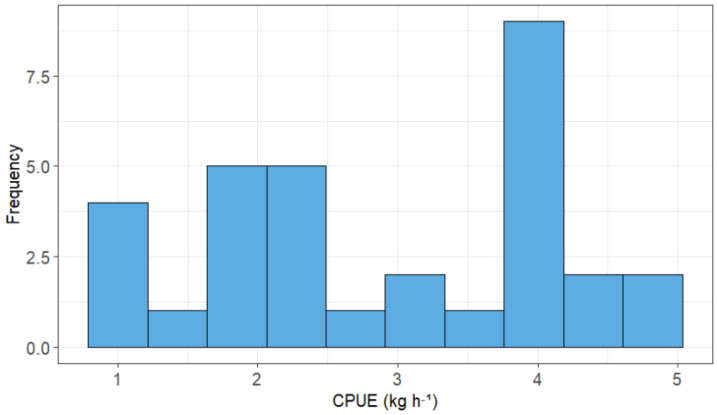


Figure 4. Distribution of CPUE among fishing operations in small-scale fisheries of Dumai Waters.

The highest CPUE value was recorded for push net operations, with an average CPUE of 3.30 kg h^{-1}, followed closely by gillnet fisheries at 3.15 kg h^{-1}. In contrast, barrier traps and longlines yielded relatively lower average CPUE values of 1.14 kg h^{-1} and 1.06 kg h^{-1}, respectively. This lower yield is attributed to their function as supplementary gears onboard the push net vessels. These findings indicate that variations in CPUE among fishing gears are driven not only by gear efficiency itself, but also by deployment intensity and the strategic operational priorities of the fishers.

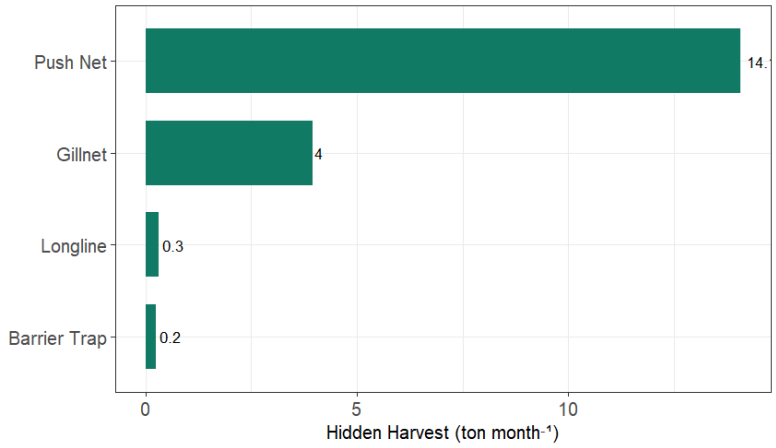


Figure 5. Estimated hidden harvest production by fishing gear categories in Dumai Waters

Small-scale fisheries generated a cumulative hidden harvest estimated at 18.59 tons $month^{-1}$. This production exhibited a highly skewed distribution among the deployed gears, with push net accounting for the vast majority of the total volume. Conversely, alternative fishing gears contributed only a marginal fraction to the overall estimate. These outcomes underscore that the bulk of unreported fisheries production is heavily concentrated within the dominant operational activities of the local small-scale fleet, highlighting a critical focal point for data rectification and fisheries management.

Push net operations alone accounted for 75.7% of the total estimated undocumented production, whereas alternative fishing gears yielded negligible contributions. This disproportionate distribution underscores that data deficiencies and unreported landings are not systemic across all small-scale operations; rather, they are heavily concentrated within the fleet's primary fishing activity, pointing to push net as the critical focal point for future fisheries monitoring and regulatory interventions.

A total of 32 small-scale fishers took part in this study as respondents. Demographic analysis revealed that fishers in the waters off Dumai are predominantly of prime working age, with a mean age of 37 years. Furthermore, they possess substantial fishing experience, averaging 12.5 years in the sector. This combination of physical maturity and extensive local ecological knowledge suggests that the fishers are highly skilled in navigating local fishing grounds and optimising gear operations. Qualitative insights from interviews further revealed that their fishing activities are heavily concentrated in the Senepis area. This strategic spatial preference is strongly reflected in the operational efficiency and tactical gear deployment observed in the study area, particularly regarding push net operations, prior to evaluating its subsequent impact on hidden harvests.

Sound technical expertise also plays a key role in the effective use of push-net fishing gear; however, as its operation is concentrated in coastal areas such as Senepis, strict monitoring is required to mitigate the impact of 'hidden harvests' or by-catches, which are often not recorded in official statistics (Pauly & Zeller, 2016).

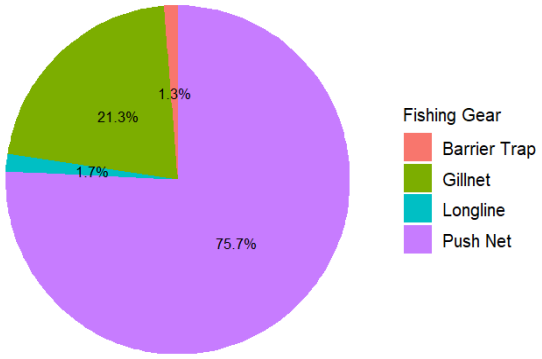


Figure 6. Proportional contribution of fishing gears to hidden harvest production

The field survey utilizing direct fisher interviews at Fish Landing Port Dumai revealed that the recorded catch for the target species from small-scale fisheries reached an estimated 18.59 tons month^{-1}. This primary data underscores a substantial production volume that is formally reported at the landing site. Within the context of the global 'Hidden Harvest' discourse, these findings demonstrate that when small-scale fisheries' data are meticulously captured through direct field interviews, their actual contribution to local fisheries production is highly significant and forms the baseline of coastal community economics in Dumai. Unveiling this magnitude of 'Hidden Harvests' is paramount for sustainable marine governance. (Aguión et al., 2025; Bitoun et al., 2024a; FAO et al., 2023; Yuliana et al., 2026).

The assessment of fisheries efficiency in Dumai waters demonstrated varying catch rates across different small-scale gears. Fishing productivity, or CPUE, is essential to the management and observation of catch fisheries (Sari et al., 2026). Our findings revealed that push nets exhibited the highest Catch Per Unit Effort (CPUE) at 3.30 kg hour^{-1}, followed by gill nets (3.15 kg hour^{-1}), longlines (1.14 kg hour^{-1}), and barrier traps (1.06 kg hour^{-1}). The superior CPUE of push net underscores its high operational efficiency as an active demersal gear specifically designed to sweep shallow muddy substrates, making it highly effective at extracting coastal shrimp populations compared to passive gears like barrier traps or longlines (Amri et al., 2023).

This technical efficiency directly reflects the macro-production trends of the region. Based on official statistics. The total recorded shrimp landing in Dumai for 2025 was 96.7 tons year^{-1}. This production was heavily dominated by *Atypopenaeus formosus* (46.9 tons) and *Metapenaeus eboracensis* (44.6 tons), followed by *Parapenaeopsis sculptilis* (5.2 tons), while *Penaeus semisulcatus* was absent from the formal reports (BPS - Statistics Dumai Municipality, 2026). Interestingly, our interview-based landing survey revealed a substantially higher production estimation, reaching 18.59 tons month^{-1}, which scales up to 223.08 tons year^{-1} (indicating that actual fisheries production was approximately 130.7% higher than the officially reported production of 96.7 tons year^{-1}).

This trend is consistently supported by previous studies, which reported that the landings of economically important shrimp species in May and June 2022 were 12.04 tons month^{-1} and 9.42 tons month^{-1}., respectively (Sari Mardiah et al., 2022). In comparison, the findings of the current study reveal a remarkably higher estimation of hidden harvests (HH). Based on field interviews conducted with 32 fishers during the May–June 2026 fishing period, the estimated HH for these economically important shrimp species caught for push nets reached up to 14.00 tons month^{-1}. This substantial volume indicates an increase in current catch levels compared with the findings of previous studies, as well as with the official data recorded by (BPS - Statistics Dumai Municipality, 2026).

This technical and mathematical insight explains the discrepancy between the datasets. While macro-level statistics often experience recording gaps due to aggregated data collection, our direct interview approach precisely isolated the high efficiency, shrimp-targeted operations of small-scale fishers. This confirms that the actual extraction of these four shrimp species in Dumai waters driven predominantly by push net fishers is heavily underestimated in formal reporting frameworks. Furthermore, our study reveals that an average of 2% of the total catch is directly allocated for fishers' home consumption. This subsistence portion, combined with post-harvest discards and catch sold through informal channels, constitutes critical components of small-scale fisheries production that consistently bypass official reporting systems. This reporting gap aligns with documented patterns in other Indonesian small-scale gill-net fisheries, such as in East Lampung, where a significant portion of non-target species (ranging from 8.76% to 11.40%) is retained for direct home

consumption or informal local marketing rather than being recorded in formal landing statistics (Zairion et al., 2019).

The total annual shrimp catch calculated from our field interviews (223.08 tons year^{-1}) noticeably exceeded the official data reported by BPS 2026 (96.7 tons year^{-1}). This data gap is a classic representation of the 'hidden harvest' phenomenon often encountered in small-scale fisheries frameworks (FAO et al., 2023). Although the interviewed fishers officially utilized the Dumai Fish Landing Port, the macro-level statistics frequently experience minor recording lags or oversight, particularly regarding small-scale daily transactions. The direct interview approach successfully illuminated these undocumented yields, proving that the actual contribution of small-scale shrimp fishers to local food security and the coastal economy is much higher than formally reported.

In conclusion, this study provides critical empirical insights into the small-scale shrimp fisheries in Dumai waters, highlighting a substantial underestimation in formal production records. Technically, push nets operates as the most efficient artisanal gear in the region, exhibiting the highest CPUE of 3.30 kg hour^{-1} compared to gill nets, longlines, and tidal traps. This high operational efficiency directly translates into intensive catch volumes, with push nets operations alone contributing an estimated 223.08 tons year^{-1}. This volume creates a profound mathematical data gap of 21.56 tons year^{-1} (22.3%) above the government's aggregated macro-level statistics (BPS, 2026) for all four documented shrimp species combined (96,7 tons year^{-1}). Ultimately, capturing this hidden production volume is not merely a statistical correction, but a regulatory necessity to prevent localized overexploitation and to restructure small-scale fisheries management based on the actual ecological footprint of artisanal gears (Bitoun et al., 2024b).

This discrepancy firmly establishes the presence of a 'hidden harvest' phenomenon within Dumai's formal landing infrastructure, driven by high-frequency, small-scale transactions that bypass formal weight-documentation. More stringent enforcement strategies and spatial-temporal management measures are needed to ensure long-term sustainability and compliance with responsible fishing practices (Sari et al., 2025). Therefore, to achieve sustainable fisheries management in the Dumai Waters, the local marine and fisheries authorities must pivot from generalized macro-level data collection toward localized, gear-specific monitoring frameworks. Integrating interview-based landing surveys into official data registration is highly recommended to accurately illuminate the true socio-economic contributions of small-scale fishers and prevent the overexploitation of these vital demersal shrimp resources.

4. Conclusion

The hidden harvests estimated for SSF in Dumai waters, specifically targeting operations linked to the Dumai Fish Landing Port, culminate at 18.59 tons month^{-1} or 223.08 tons year^{-1}, actual fisheries production in the region is roughly 130.7% higher than official statistics indicate. This stark discrepancy underscores an urgent need for local marine and fisheries authorities to shift from generalized macro-data collection toward localized, gear-specific monitoring frameworks. To ensure sustainable management in Dumai waters, integrating interview-based landing surveys into official registration systems is imperative to illuminate the true socio-economic footprint of small-scale fishers and mitigate the risk of overexploiting vital demersal shrimp stocks.

5. Acknowledgements

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6. Conflict of Interest

The authors declare that they have no competing financial or personal interests that could have influenced the work reported in this study. This research was funded by the DIPA of Marine and Fisheries Polytechnic of Dumai. The funding institution had no role in the study design, data collection, analysis, interpretation of data, manuscript preparation, or the decision to publish the results.

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