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Catch Analysis of Bali Sardinella (*Sardinella Lemuru*) in Damas Beach Small Landing Site, Trenggalek, Indonesia

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Abstract: *The availability of reliable fisheries data from small landing sites is essential for effective fisheries management, yet such sites often lack systematic data collection. This study examines the catch composition of Bali Sardinella (Sardinella lemuru) at the Damas Beach landing site, Trenggalek, Indonesia, and compares it with data from the Prigi fishing port to highlight discrepancies and potential impacts on stock assessments. Surveys conducted from January to March 2023 involved 257 local fishers, gathering data on catch composition and fishing grounds. Results revealed a 2.66% discrepancy between recorded and unrecorded catch data, suggesting that unreported landings could skew regional stock assessments. The study also highlights species overlap in fishing grounds, indicating competition that may affect other fisheries in Prigi waters. These findings underscore the need for improved data collection systems at small landing sites to ensure accurate stock estimates and promote sustainable fisheries management.*

Keywords: *unrecorded data, catch composition, species distribution, fisheries management, fisheries data statistics.*

1. Introduction

The Ministry of Marine Affairs and Fishery of the Republic of Indonesia issues fishery data statistics collected from local fishery authorities and fishing ports to depict the potency of fishery resources (Nurhadi and Sumarsono 2017) and to be applied for generating fishery management (Harlyan et al. 2022a; Harlyan et al. 2022b). In this situation, fishing ports or fish landing sites might be the sources of fishery data statistics (Darmawan et al. 2022)

One of fishing ports in the Southern Java, Indonesia, as a part of Indian Ocean region in the Fisheries Management Area (FMA-573) is Prigi fishing port. In this port, several economically important species are dominantly landed, such as Bali Sardinella (*Sardinella lemuru*) (Ma'mun et al. 2017). Regularly, landing data is recorded and collected by fishing port officers (Tampubolon et al. 2019). However, as a matter of fact, not all fishing ports or fish landing sites can provide reliable data documentation, especially for small landing sites or locally named as Tangkahan (Situmeang et al. 2019).

The existence of small landing sites with lack of data documentation might result in uncertainty in stock assessment. Unrecorded data will affect underestimation of stock availability and impair in fisheries management (Yuniarta et al. 2017), since the data used is only available from the official fishing port. Several studies investigated that these uncertainty conditions might frequently occur in multispecies fisheries, that arise other problems such as uncertainty in stock assessment and fisheries management (Chen 2003; Harlyan et al. 2021; Privitera-Johnson & Punt 2020).

Damas Beach is a small landing site with comparable landing species to Prigi fishing port. As with other small landing sites, Damas Beach small landing sites could not perform fisheries data collection. This small landing site lacks infrastructure and data collection system, which might raise unreliable fisheries data statistics of all fishery resources landed, including economically important species such as Bali Sardinella. This will cause challenges in stock assessment and management (Sari et al. 2021; Yuniarta et al. 2017). This study revealed fishery profile of Damas Beach small landing site including the productivity of the Bali Sardinella as dominant landing species. As limited information of Damas Beach small landing site, the technical comparison of unrecorded landing data between Prigi fishing port as an official fishing port and Damas Beach small landing site is required to be analysed as reference of Damas Beach small landing site improvement plan into fishing port.

2. Materials And Methods

2.1. Study Area

The study was conducted in two landing sites, Damas Beach small landing site and Prigi fishing port (Figure 1) from Januari to March 2023. A field survey to gather daily catch-effort data and fishing ground coordinates of Bali Sardinella landed in Damas Beach small landing site, since there is no fishery data collection available in the landing site. The fishing coordinate data were collected from fishers who landed their catch in the Damas Beach small landing site through participatory mapping. The local fishers were assisted to identify and indicate their fishing coordinates. Monthly fisheries statistics data were gathered in Prigi fishing port contains catch-effort data of Bali Sardinella collected by enumerators.

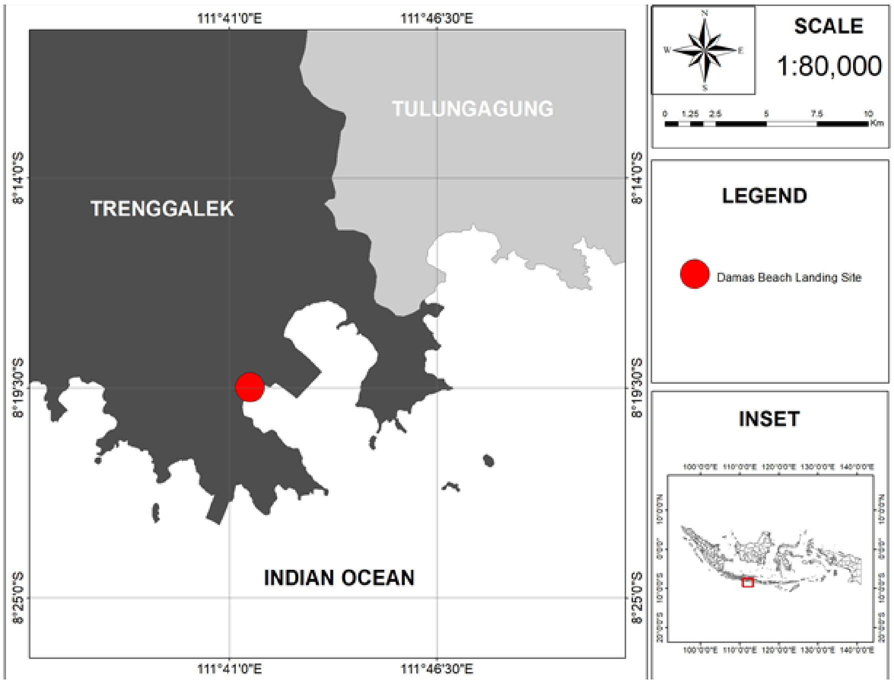


Figure 1. *Research sites.*

2.2. Data analysis

To portray the landing composition of Bali Sardinella fishery, all species landed were identified for each fishing coordinates. The distribution of catch composition over 257 fishing coordinates and species composition were digitized to produce a fishing distribution map. The coordinates of landing data was produced by the ArcMap 10.3 application.

To explore Damas Beach fishing areas, two spatial diversity analyses were conducted, namely species diversity and cluster analysis.

Two diversity indices were estimated to clarify the spatial pattern of Prigi waters, namely species diversity and cluster analysis. To illustrate the species diversity in each fishing ground in the Prigi waters, the Shannon-Wiener index (H') and Margalef's richness index (S) were applied (Zhu et al. 2011; Boyle et al. 2016)

Shannon-Wiener index $(H') = \sum_{i=1}^{S} p_i \ln p_i$ ……………………………………………………(1)

Margalef's richness index $(S') = \frac{s-1}{\ln n}$ …………………………………………………..………(2)

H' performs the number of equally common species that generate similar heterogeneity, where p_i represents the ratio of the landed species over *n* denotes the weight of all caught individuals with *i* stand for species 1, 2, 3,…s. For the richness index (S'), it considers the number of individuals landed over the number of species collected (Harlyan et al. 2021a; Harlyan et al. 2021b; Harlyan et al. 2021c; Harlyan et al. 2022; Lipps et al. 1979).

To discover specific fishing ground pattern, cluster analysis was applied with bootstrapped p – values (Harlyan et al. 2021b; Harlyan et al. 2022c; Maechler et al. 2018). In this study, 257 fishing coordinates were assumed to be clustered based on portion similarity of species composition collected. The 7 group of species landed were considered as the variables, while their weights were assumed as the observed values. To distinguish similarity among individuals within cluster and dissimilarity among clusters, a cluster analysis was performed to form a dendogram. The dendogram will indicate the hierarchical distance among individuals or clusters by computing their Euclidean distances by following formula (Himmelstein et al. 2010; Roy et al. 2015; Harlyan et al. 2022c):

$$d_{x,y} = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \quad \text{...(3)}$$

In this formula, x and y are points in the Euclidean space, while x_i and y_i are the Euclidean vectors in n Euclidean space.

With the total number of 257 fishing coordinates were grouped by species composition based on 40 species. In the dendrogram, multi-scale bootstrap resampling and normal bootstrap resampling generate the approximated unbiased probability value (AU value) and bootstrap probability value (BP value). Compared to the BP values, the AU values have a better approximation. Due to the stable number of observations, a cluster with AU value of more than 0.95 indicates that the cluster may exist (Suzuki and Shimodaira, 2017). The fishing coordinate clusters and their species composition were digitized to discover the clustering of potential fishing grounds.

To reveal the catch profiles of the Damas Beach small landing site, the catch productivity of Bali Sardinella was compared technically between the total catch productivity at Prigi fishing port and the Damas Beach small landing site. The small landing site catch is the catch landed in Damas Beach small landing site, while the recorded catch is the catch recorded in Prigi fishing port. It is partly assumed that the catch data of the Damas Beach small landing site is part of the catch data of Prigi fishing port. Therefore, to analyze the catch contribution of Damas Beach small landing site towards the total catch productivity of Prigi Regency, there were two assumptions was generated about the catch contribution of Damas Beach small landing site:

a. If the catch landed at Damas Beach small landing site is recorded and included in the catch data collection in Prigi fishing port, the catch contribution of Damas Beach small landing site was calculated by:

$$Proportion\ of\ recorded\ catch\ (\%) = \frac{Small\ landing\ site\ catch}{Recorded\ catch} \times 100\% \quad \text{....................................(4)}$$

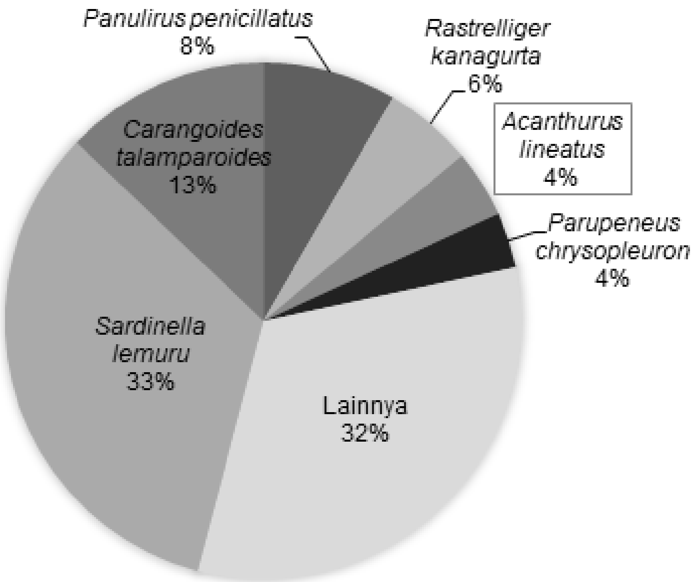
b. If the catch landed at Damas Beach small landing site is unrecorded and/or excluded in the Prigi fishing port, the unrecorded catch contribution of Damas Beach small landing site was calculated by:

$$Proportion\ of unrecorded\ catch\ (\%) = \frac{Small\ landing\ site\ catch}{Recorded\ catch + small\ landing\ site\ catch} \times 100\% \quad \text{.......(5)}$$

3. RESULTS

3.1. Species Composition

Bali Sardinella (*Sardinella lemuru*) is the dominant species landed in Damas Beach small landing site (33%), exploited by seine net fishing with dimension of 9 units of 10 GT and 5 units of 7 GT. In the Figure 2, it is shown that the catch composition of Imposter Trevally (*Carangoides talamparoides*), Spiny lobster (*Panulirus penicillatus*) and Indian Mackerel (*Rastrelliger kanagurta*) occupied dominantly in the second third position after Bali sardinella (*Sardinella lemuru*) with proportion of 13%, 8%, and 6% respectively. It is followed by Lined Surgeonfish (*Acanthurus lineatus*) and Yellow striped goatfish (*Parupeneus chrysopleuron*) with the similar proportion (4%) and other species. In the Prigi fishing port, the landing of Bali Sardinella is also considered as primary species which collected by seine net.



n = 41.262 kg

Figure 2. *Species composition by weight of Bali Sardinella from seine net fishing.*

3.2. Fishing Ground Distribution in Prigi Waters

Fishing ground distribution of seine net fishery was composed by landing composition of seine net fishing ground coordinates (Figure 3). The Bali Sardinella was the dominant species for the fishery which followed by other dominant species, such as the Imposter Trevally, and Indian Mackerel that widely distributed in the Prigi waters. Fishers do not have target species for the fishery, therefore the landing species might be described the actual species diversity in the Prigi waters. In the fishing distribution map, some overlapped fishing ground occurred for the Indian Mackerel and other species.

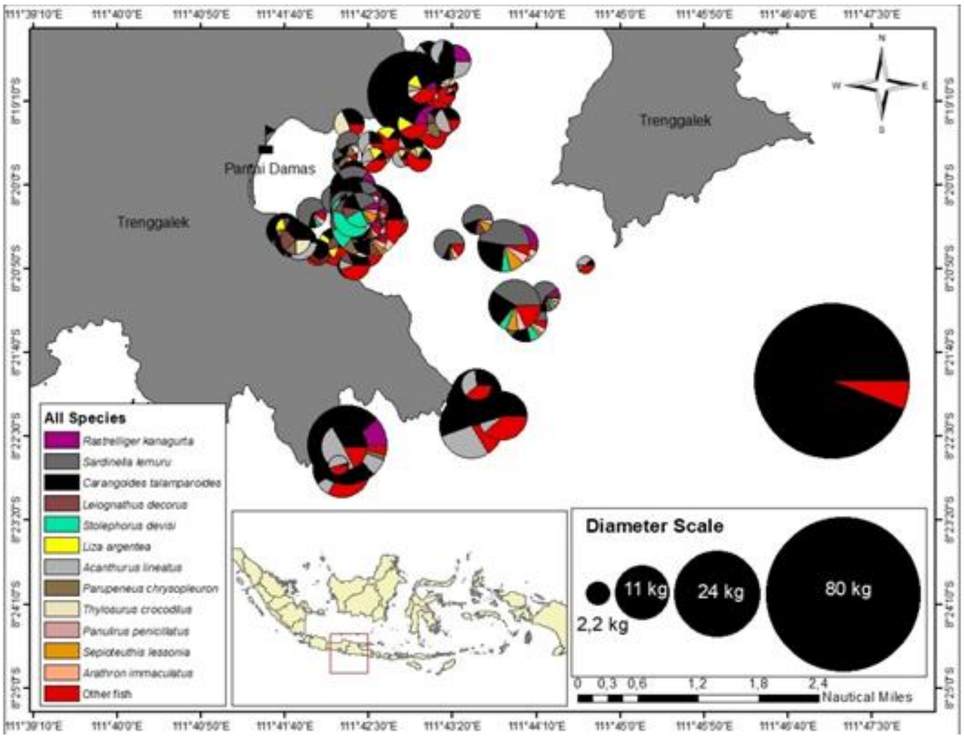


Figure 3. *Fishing ground distribution in Prigi waters.*

3.2.1. Species Diversity

Two diversity indices, species diversity and richness, were calculated to picture the Prigi waters fisheries. Species diversity (H') reached from 0 – 2, while species richness ranged from 1 – 8 (Figure 4

– 5). Some overlaps were depicted between fishing grounds with low and high diversity and richness index due to differences in temporal data collection. Both indices could not structured fishing ground pattern.

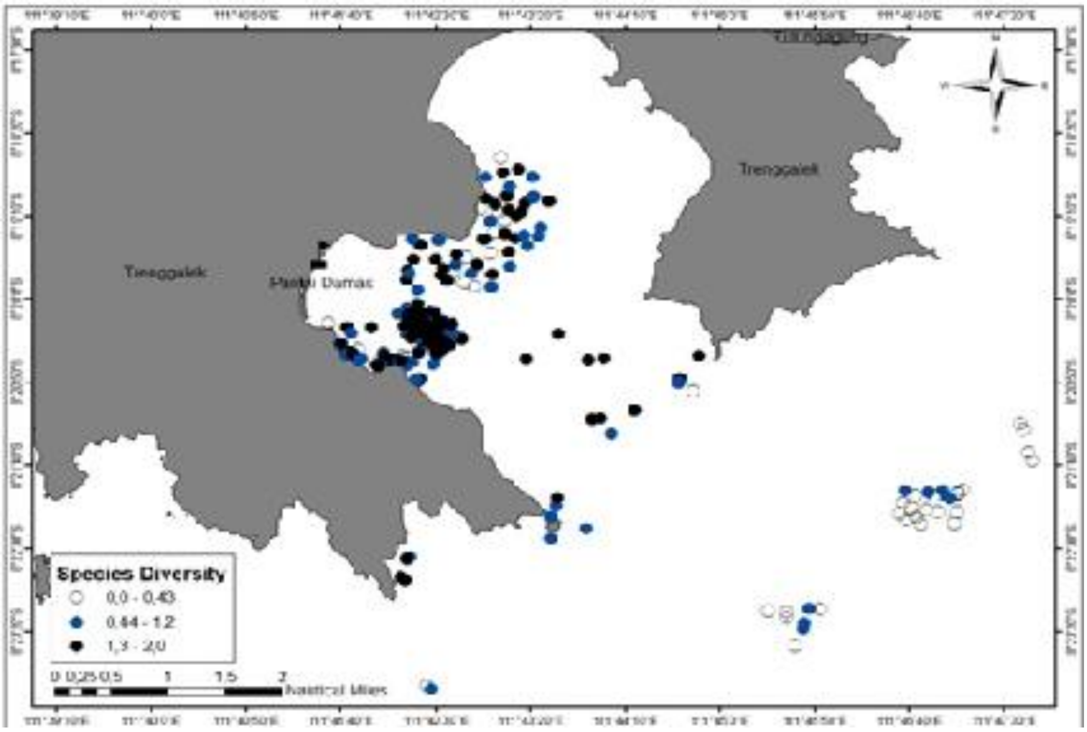


Figure 4. *Species diversity in the Prigi waters.*

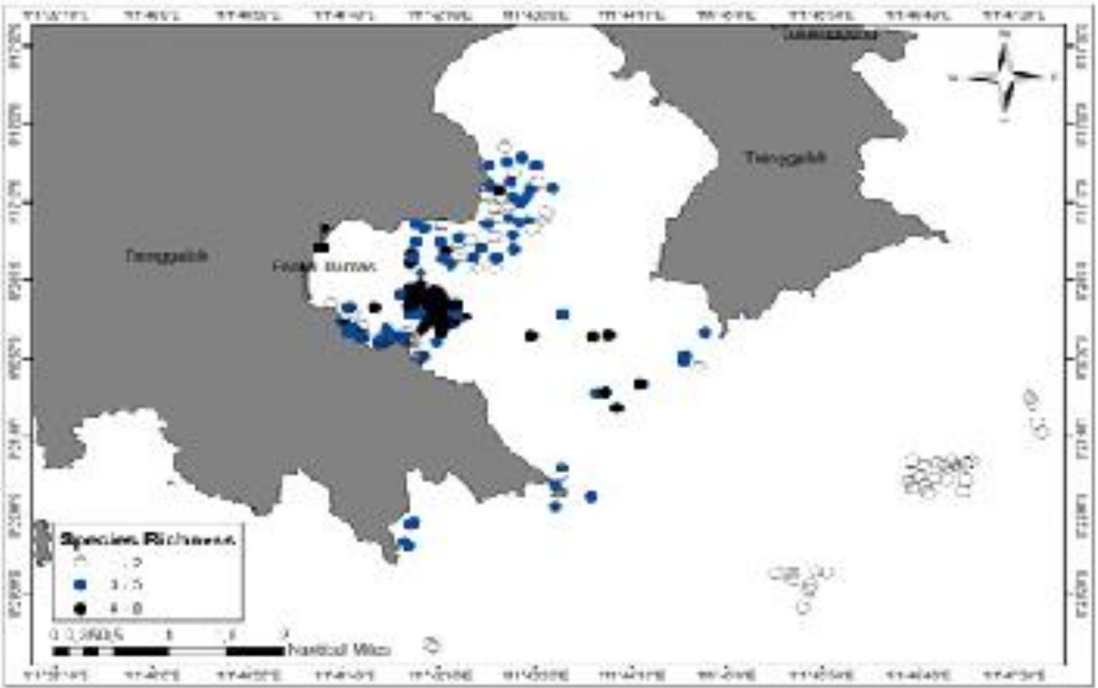


Figure 5. *Species richness in the Prigi waters.*

3.2.2. Cluster Analysis

Due to the inability of both diversity indices to delineate the fishing grounds of Bali Sardinella fisheries in the Prigi waters, a cluster analysis was performed to identify the patterns of these fishing grounds (Figure 6). Twenty-two clusters of fishing grounds were identified based on the similarity distance of each species. Cluster 18 comprises the highest proportion of fishing grounds, accounting for 27% of the total sites, which amounts to 117 fishing grounds. Analysis of cluster species composition (Figure 7) reveals that Bali Sardinella is the dominant species in the majority of clusters (Clusters 1-15). Pronghorn

Spiny Lobster (*Panulirus penicillatus*) dominates in two clusters, specifically Clusters 16 and 17, while Imposter Trevally (*Carangoides talamparoides*) is dominant in three clusters, namely Clusters 19-21.

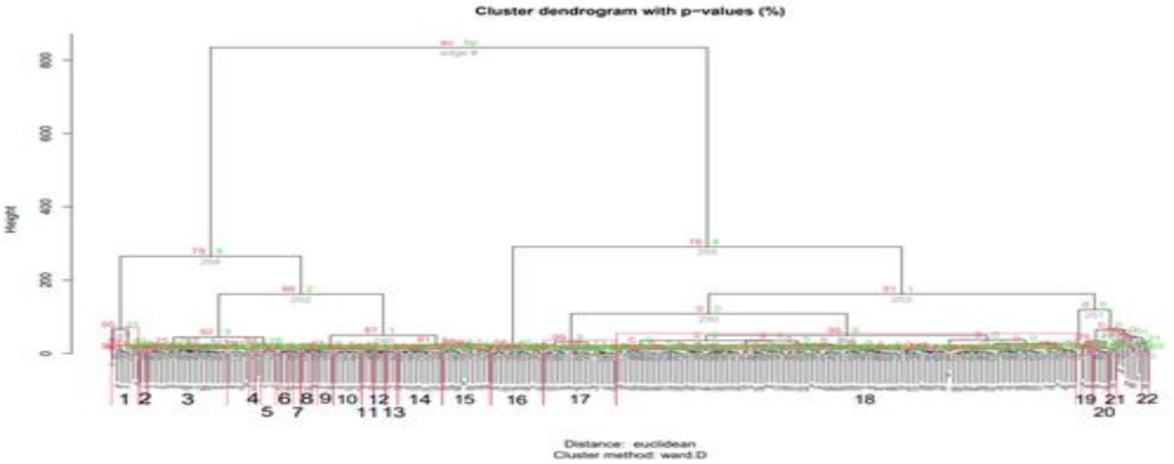


Figure 6. *Dendrogram of clustered fishing locations. The approximated unbiased probability (AU) values are in red, while bootstrap probability values are in green. The red frames specify clusters with AU values more than 0.95.*

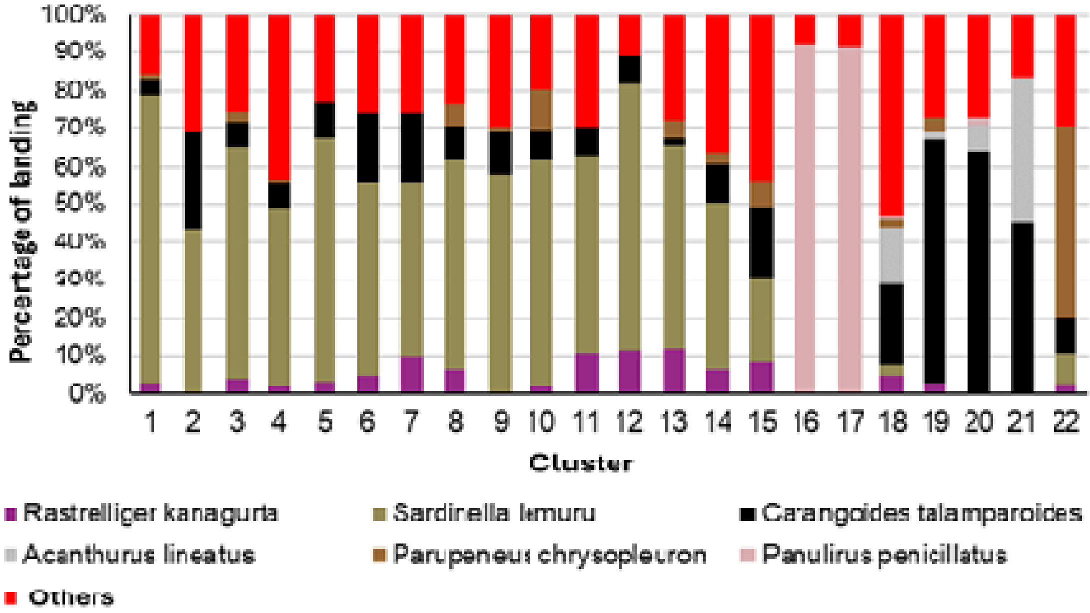


Figure 7. *The species composition based on samples from Bali Sardinella fishery.*

3.3. The Catch Contribution of Bali Sardinella Fishery

In the period of study, the catch of Bali Sardinella recorded in Damas Beach small landing site is less compared to that recorded in Prigi fishing port in the period of January to March 2023 (Table 1).

Table 1. *The Catch production of Bali Sardinella in Damas small landing site and Prigi fishing port.*

Month	Catch recorded at Damas Beach small landing site (kg)	Catch recorded at Prigi fishing port (kg)
January	174	22,919
February	160	5,179
March	1,726	46,364
Total	2,060	74,462

According to the catch distribution calculations, two assumptions were generated as follows:

a. If the catch landed at Damas Beach small landing site is recorded and included in the catch data collection in Prigi fishing port, the catch contribution of Damas Beach small landing site was about 2.74%

b. If the catch landed at Damas Beach small landing site is unrecorded and/or excluded in the Prigi fishing port, the Prigi fishing port will lost their production from Damas Beach small landing site about 2.66%.

4. DISCUSSION

This study underscores the significant role of small landing sites, such as Damas Beach, in capturing accurate fisheries data essential for sustainable management. The absence of systematic data recording at these sites may lead to stock underestimations, resulting in compromised management and conservation outcomes. Yuniarta et al. (2017) similarly noted that unrecorded data in small-scale fisheries often introduces substantial uncertainties in stock assessments, potentially leading to either over- or under-harvesting if actual stock levels are misrepresented. In line with these findings, our study emphasizes the necessity for improved data collection at small landing sites to strengthen resource assessment frameworks and ensure sustainable fisheries management.

The observed 2.66% discrepancy between recorded catches at Damas Beach and the official Prigi fishing port, though modest, reflects a notable volume of unaccounted fish in total catch assessments. Such data gaps can distort stock assessments, affecting decision-making for sustainable harvest levels. Privitera-Johnson and Punt (2020) emphasized that data inconsistencies add significant uncertainty to stock assessments, creating potential risks for over- or under-exploitation of marine resources. Addressing discrepancies between recorded and unrecorded data is critical, particularly in regions where small landing sites serve as primary fishery sources yet lack the capacity for thorough data collection.

Additionally, the non-selective nature of seine net fishing, as practiced in Prigi waters, raises sustainability concerns, particularly regarding species diversity and ecosystem balance. While economically advantageous, seine net fishing often results in bycatch of non-target species, as observed in the landings at Damas Beach. This lack of species selectivity can threaten ecosystem stability and poses a risk for both target and bycatch species. Previous studies (Sambah et al. 2022; Wagiyo et al. 2018) have emphasized that seine nets, while effective in economic terms, indiscriminately capture a broad range of species. Implementing alternative fishing methods or modifications to fishing gear that enhance species selectivity could mitigate these impacts, supporting a more balanced marine ecosystem.

The spatial distribution analysis of Bali Sardinella and other co-occurring species, such as Indian Mackerel, revealed overlapping fishing grounds, which may lead to interspecies competition. Effective, localized management approaches are therefore necessary to address these dynamics and promote coexistence within shared habitats. Harlyan et al. (2021) and Zhu et al. (2011) highlighted that understanding spatial patterns and interspecies interactions is vital for implementing specific management interventions. Potential strategies include spatial zoning, seasonal fishing closures, or the establishment of marine protected areas, which could mitigate interspecies competition, conserve biodiversity, and foster the long-term sustainability of fisheries in Prigi waters.

In summary, improving data collection methods at small landing sites like Damas Beach is essential for accurately assessing fish stocks and supporting the sustainable management of these resources. Enhanced fishery data, paired with gear modifications and spatial management strategies, could ensure that small-scale fisheries contribute positively to the broader objectives of resource conservation and ecosystem health in the Prigi waters.

5. CONCLUSION

This study underscores the importance of small landing sites, such as Damas Beach, in collecting accurate fisheries data. The observed 2.66% data discrepancy highlights the need for consistent data recording to prevent stock underestimations. Additionally, the non-selective nature of seine net fishing and overlapping fishing grounds call for targeted management strategies. Integrating small landing sites into data frameworks and adopting species-sensitive regulations can enhance stock assessments and promote sustainable fisheries management in Prigi waters.

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AUTHOR CONTRIBUTIONS

Harlyan LI: Conceptualization, Methodology, Formal Analysis, Writing-draft preparation, and Editing the manuscript. Safitri TM: Data processing and analysis. Bintoro G: Conceptualization, Supervision, and Review. Rahman MA: Editing the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no competing and conflict of interests.

ETHICS STATEMENT

Additional informed consent was obtained from all individuals for whom identifying information is included in this article

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