Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(2): 1291 – 1304 (2025)
www.ejabf.journals.ekb.eg

Ecological Aspects of Bottom Gill Nets Catches During the Evening and Pre-dawn Periods in Inner Ambon Bay, Indonesia

Ruslan H.S Tawari[1]*, Agustinus Tupamahu[1], Haruna[1]

Department of Utilization of Fisheries Resources, Faculty of Fisheries and Marine Science, Pattimura University
***Corresponding author:** ruslan.tawari@lecturer.unpatti.ac.id*

ARTICLE INFO

Article History:
Received: Jan. 12, 2025
Accepted: March 11, 2025
Online: March 25, 2025

Keywords:
Gill nets,
Catch composition,
Inner Ambon Bay,
Sustainable fisheries,
Temporal variations

ABSTRACT

Gill nets are widely used in small-scale fisheries because of their simplicity and efficiency, particularly for capturing demersal and pelagic species. This study analyzed the catch characteristics of bottom-set gill nets with a 5.08cm mesh size during the evening (7:00–8:30 PM) and pre-dawn (4:00–5:30 AM) periods in Inner Ambon Bay, Indonesia. A total of 30 fishing trips were conducted, and data on species composition, catch diversity, and length frequency distribution were collected. The results revealed significant temporal variation in species composition and dominance. In the evening, *Selar crumenophthalmus* was the most dominant species (64.57%), whereas its proportion decreased to 38.15% in the pre-dawn period, accompanied by an increase in *Upeneus moluccensis* (19.61%). Diversity indices (Shannon-Wiener) indicated moderate diversity, with higher values during the pre-dawn period (1.51) than during the evening (1.36). Dominance was lower in the pre-dawn period (0.09) than in the evening (0.44). Length frequency analysis showed that the gilled method was the most effective capture mechanism, selectively targeting fish in the 21.5–22.5cm range. These findings emphasize the influence of fishing time on catch composition and size selectivity, providing insights for optimizing fishing practices and supporting sustainable fishery management in Inner Ambon Bay.

INTRODUCTION

Inner Ambon Bay (IAB), a semi-enclosed coastal waterbody, is characterized by its unique hydrodynamics and ecological significance, offering abundant resources for artisanal fisheries. This bay is divided into Inner and Outer Ambon Bay, separated by the shallow Galala-Rumah Tiga sill, which influences water exchange and creates distinct biophysical conditions **(Kesaulya *et al.*, 2022)**. The inner part, with a maximum depth of approximately 40m, supports various small-scale fishing activities, particularly the use of gill nets, which are favored for their cost-effectiveness and operational simplicity **(Hehanussa *et al.*, 2024)**.

Gill nets, as passive fishing gear, have long been recognized for their selectivity and efficiency. They target fish species based on size and morphology, influenced by factors such as mesh size, twine thickness, and deployment depth **(Rananmasse *et al.*, 2022)**. In Inner Ambon Bay, drift and bottom gill nets are the primary tools utilized by local fishers, often employed during critical periods such as evening and pre-dawn, coinciding with the active phases of target species **(Kurniasih *et al.*, 2021)**.

Studies in other regions have highlighted the effect of fishing time on catch composition and volume. For instance, research on the Gulf of Thailand has revealed distinct seasonal variations in catch rates and species vulnerability based on gill net operations **(Jutagate & Sawusde,e 2022)**. Similarly, in Ambon Bay, previous findings indicate that fishing activities during the pre-dawn period yield higher diversity and biomass compared to evening operations, which is attributed to the diel migratory patterns of key species (**Matrutty *et al.*, 2022; Tuapetel & Rahman, 2025)**.

Inner Ambon Bay's productivity is influenced by its trophic status, with periods of elevated nutrient input fostering primary production that supports diverse fish populations. This eutrophic condition is compounded by anthropogenic activities, including coastal development and fishery exploitation, necessitating a detailed study. Understanding catch dynamics is radical in order to inform sustainable management practices **(Pello *et al.*, 2012)**.

Moreover, research on the catch characteristics of gill nets in Inner Ambon Bay is highly relevant in the context of sustainable fisheries management. Understanding the dynamics of catch composition based on fishing time not only provides insights into fish behavior but also contributes to optimizing selective fishing strategies. By identifying variations in species diversity and fish size across different periods, this study can help minimize bycatch and support the implementation of more environmentally friendly fishing gear regulations **(Pailin *et al.* 2024; Tawari *et al.*, 2025)**. Furthermore, the findings can serve as a basis for establishing guidelines on fishing operation times to enhance catch efficiency while ensuring the sustainability of fish stocks in Inner Ambon Bay.

Despite the extensive use of gill nets, the efficiency and ecological implications of their operations remain underexplored, particularly with respect to their temporal dynamics in Inner Ambon Bay. The evening and pre-dawn periods are pivotal for many demersal and pelagic species; however, the interactions between gear selectivity, species behavior, and environmental conditions during these times require further elucidation **(Hickford *et al.*, 1997)**.

The objective of this study was to analyze the catch composition of bottom-set gill nets in Inner Ambon Bay during the evening and pre-down periods. This includes assessing species diversity, similarity, and dominance indices, as well as evaluating the total length distribution of key species. By providing these insights, this study aimed to support sustainable fishery management in this region. Additionally, we addressed the

implications of gill net operations on bycatch and potential risks to non-target species, contributing to the broader discourse on responsible fishing practices **(Hidayati & Mohamad, 2024)**.

MATERIALS AND METHODS

Description of study area

This study was conducted in Inner Ambon Bay, Indonesia (Fig. 1) from December 2022 to January 2023. Inner Ambon Bay is a semi-enclosed body of water with coastal line of 20.047km, covering an area of 11.579km² and a maximum depth of 42 meters. It has a total water volume of approximately 221,473,019m³ **(Kesaulya *et al.*, 2022)**. The inner region of the bay serves as a critical fishing ground for local communities. Bottom-set gill nets with a mesh size of 5.08cm were used to collect data during the evening (7:00–8:30 PM) and pre-dawn (4:00–5:30 AM). These nets are commonly employed in artisanal fisheries to target demersal and pelagic species **(Ranamase *et al.*, 2023; Hehanusa *et al.*, 2024)**.

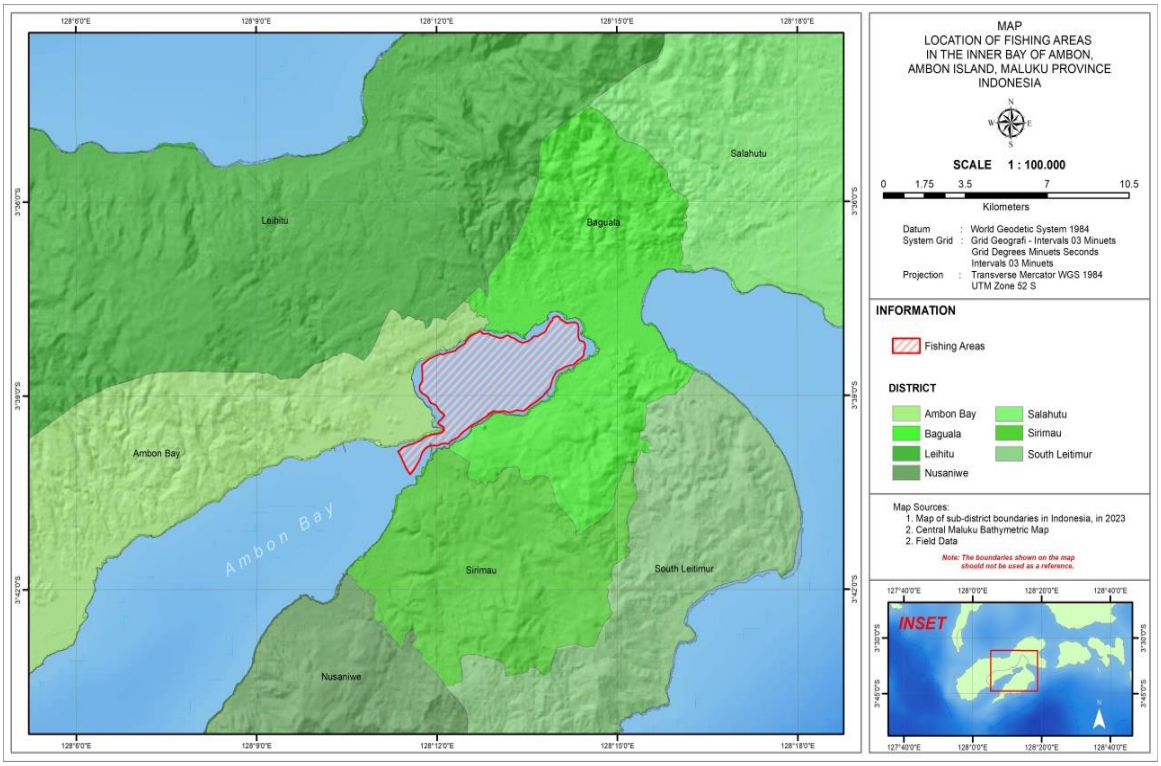

Fig. 1. Map of the study area

Data sampling

The fishing gear used in this study was a bottom gill net commonly utilized by local fishermen. This net measured 234–236 meters in length, with a depth of 141 mesh and a

mesh size of 5.08cm. It was made of nylon PA monofilament, with a hanging ratio ranging from 0.52 to 0.56.

For data collection, a stratified temporal sampling approach was applied to capture variations in catch characteristics between the evening and pre-dawn periods. A total of 30 sampling trips were conducted in the same fishing locations to minimize spatial variability. Identical fishing gear and operational techniques were used throughout the study to ensure consistency.

The collected data included species composition, total catch weight, and individual fish length. Each fish was identified to the species level, and its total length was measured using a measuring board. Additionally, capture mechanisms such as gilled, snagged, and wedged were recorded to assess gear selectivity.

Data analysis

Species diversity, similarity, and dominance indices were calculated using the Shannon-Wiener diversity, evenness, and Simpson dominance indices. These indices provide insights into the ecological dynamics of fish populations during the two time periods. The Shannon-Weaver diversity index was calculated using the following formula **(Pielou, 1966)**:

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

The proportion of species *i* relative to the total number of species (**S**) was initially determined and then multiplied by the natural logarithm of this proportion **ln**(**pi**). The resulting values were summed across all species and were multiplied by −1. Here, **H** denotes Shannon's diversity index; **S** represents the total number of species in the community (richness), and **pi** is the proportion of **S** contributed by species *i.*

The evenness index was calculated based on the fuction of Shannon-Wiener **(Magurran, 2004)** as follows:

$$E = \frac{H'}{lnS}$$

The evenness index (**E**) measures the distribution of individuals among the species within a community. It is closely related to the Shannon-Wiener diversity index (**H'**), which quantifies species diversity. The natural logarithm of the total number of species (**ln S**) represents the theoretical maximum H value, which occurs when all species have an equal number of individuals. The evenness index (**E**) ranges between 0 and 1, where E = 1 indicates a perfectly even distribution of individuals across all species, while E values approaching 0 reflect a highly uneven distribution dominated by a few species.

The formula for Simpson's dominance index used is as follows **(Krebs, 1985)**:

$$D = \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

Simpson dominance index (D) is a metric used to measure the dominance of species within a community, with values ranging between 0 and 1. A value close to 1 signifies high dominance by one or a few species, whereas a value close to 0 indicates a more even distribution of species. The index was calculated using the number of individuals of each species (n_1, n_2, ..., n_i) and the total number of individuals of all species in the community (N).

The frequency distribution of the total length of fish predominantly caught using bottom gill nets with a 5.08cm mesh size was descriptively analyzed in the form of a frequency histogram based on the capture process (gilled, snagged, and wedged).

RESULTS

Catch compositions

The composition of catches from bottom gillnets with a mesh size of 5.08cm during the fishing period is shown in Table (1). The composition of the bottom gill net catch varied significantly between the evening (7:00–8:30 PM) and pre-dawn (4:00–5:30 AM). In the evening, *Selar crumenophthalmus* was the most dominant species, comprising 64.57% of the total catch. This indicates its high activity and availability during this time. Other notable species included *Upeneus moluccensis* (12.04%) and *Lutjanus russelli* (7.66%), whereas *Caranx ignobilis*, *Rastreliger kanagurta*, and *Mugil* sp. contributed smaller proportions. A few species, such as *Priacanthus Tayemus* and *Leiognathus splendens*, were absent in the evening catch, suggesting their inactivity or lack of vulnerability to gear during this period.

Table 1. The composition of the bottom gill net catch with a mesh size of 5.08cm

Species	7:00-8:30 PM (Evening)	%	4:00-5:30 AM (Pre-dawn)	%
Hampala macrolepidota	4	0.55	-	-
Caranx ignobilis	25	3.42	70	15.09
Selene vomer	5	0.68	10	2.16
Caranx melampygus	5	0.68	-	-
Mugil sp.	3	0.41	13	2.80
Etelis radiosus	1	0.14	2	0.43
Lutjanus russelli	56	7.66	24	5.17
Psettodes erumei	1	0.14		0.00
Selar crumenophthalmus	472	64.57	177	38.15

Terapon jarbua	7	0.96	15	3.23
Coryphaena sp	1	0.14		0.00
Rastreligger kanagurta	34	4.65	18	3.88
Argyrosomus amoyensis	4	0.55	-	-
Chirocentrus dorab	2	0.27	12	2.59
Sphyraena barracuda	14	1.92	16	3.45
Upeneus moluccensis	88	12.04	91	19.61
Megalaspis cordyla	9	1.23	11	2.37
Priacanthus tayenus	-	-	4	0.86
Leiognathus splendens	-	-	1	0.22
Total	731	100.00	464	100.00

In the pre-dawn period, *S. crumenophthalmus* remained the dominant species but contributed a smaller share (38.15%) compared to the evening. Meanwhile, *U. moluccensis* showed an increased presence, making up 19.61% of the catch, reflecting a possible rise in its activity during early morning hours. Other significant species during pre-dawn included *C. ignobilis* (15.09%), *L. russelli* (5.17%), and *R. kanagurta* (3.88%). Some species, such as *Hampala macrolepidota* and *Caranx melampygus*, were absent during pre-dawn, highlighting potential differences in species behavior or habitat preference between the two periods.

Overall, the species composition and proportions differed between the evening and pre-dawn catches. *S. crumenophthalmus* was the most consistent and dominant species overall, although its contribution decreased pre-dawn. The shift in dominance of other species, such as the increase in *U. moluccensis* in the pre-dawn period, reflects changes in fish behavior or movement patterns over the day. Additionally, the broader diversity of species in the pre-dawn period may indicate a wider range of activity among fish species during early morning hours. These differences are likely driven by behavioral and environmental factors influencing the vulnerability of fish to the gear at different times.

Indices of diversity, similarity and dominance

Table (2) shows the results of the analysis of catch data from bottom gill nets at two different times, in the evening and early morning. The diversity index value during the evening fishing period was 1.36, which falls into the moderate category. This indicates that the types of fish caught have moderate diversity. The catch during the early morning fishing period had a diversity index value of 1.51, which also falls into the moderate category but is higher than in the evening. This suggests an increase in fish species diversity in the early morning period.

Table 2. Indices of diversity, similarity and dominance of bottom gillnet catches during dusk and dawn.

Indices	Evening		Pre-dawn	
	Value	Categories	Value	Catagories
Diversity	1.36	Moderate	1.51	Moderate
Similarity	0.21	Low	0.25	Low
Dominance	0.44	Moderate	0.09	Low

The similarity index for the fishing period in the evening was 0.21, which was categorized as low. This indicates that the similarity in fish species between catches during this time was quite low. In the early morning, the similarity index was 0.25, which was also categorized as low, but slightly higher than that in the evening. This suggests that the fish species caught at this time were slightly more uniform than those caught in the evening.

The dominance index in the evening was 0.44, which falls under the medium category. This means that there are some dominant species in the catch at this time, but they do not dominate overwhelmingly. In the early morning, the dominance index value was 0.09, categorized as low. This indicates that no species overwhelmingly dominated the catch during this time, resulting in a more even distribution among species.

Frequency distribution of total length of dominant species caught

The frequency distribution of the total length of *S. crumenophthalmus* caught with a basic gill net (mesh size 5.08cm) showed distinct patterns between the evening and pre-dawn periods (Fig. 2). During the evening, the gill net captured the majority of fish using the gilled method, with the highest frequency recorded for fish in the 21.5–22.5cm length range. The snagged method captured fewer fish and was also concentrated in the same length range, whereas the wedged method demonstrated a more evenly distributed catch across different size ranges, although the frequency was lower than that of the gilled method. This indicates that in the evening, gill nets were most effective in catching medium-sized fish using the gilled method.

In the pre-dawn period, the catch frequency was generally lower than that in the evening for all methods. The gilled method remained the most effective, but its peak frequency in the 21.5–22.5cm size range was less pronounced compared to the evening. Interestingly, the snagged method captured slightly larger fish (22.5–23.5cm range) during this period, suggesting a shift in the size selectivity of the net. The wedged method showed the lowest overall catch frequency in the pre-dawn period, with most of the fish falling within the 21.5–22.5cm size range. This pattern highlights the reduced effectiveness of the wedged and snagged methods during pre-dawn hours.

Overall, the results emphasize the significant influence of the time of day and the catching method on gill net selectivity and efficiency. The 5.08cm mesh size is highly selective for fish within the 21.5–22.5cm length range, with the gilled method

consistently dominating in both evening and pre-dawn periods. The snagged and wedged methods were less effective, especially during pre-dawn hours. These findings underline the importance of understanding fishing gear selectivity and timing for sustainable fishery management practices.

Frequency distribution of *U. moluccensis*. caught using a bottom gill net with a mesh size of 5.08cm reveals notable differences between the evening and pre-dawn periods. During the evening, fish caught by the gilled method predominantly belonged to the size class of 21.5–22.5cm, which corresponds to the selectivity of the gill net. Snared fish, however, are more evenly distributed across smaller size classes, particularly between 17.5–19.5cm, reflecting a less size-selective mechanism where smaller fish are entangled by fins or other body parts. Wedged fish are less frequent, with most found in the mid-size range of 19.5–21.5cm, indicating that wedging is a less common mode of capture during the evening.

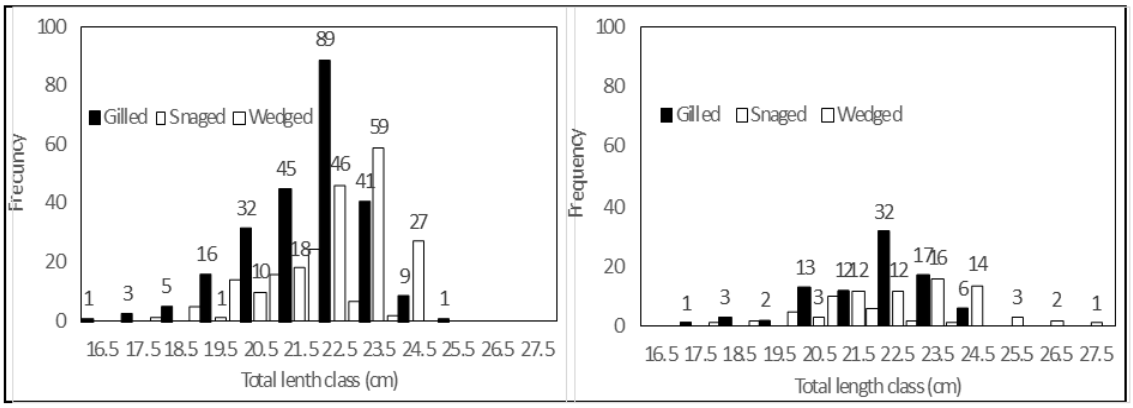

Fig. 2. The frequency distribution of the total length of *S. crumenophthalmus* caught using bottom gillnets with a mesh size of 5.08cm, during the evening period (left) and the pre-dawn period (right), based on the capture mechanism (gilled, snagged, and wedged)

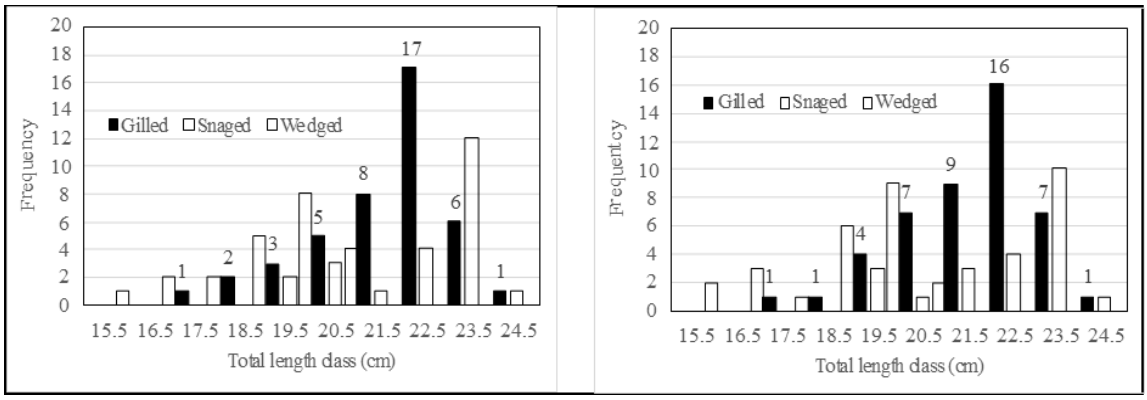

Fig. 3. The total length frequency distribution of *U. moluccensis* caught using bottom gillnets with a mesh size of 5.08cm during the evening period (left) and early morning period (right), based on capture methods (gilled, snagged, wedged)

In the pre-dawn period, the frequency of fish caught was generally higher for all methods, suggesting an increased activity or abundance of fish at this time. Gilled fish continue to dominate in the 21.5–22.5cm size class, consistent with the evening data and indicative of the gill net's selectivity for fish of this size. Snaged fish maintained their broader size distribution, capturing smaller fish within the 17.5–19.5cm range, while wedged fish showed a slightly wider distribution in the 19.5–21.5cm range. However, wedging remained the least frequent capture mechanism in both the time periods.

These results highlight the effectiveness of gill nets in selectively catching fish of certain sizes (21.5–22.5cm) through the gilling method while also capturing smaller individuals through snaging and wedging. The higher frequency of catches during the pre-dawn compared to the evening suggests that fish are more active or abundant before dawn. These observations are valuable for understanding fish behavior and optimizing fishing practices, while supporting sustainable fisheries management by considering time-of-day variations in fish activity.

DISCUSSION

In the pre-dawn period, *S. crumenophthalmus* remained the dominant species, but contributed a smaller share (38.15%) than in the evening. Meanwhile, *U. moluccensis* showed an increased presence, accounting for 19.61% of the catch, reflecting a possible rise in its activity during the early morning hours. Other significant species included *C. ignobilis* (15.09%), *L. russelli* (5.17%), and *R. kanagurta* (3.88%). Some species such as *H. macrolepidota* and *C. melampygus* were absent during the pre-dawn period, highlighting potential differences in species behavior or habitat preference between the two periods.

Overall, species composition and proportions differed between the evening and pre-dawn catches. *S. crumenophthalmus* was the most consistent and dominant species overall, although its contribution decreased pre-dawn. The shift in dominance of other species, such as the increase in *U. moluccensis* in the pre-dawn period, reflects changes in fish behavior or movement patterns over the day. Additionally, the broader diversity of species in the pre-dawn period may indicate a wider range of activity among fish species during the early morning. These differences are likely driven by behavioral and environmental factors that influence the vulnerability of fish to gear at different times.

The results of the study on catch composition from bottom gillnets with a mesh size of 5.08cm showed significant differences between the evening (7:00-8:30 PM) and pre-dawn (4:00-5:30 AM) periods. *S. crumenophthalmus* dominated the catch during both periods, decreasing from 64.57% in the evening to 38.15% pre-dawn. This decline highlights changes in diel activity and vulnerability of the species. Similar studies have shown that diel patterns affect fish behavior, with species such as *S. crumenophthalmus* being more active and easier to catch during certain periods **(Jutagate & Sawusdee, 2022)**. The reduced catch before dawn might reflect lower movement or dispersion of the

species, as documented in fisheries off Demak Waters, Indonesia, where time-dependent variations influenced the catch of *Rastrelliger* spp. **(Setyawan *et al.*, 2023)**.

The study also observed an increase in the catch proportion of *U. moluccensis* during the pre-dawn period, rising to 19.61%. This shift may indicate peak foraging activity or habitat movement of the species during early morning hours. Similarly, research along the Sudanese Red Sea coast found that fish species exhibit temporal variability, increasing their vulnerability to nets during specific periods **(Olsen *et al.*, 2021)**. These findings emphasize that diel activity, which is influenced by feeding and habitat preference, affects catch dynamics. Similarly, *L. russelli* and *C. ignobilis*, although present in both periods, showed varied proportions, reflecting their differing behavioral responses to light and fishing pressure.

The absence of species such as *Priacanthus tayenus* and *Leiognathus splendens* in the evening and their presence pre-dawn suggests behavioral factors, such as nocturnal or crepuscular activity. Studies on bottom gillnets in Indonesian waters have highlighted that certain species are more vulnerable to low-light conditions owing to changes in movement and foraging behavior **(Pondaag *et al.*, 2018)**. Moreover, differences in catch composition due to diel activity have been reported in Bandon Bay, Thailand, where fish movement patterns influence species vulnerability to gillnets **(Jutagate & Sawusdee, 2022)**. These findings reinforce that fishing time, combined with gear selectivity, determines the diversity and abundance of the species caught.

The observed differences in catch composition between the evening and pre-dawn periods underline the importance of understanding species behavior and habitat preferences to optimize fishing practices. The dominance of *S. crumenophthalmus* in both periods, despite its decline pre-dawn, shows its overall abundance and activity in the area. However, the increased diversity of species before dawn, including *U. moluccensis*, indicates broader fish movement during the early morning hours. Similar findings in Egyptian Mediterranean fisheries show that catch composition is influenced by fishing gear type, operation time, and species behavior **(Ragheb *et al.*, 2022)**. Understanding these temporal variations can help improve gillnet selectivity, reduce bycatch, and promote sustainable fishery management.

The diversity index slightly increased to 1.51 during the early morning period and the evening. This trend can be attributed to the nocturnal behavior of fish species and their heightened activity during the early morning hours. Similar patterns have been observed in Prigi Waters, where diversity indices for surface gillnet catches vary based on the time of operation and mesh size **(Bintoro *et al.*, 2022)**. Furthermore, findings from Bushehr County in the Persian Gulf support this observation, showing that changes in fish behavior and environmental stability during specific periods contribute to variations in diversity indices **(Pouladi *et al.*, 2020)**. These results emphasize the role of diel (daily) rhythms in influencing fish movement and species availability in gillnet fisheries.

The similarity index for species composition remained low during both fishing periods, with values of 0.21 in the evening and 0.25 in the early morning, reflecting limited overlap in species composition. These low values indicate high species variability across different time periods. Comparable trends have been reported on the Alexandrian Mediterranean coast, where significant species variability arose due to shifts in fish distribution, despite the consistent use of gillnets **(Ragheb *et al.*, 2022)**. The marginal increase in similarity observed during the early morning may signify a more uniform fish distribution, likely resulting from shifts in fish movement and aggregation patterns. These findings underscore the temporal influence on species composition in fisheries.

Notable differences also emerged in the dominance index between the evening and early morning periods. The evening dominance index, recorded at 0.44 (categorized as moderate), suggests that a few species were more prevalent but did not overwhelmingly dominate the catch. This pattern aligns with studies conducted in Kulu waters, where moderate dominance values signify a balanced species distribution **(Purwanto *et al.*, 2021)**. In contrast, the dominance index dropped significantly to 0.09 in the early morning and was classified as low, indicating a more even distribution of species. Similar observations have been reported in Bushehr, Persian Gulf, where low dominance indices reflect ecological stability and species balance **(Pouladi *et al.*, 2020)**. In conclusion, bottom gillnets exhibited time-dependent variations in diversity, similarity, and dominance indices. The moderate diversity and low dominance during the early morning highlights its potential to provide a broader and more sustainable representation of fish species, as supported by findings from Prigi Waters, Bushehr County, and the Alexandrian coast **(Pouladi *et al.*, 2020; Purwanto *et al.*, 2021; Ragheb *et al.*, 2022)**.

The frequency distribution of the total length of *S. crumenophthalmus* and *U. moluccensis* caught with a bottom gill net using a 5.08cm mesh size demonstrated notable differences between the evening and pre-dawn periods. For *S. crumenophthalmus*, the evening period showed a higher catch frequency concentrated in the 21.5–22.5cm size range, with the gilled method dominating the capture mechanism. This trend aligns with previous studies highlighting gill net selectivity, where the gilled method efficiently targeted fish sizes matching the mesh perimeter **(He, 2006)**. The snagged method, although less effective, similarly targeted fish in the same size range, whereas the wedged method exhibited a more even distribution across size classes. In contrast, the pre-dawn period displayed a slightly lower overall catch frequency, with the snagged method capturing larger fish (22.5–23.5cm). This pattern reflects a possible behavioral shift, as fish activity and movement differ between the evening and pre-dawn hours **(Retraubun *et al.*, 2021)**. These results emphasize the role of fish behavior and net selectivity in determining catch efficiency.

For *U moluccensis*, a similar trend was observed, where the gilled method dominated the evening catch, primarily targeting fish in the 21.5–22.5 =cm size range. This size preference corresponds to the findings of previous biological studies on *U.*

moluccensis populations, which reported an active growth phase within these size ranges **(Abdullah *et al.*, 2015)**. The snagged method captured smaller fish, broadly distributed in the 17.5–19.5cm range, due to its less selective nature. During the pre-dawn period, catch frequencies increased for all methods, with the gilled method maintaining selectivity for medium-sized fish. Meanwhile, the snagged and wedged methods showed slight shifts in distribution but remained less efficient, which is consistent with previous reports on gear performance **(Rananmasse *et al.*, 2022)**. These findings highlight the importance of understanding net selectivity and time-based fish behavior to improve fishing efficiency and support sustainable fisheries management in line with the resource conditions in Indonesian waters.

CONCLUSION

In conclusion, fishing time significantly affected species composition, diversity, dominance, and size selectivity in bottom gill net fisheries. The increased species diversity and reduced dominance during the pre-dawn period suggests that fishing during this timeframe may yield a more balanced and ecologically sustainable catch. Understanding these temporal variations is essential for optimizing fishing practices, improving gear selectivity, and supporting sustainable fishery management in Inner Ambon Bay. By aligning fishing strategies with fish behavior and diel activity patterns, both productivity and ecological balance can be enhanced. The findings of this study have significant implications for sustainable fisheries management in Inner Ambon Bay. By understanding the influence of fishing gear operation time on species composition, fishers can optimize their harvesting strategies to enhance efficiency and sustainability. Additionally, adjusting fishing schedules based on the activity patterns of target species can minimize bycatch and reduce unintended ecological impacts. This information serves as a valuable basis for developing fisheries management policies that balance ecological and economic considerations, thereby supporting the long-term sustainability of fish resources in the region.

ACKNOWLEDGEMENTS

Thank you to the gillnet fishing community in Poka Village and Halong State, Ambon City, for providing the opportunity for this research. Special thanks to Aprilia Tupalassy and Radyah Laturua for their assistance in data collection and participating in fishing operations with the fishermen.

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