

PRODUCTION DYNAMICS AND UTILIZATION STATUS OF SPINY LOBSTER (*Panulirus Spp*) SMALL SCALE FISHERIES IN INDONESIA 2019-2024

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ABSTRACT

Spiny lobster (*Panulirus*) fisheries in Indonesia are dominated by small-scale fishers. This study analyzes production dynamics, value, utilization status, and fishing operation characteristics based on Ministry of Marine Affairs and Fisheries secondary data of 2019–2024. Methods include quantitative descriptive analysis of temporal trends, spatial distribution by Fisheries Management Area (FMA), utilization rate evaluation, and fishing gear and fleet composition. Results showed that national production fluctuated, highest production was 11,191.03 tons in 2023. Production concentrated in three FMAs: 572, 718, and 573, with a combined 74.10% contribution. Actual utilization rates (2022–2024) for FMAs 572 and 573 reached 2.51 and 1.46, indicating critical over-exploited status. Passive gear dominates (>73% of production), and small-scale fleets (<5 GT) contribute >60% of national catch. These findings reveal a paradox between small-scale sector's economic contribution and severe ecological pressure, alongside a policy-implementation gap, necessitating more responsive, FMA-based management reorientation.

Keywords : Fisheries Management Area (FMA), Spiny Lobster, Small-Scale Fisheries, Over-exploited, Utilization Rate

INTRODUCTION

Spiny lobster (*Panulirus*) is a high-value fishery commodity that is a mainstay of Indonesian exports (Hotijah & Faridatussalam, 2024) and supports the livelihoods of thousands of small-scale fishermen. This sector's contribution to food security and the local economy is significant, however, its sustainability faces complex challenges due to high fishing pressure and the dynamics of frequently changing management policies (Arkan & Rosdiana, 2024; Rahayu *et al.*, 2023; Suherman *et al.*, 2025)

Previous literature reviews have extensively discussed aspects of spiny lobster biology and distribution (Goldstein *et al.*, 2025), the socio-economic impacts of policy changes, and the productivity of small-scale fishing gear (Simbolon *et al.*, 2024). Studies at the local level, such as in Pangandaran (Rahayu *et al.*, 2023), Palabuhanratu (Simbolon *et al.*, 2024), and Gunungkidul (Djasmani *et al.*, 2012; Febriani *et al.*, 2014) have pointed specific descriptions of pressure on stocks. However, recent comprehensive analyses that combine the dynamics of

national production performance with an evaluation of stock utilization status based on Fisheries Management Areas (FMAs), as well as the characterization of fishing operations (gear and fleet) for the period 2019–2024 are still limited. This period covers policy transition period and the recovery phase after the COVID-19 pandemic.

Gap analysis indicates that there is no study that specifically focuses on quantitatively evaluating the status of spiny lobster stock utilization through direct comparison between actual production data for the current period and the Total Allowable Catch (TAC) applicable at the FMA level, combined with an in-depth analysis of fishing gear profiles and fleet composition. These characteristics are similar to small-scale spiny lobster fisheries in Caribbean (Kelly, 2003). However, this information is crucial for designing targeted management strategies (Hoyle *et al.*, 2024).

Therefore, this study aimed to analyze temporal trends of Indonesian spiny lobster fishery production and value for 2019-2024 period, map the spatial distribution of

production contributions based on FMA, evaluate utilization status of spiny lobster stocks by comparing production realization to TAC in major FMAs and characterize fishing operations based on composition of fishing gear and fleet.

METHODS

This study used a quantitative descriptive approach relying on secondary data from the capture fisheries statistics of the Ministry of Maritime Affairs and Fisheries (MMAF) of the Republic of Indonesia within request to <https://portaldata.kkp.go.id>. A bioeconomic spatial analysis approach was adopted to understand the distribution of activities (Efendi *et al.*, 2020). Data analyzed covers within six-year period, from 2019 to 2024, and includes key variables such as production volume, production value, spiny lobster species, fishing gear types used, and spiny lobster fishing vessel size groups for all FMA in Indonesia.

Temporal trend analysis was conducted by observing the fluctuation patterns in the volume and value of national spiny lobster production from year to year. To understand spatial economic dynamics, contribution of production value to each FMA was also calculated. Given limited detailed and nationally standardized fishing effort data, analysis focused on aggregate production data and the Utilization Rate (TP) value. Meanwhile, to understand the spatial distribution, production contribution of each FMA was calculated as a percentage of total national production. Evaluation of utilization status of

spiny lobster stocks focused on FMAs that are the main production centers (Rubec, 2016). This evaluation was conducted by calculating TP by comparing the average production period corresponding to the TAC of each ministerial decree. The first comparison used the TAC based on Ministerial Decree of Fisheries and Marine Affairs No. 50 of 2017 (KKP, 2017), and the second comparison used the TAC reference based on Ministerial Decree of Fisheries and Marine Affairs No. 19 of 2022 (KKP, 2022). Stock status is interpreted based on the TP value, where TP greater than 1 indicates over-exploited status.

Moreover, characteristics of fishing operations were analyzed by examining the composition of fishing gear and fishing fleet size groups. This analysis was conducted by calculating the percentage contribution of each type of fishing gear and each vessel size category to total national production during 2019-2024. To facilitate interpretation and presentation of the findings, all analysis results were visualized in tables and figures depicting distribution and concentration of production per FMA. All analyses were conducted using Microsoft Excel.

RESULTS AND DISCUSSION

National Temporal Trends and Dynamics of Responses to the Pandemic and Market Fluctuations

Analysis of annual data (Figure 1) shows that the dynamics of national spiny lobster fisheries production and value during the 2019–2024 period were complex.

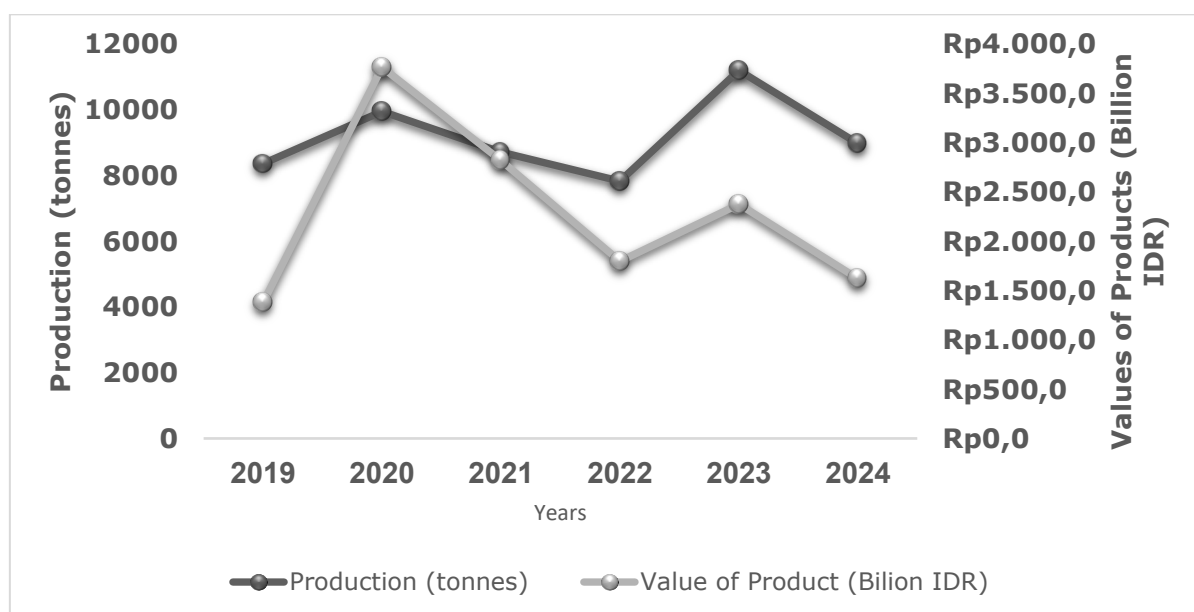


Figure 1. Trends in Indonesia spiny lobster (*Panulirus*) fisheries production and values 2019–2024.

This pattern does not entirely align with the general narrative regarding the contraction of the fisheries sector due to the COVID-19 pandemic. Unlike many other fisheries commodities that experienced declines in production and value in the early phase of the pandemic, spiny lobster fisheries showed a response that was significantly influenced by global price volatility and short-term economic signals, as also found in various studies of the impact of COVID-19 on global fisheries sector (OECD, 2020; Villasante *et al.*, 2024).

Recorded in 2020 a 19% increase in production (9,941.80 tons) compared to 2019, accompanied by a very extreme surge in production value of 173% to IDR 3.76 trillion. This phenomenon indicates a decoupling between production volume and value, which indicates a sharp increase in prices per unit. Global literature shows that the pandemic caused disruptions in international supply, changes in consumption patterns, and fluctuations in demand for high-value fishery products (luxury seafood), including spiny lobster, which in some countries actually triggered price spikes even though production volume was relatively stable or increased (FAO, 2021; OECD, 2020). In addition, the depreciation of the IDR (Indonesia Rupiah) exchange rate against the USD (United States Dollar) during 2020 also increased the value of production in Rupiah denominations, although it did not fully reflect the real increase in fishermen's welfare, a phenomenon also noted in socio-economic studies of fisheries during the pandemic (Bennett *et al.*, 2020).

The 2021–2022 period shows a correction phase, where production and value both experienced a decline, with a sharper value contraction of up to IDR 1.80 trillion in 2022. This pattern is in line with the findings of various studies that emphasize that the economic impact of the pandemic on the fisheries sector is often lagged effects, due to prolonged logistical disruptions, the re-normalization of global supply chains, and the global economic slowdown that suppresses demand for high-value fishery products (FAO, 2021; Villasante *et al.*, 2024).

Most significant production surge occurred in 2023, reaching a record 11,191.03 tons, coinciding with a recovery in production value to IDR 2.38 trillion. This pattern is consistent with the phenomenon of compensatory fishing or revenge fishing, which is an increase in fishing effort by fishers

following a period of economic stress or income uncertainty. Fisheries economics literature explains that when prices or income expectations improve, fishers especially in small-scale fisheries with limited social safety nets tend to respond by increasing fishing intensity to recover from previous income losses (Bennett *et al.*, 2020; Hilborn *et al.*, 2020). A similar phenomenon has also been reported in post-COVID-19 context in various fisheries worldwide, where price recovery is followed by a surge in effort that risks accelerating stock declines.

Implication of this analysis is that Indonesia's spiny lobster fishery, dominated by small-scale operators, not contract during the pandemic but instead experienced extreme market volatility. Price surge in 2020 provided a short-term economic incentive but triggered overfishing dynamics in subsequent recovery phase. These findings suggest that spiny lobster exploitation pressure is more influenced by the vulnerability of fishers' livelihoods and responses to short-term economic signals. Compliance with long-term management policies appears less dominant.

Spatial Concentration Patterns of National Spiny Lobster Production and Value

Analysis showed that national spiny lobster production for 2019–2024 period is not only temporally fluctuating but also extremely spatially concentrated in a handful of Fisheries Management Areas (FMA). Three main FMAs, i.e. 572 (West Indian Ocean, Sumatra), 718 (Arafura Sea), and 573 (South Java), collectively contribute 74.10% of total national production (Table 1). FMA 572 emerged as the center of the highest volume production with a contribution of 32.38% (an average of 2,968.07 tonnes/year) followed by FMA 718 (30.85%) and FMA 573 (10.86%).

Beyond volume concentration, analysis of production value data (Table 1) reveals striking economic disparities between central FMAs. FMA 718 (Arafura Sea), despite contributing 30.85% of production volume, dominates the national value contribution, accounting for 52.80% (an average of IDR 1,210 billion/year). Conversely, FMA 572, which contributes 32.38%, only contributes 18.58% of the national value. This drastic difference directly reflects the composition of spiny lobster species with varying economic value (Table 2).

Table 1. Distribution of spiny lobster (*Panulirus*) production and value per fisheries management area 2019-2024.

FMA	Production (Tonnes)	Production Average (Tonnes)	Contribution (%)	Values (Billion IDR)	Values Average (Billion IDR)	Contribution (%)
572	17808.42	2968.07	32.38	2554.82	425.80	18.58
718	16968.82	2828.14	30.85	7260.52	1210.09	52.80
573	5974.30	995.72	10.86	1353.92	225.65	9.85
714	4475.84	745.97	8.14	408.54	68.09	2.97
713	4345.41	724.24	7.90	1215.59	202.60	8.84
715	1659.14	276.52	3.02	338.79	56.46	2.46
716	1042.70	173.78	1.90	197.80	32.97	1.44
711	987.56	164.59	1.80	179.31	29.89	1.30
712	927.84	154.64	1.69	199.50	33.25	1.45
717	655.58	109.26	1.19	32.72	5.45	0.24
571	152.98	25.50	0.28	10.42	1.74	0.08
Total	54998.59	9,166.43	100.00	13,751.92	2,291.99	100

This extreme spatial concentration confirms and quantifies findings of various previous local studies (Rahayu *et al.*, 2023; Simbolon *et al.*, 2024; Widiarti *et al.*, 2021). This phenomenon occurs because these FMAs have ideal oceanographic characteristics as spiny lobster habitats. For example, FMA 572 and 573 are known for their rocky waters and strong currents along the southern coast of Java-Sumatra (Arief *et al.*, 2025), while FMA 718 (Arafura Sea) has nutrient-rich sandy mud bottoms, providing extensive spawning and nursery areas. The implication is that fishing pressure is massively focused on these three key ecosystems, creating fishing pressure accumulation centers of exploitation that ignore precautionary principle in fisheries management.

Species Diversity and Area-Specific Exploitation Patterns

Pattern of economic value disparity between FMAs can be further explained by looking at the composition of spiny lobster species (Table 2). FMA 718 is dominated by ornate spiny lobster (*Panulirus ornatus*) (7,831.41 tons; 46% of FMA production), which is a very high-value export commodity, reaching an average of IDR 1.4 million/kg based on value/production calculations. In contrast, FMA 572 is dominated by painted spiny lobster (*P. versicolor*) (10,025.99 tons; 56% of FMA production) with a lower value per

unit ($\pm$ IDR 240,000/kg). Meanwhile, FMA 573 is the main source of scalloped spiny lobster (*P. homarus*) (2,366.42 tons; 40% of FMA production), which is widely used for domestic and regional markets.

These differences in composition reflect different exploitation strategies between the regions: in FMA 718, this involves selective fishing of high-value species, while in FMA 572, this involves multi-species mass exploitation. This creates dual pressure on key ecosystems: in FMA 572, pressure is driven by mass catch volume, while in FMA 718, pressure stems from very high economic value per unit, which drives fishing intensification.

Management implications are significant. Massive exploitation pressure and overexploitation in FMA 572 and 718 not only threaten stocks in aggregate, but specifically endanger local populations of most economically valuable species (painted and ornate spiny lobsters). Overexploitation of these key species can result in erosion of genetic diversity, disruption of ecosystem function, and severe long-term economic losses. Therefore, a uniform management approach for all spiny lobster species is no longer adequate. Species- and location-specific strategies are needed, for example, by establishing different minimum catch sizes, fishing seasons, or quotas based on the most stressed spiny lobster species in each FMA.

Table 2. Spiny lobster (*Panulirus*) species (tonnes) per Fisheries Management Area (FMA) 2019-2024.

FMA	Painted	Common	Ornated	Scalloped	Longlegged	Slipper	Pronghorn	Mud
572	10025.99	2558.54	2571.40	1348.41	742.48	91.98	447.89	21.73
718	2318.79	5114.11	7831.41	0	1017.69	18.16	668.66	0
573	343.51	2234.50	344.58	2366.42	276.14	2.85	406.30	0
713	2233.10	986.95	755.17	7.96	186.50	130.70	33.50	11.53
714	825.35	1576.93	216.71	556.08	102.60	1160.44	37.73	0
715	370.52	819.42	0	0	175.36	252.00	41.84	0
716	158.68	539.74	169.02	51.35	9.58	10.07	0	104.26
711	339.92	523.62	0.19	0	0.70	122.90	0.23	0
712	121.26	771.98	0	0	0.00	34.58	0.02	0
571	15.76	121.75	0	0	14.72	0.75	0	0
717	1.16	652.50	0	0	1.04	0.88	0	0
Total	16754.04	15900.04	11888.48	4330.22	2526.81	1825.31	1636.17	137.52

Change in Stock Utilization Status towards Over-Exploited Phase

Ecological implications of production dynamics need to be evaluated stock utilization status by comparing production realization and TAC (Table 3).

Previous policy estimates were inaccurate, creating misinterpreted data. Based on Ministerial Decree No. 50/2017, FMA 572 and 573 were categorized as fully exploited with estimated TP of 0.93 and 0.61, respectively. However, calculations of actual TP based on average production from 2019-2021 indicate that both FMAs are already over-exploited, with TP of 2.12 and 1.10, respectively. This significant disparity indicates that the fishery resource potential (TAC) estimates in the 2017 Ministerial Decree may have been overly optimistic or based on outdated data. Even more worrying, FMA 718, officially fully exploited (TP of 0.97), actually has an actual TP of 3.67, meaning exploitation has exceeded three and a half times the estimated limit. This creates an illusion of management. Formally, the policy states that spiny lobster stocks are safe. However, actual production data shows that overexploitation has occurred on a large scale in the field.

Despite policy revisions, exploitation pressure continues to increase, indicating a lagging management response. Ministerial Decree 19/2022 revised the TAC for most FMAs, including increasing the TAC for FMA 572 from 1,186 tons to 1,361 tons. However, the increase in average production from 2022-2024 was even more significant, causing the actual TP for FMA 572 to increase from 2.12 to 2.51. A similar trend occurred in FMA 573, where the actual TP increased from 1.10 to

1.46. This increase in TP occurred despite the revised TAC, indicating that fishing dynamics in the field are moving faster than the policy response. This phenomenon is particularly evident in FMA 713, where the actual TP jumped from 0.52 to 2.78 a more than fivefold increase, signaling the emergence of new, highly intensive exploitation pressure. Production of 2023 surge as part of the revenge fishing phenomenon contributed directly to this exceedance of tighter TAC.

Problem of overfishing has become systemic and worsening. Based on actual TP calculations for the 2022-2024 period, 7 of 11 FMAs (64%) have TP > 1, with several FMAs such as 572, 713, and 718 achieving TP above 2.0. This condition exacerbates the manifestation of the 'tragedy of the commons' (Hardin, 1968), where each actor is encouraged to increase fishing intensity due to the lack of clear ownership rights to resources. Persistently high TP values accompanied by large or increasing production volumes also indicate the need to be vigilant about the phenomenon of hyperstability in catch data (Griffeth et al., 2023). This pattern can create misleading that stocks are still healthy because production remains high, even though fishers have compensated for the decline in abundance by massively increasing fishing efficiency and intensity. As a result, aggregate production data can provide a misleading signal about stock health. Therefore, the finding of high TP should not be interpreted as a sign that the stock is still able to withstand high pressure, but rather as a critical indicator that requires confirmation through further research with standardized fishing effort data.

Table 3. Comparison of spiny lobster (*Panulirus*) stock utilization status: policy estimates (Ministerial Decrees of MMAF 50/2017 and 19/2022) and actual production

FMA	Decrees 50/2017		Production average 2019-2021	Status Decrees 50/2017	Decrees 19/2022		Production average 2022-2024	Status Decrees 19/2022
	TAC	Status			TAC	Status		
		(TP)				(TP)		
571	539	Over (1.30)	11.53	0.02	239	Over (1.4)	39.47	0.17
572	1186	Fully (0.93)	2515.77	2.12	1361	Over (1.6)	3420.37	2.51
573	776	Fully (0.61)	852.93	1.10	782	Over (2.0)	1138.50	1.46
711	1137	Fully (0.54)	120.86	0.11	734	Over (1.1)	208.32	0.28
712	791	Over (1.36)	109.02	0.14	1037	Fully (0.5)	200.26	0.19
713	742	Over (1.40)	384.99	0.52	383	Over (1.3)	1063.48	2.78
714	579	Over (1.73)	924.90	1.60	362	Over (1.7)	567.05	1.57
715	677	Over (1.32)	166.84	0.25	609	Over (1.2)	386.21	0.63
716	715	Fully (0.75)	244.37	0.34	1046	Fully (0.9)	103.20	0.10
717	835	Over (1.04)	182.16	0.22	515	Fully (0.8)	36.37	0.07
718	950	Fully (0.97)	3490.66	3.67	950	Fully (0.97)	2165.62	2.28

Information: TAC: Total allowable catch; Status: ≤ 0.5 (Moderate exploited), $0.5 < TP \leq 1$ (Fully exploited), $TP > 1$ (Over exploited); TP: utilization status- production/TAC

Despite these potential data biases, one thing is clear: the dynamics of catches on the ground driven by massive small-scale fisheries structures have far exceeded the sustainable limits (STLs) set in the latest policy.

Dominance of Small-Scale Fishing Operations in Spiny Lobster Fisheries

Contrary to the common narrative that often blames large vessels, fleet composition analysis actually shows that very small vessels (<5 GT) consistently contribute more than 50% of national production (Figure 2). This dominance becomes particularly significant (>60%) when combined with the contribution of non-motorized vessels.

Indonesian spiny lobster fishery was used artisanal fishing gear, dominated by passive gear, particularly gillnets and traps, which together contribute more than 80% of production (Figure 3). Although individually these gears are relatively selective and

environmentally friendly, unregulated soaking times can increase the risk of bycatch (Vanderstichel *et al.*, 2025) and the accumulation of thousands of units from small fleets is the root of the problem.

These findings align with studies in Pangandaran (Rahayu *et al.*, 2023) and Gunungkidul (Febriani *et al.*, 2014) that also revealed the dominance of small-scale fishers. However, this study provided quantitative evidence at a national scale that the main paradox of Indonesia's spiny lobster fisheries is that the small-scale, socio-economically vulnerable sector is the main driver of overexploitation that threatens the sustainability of the resources on which they depend. Management complexity is increased by the large number of actors, spread out, and difficult to monitor, making quota-based policies such as the TAC very difficult to implement and enforce.

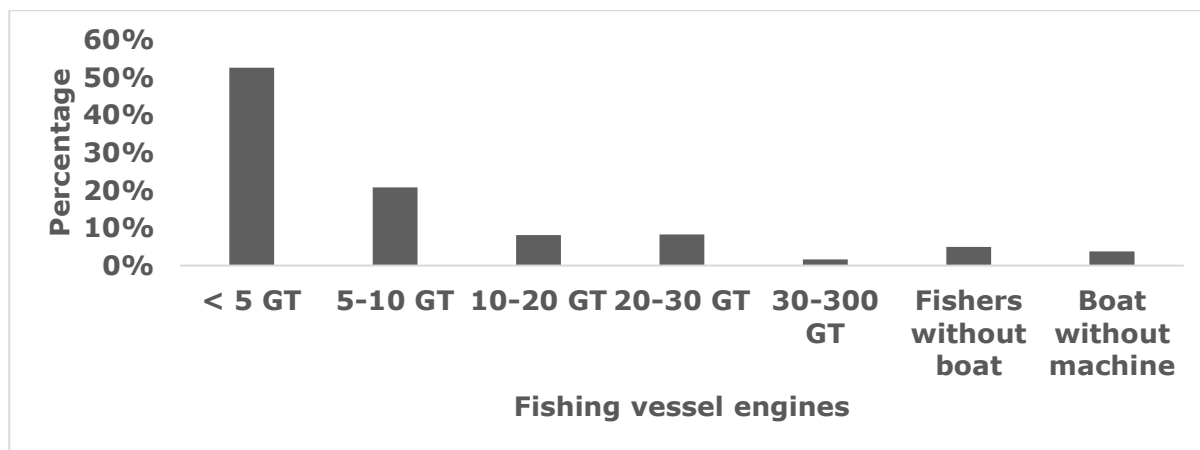


Figure 2. Average composition of spiny lobster (*Panulirus*) production using different fishing vessel engines.

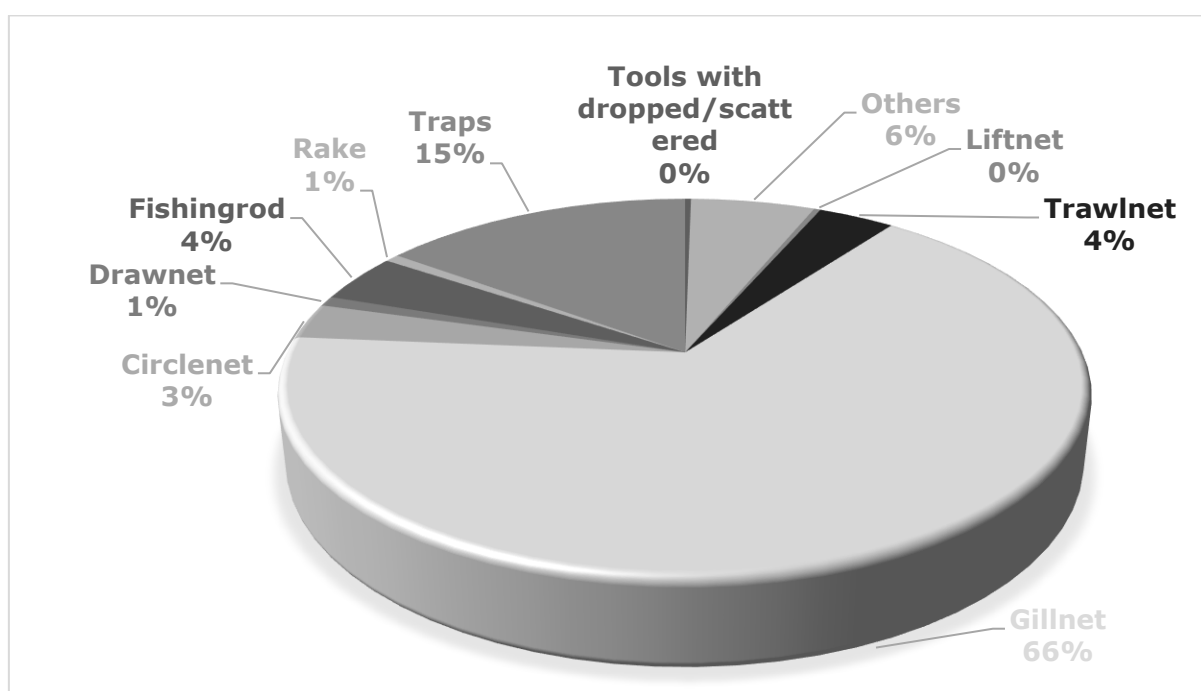


Figure 3. Composition of spiny lobster (*Panulirus*) fishing gear in Indonesia 2019-2024.

Theoretical Implications and Policy Recommendations Towards Adaptive and Site-Specific Management

Results of this study strongly confirm the gap between actual catch dynamics and the effectiveness of existing management policies. Theoretical implication of these findings is that open-access fisheries management approaches with static instruments (such as the WWP-level TAC) are inadequate for resources dominated by numerous small-scale actors. A more adaptive integration of rights-based and ecosystem-based management theoretical frameworks is needed. Based on the above discussion, an urgent policy implication or implementation

recommendation is a transition to rights-based or spatial management in critical areas such as FMA 572 and 573. In these areas, it is necessary to trial management systems that limit fishing effort, such as limited licenses, spatial access rights, or community-based quotas, which have proven successful in other countries (Linnane *et al.*, 2022). These approaches are more manageable and can build a sense of local ownership. Furthermore, strengthening spatial protection instruments through the establishment of protected areas in spiny lobster spawning and nursery areas should be a priority, following the success of stock restoration in other regions that consider

fisher behavior (Lenihan *et al.*, 2024; Young *et al.*, 2024).

Direct pressure on natural stocks can be reduced directly by diversifying livelihoods through the development of sustainable and independent spiny lobster hatchery systems that need to be encouraged (Haj *et al.*, 2022; Zulfainarni *et al.*, 2024). Finally, a revolution in data systems and participatory governance through use of digital technology, the establishment of priority areas for spatial management, and participatory mapping approaches are crucial to improve data accuracy, compliance, and policy acceptance at the fishing community level (Murillas-Maza *et al.*, 2023; Panzeri *et al.*, 2024). Alternative models such as Islamic bioeconomic can also be explored for socio-cultural approaches (Wahyudin & Mahipal, 2024).

Policy changes for small-scale fisheries must adhere to the principle of a just transition. This means that reducing or shifting fishing effort must not sacrifice the livelihoods of fishermen. Before strict control regulations are implemented in critical FMAs, social safety nets such as conditional cash transfers or labor-intensive programs are needed to ensure basic needs. Policy design processes, such as establishing no-take zones or rotating fishing systems, must involve the active participation and ownership of local fishing communities. Livelihood diversification must also be concrete and contextual, for example, into hatchery-based aquaculture, ecotourism, supported by access to capital, technology, and markets (OECD, 2022).

Optimal solution lies in management that balances stock health with the long-term well-being of fishers. Rather than a total ban, a more effective approach is to wisely regulate methods, timing, and locations of fishing. Examples include implementation of a rotational zoning system, where some areas are restored while others are exploited under strict regulations, or incentives for the adoption of more selective fishing gear. Granting community-based fishing rights can create incentives for fishers to maintain stock health because they perceive the benefits of sustainable management (OECD, 2022).

Based on theory of co-management and its relevance to the Sustainable Development Goals (SDGs), best approach is to empower local communities as active partners in management. Co-governance has been shown to contribute to the recovery of fish stocks (SDG 14.4) and strengthen the access rights of small-scale fishers (SDG 14.b) (Kuran *et al.*, 2025; Smallhorn-West *et al.*, 2022). However,

to simultaneously improve economic well-being (SDG 1) and food security (SDG 2), this governance framework needs to be strengthened with investments beyond pure fisheries sector, namely in programs supporting livelihood diversification, skills development, and access to inclusive value chains Kuran *et al.*, 2025).

CONCLUSIONS

Indonesia's spiny lobster fishery, dominated by small-scale fisheries from 2019 to 2024, is facing serious sustainability challenges. High and highly concentrated production in FMA 572 and 573 has led to overexploitation in these two central areas, with actual catches far exceeding the permitted limits according to the latest policy (Ministerial Decree of Maritime Affairs and Fisheries 19/2022). A more in-depth analysis reveals a significant disparity between the estimated stock status in official policy and actual utilization levels in the field, with several FMAs declared fully exploited having experienced overexploitation since the previous period. The fact that this exploitation pressure stems primarily from the accumulated activities of thousands of small-scale fleets (<5 GT) highlights the ineffectiveness of the current open-access management approach.

A policy paradigm shift is needed, moving from a static, uniform, output-based (TAC) approach to adaptive management based on the FMA that integrates input control instruments such as fleet and gear restrictions, a real-time monitoring and evaluation system to bridge the gap between policy and field reality, strict spatial protection in critical areas such as spawning and nursery grounds, and the creation of sustainable livelihood alternatives for small-scale fishers. Without improved adaptive and FMA-based management policies, overexploitation pressures have the potential to continue to increase and threaten the sustainability of spiny lobster resources and livelihoods of fishers.

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