

Estimates of Gear Loss and Contributing Factors in Gillnet Fisheries in the Pangandaran Waters of Indonesia

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Abstract— Abandoned, Lost, or Otherwise Discarded Fishing Gear (ALDFG), or ghost gear, poses a major threat to marine ecosystems and the sustainability of fisheries. This study in Pangandaran, Indonesia, estimated gillnet losses, identified key causal factors, and developed management recommendations. Data were collected through field observations and structured interviews with 90 gillnet fishers at Cikidang Fishing Port (PP) and analyzed using Confidence Intervals (CI) to estimate annual losses. All respondents reported ALDFG incidents, with losses ranging from 16,473–19,648 pieces (752,528–897,605 meters) per year, equivalent to IDR 8.66–10.33 billion. The main causes included strong currents, coral reef snags, and adverse weather. ALDFG not only drives ghost fishing but also degrades marine habitats and imposes economic burdens on fishers. Recommended mitigation measures include awareness programs, adoption of modern technologies (GPS, RFID, AIS), gear marking, planning of fishing grounds, skill enhancement, use of durable materials, avoiding gillnet deployment in high-risk areas, lost gear reporting systems, onshore facilities for storing end-of-life fishing gear (EOLFG) and ALDFG, providing incentives to support these interventions, and circular economy practices. This study provides critical local quantitative data and causal analysis to inform management strategies and policy interventions to reduce ALDFG at the local level.

Keywords— Abandoned Lost or Discarded Fishing Gear (ALDFG), Environmental impact, Marine debris, Ghost fishing, Gear marking, Fishing impact, Ghost gear.

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I. INTRODUCTION

Abandoned, Lost, or Otherwise Discarded Fishing Gear (ALDFG) or ghost gear, refers to fishing gear that is intentionally or unintentionally lost, discarded, or abandoned in marine waters [1][2]. Ghost gear is a major contributor to marine debris, with studies estimating that more than 50% of global marine litter consists of ghost gear [3]. A meta-analysis further suggests that 5.7% of all gillnets, 8.6% of all traps, and 29% of all longlines are lost worldwide each year [4]. ALDFG is closely associated with ghost fishing, in which uncontrolled gear continues to capture both target and non-target species even when no longer operated by fishers [5][6]. In addition, ALDFG damages coral reefs and seagrass beds [7], increases maritime safety risks, including navigation hazards and vessel damage [8], and imposes economic burdens on fishers [9][10]. These facts highlight ALDFG as a critical issue at both global and local scales.

Gillnets are considered the most prone fishing gear to becoming ALDFG and to have the greatest potential impact [11]. In Indonesia, particularly at Cikidang

Fishing Port (PP) in Pangandaran, small-scale fleets (<5 GT) are dominated by gillnets, which increases the risk of ALDFG due to passive fishing gear, overlapping fishing grounds, and frequent gear component replacement [12][13][14]. International studies have identified multiple causes of gillnet loss, both intentional and unintentional, including strong currents and adverse weather [15][16], vandalism [17], snagging on seabed obstacles or coral reefs [18][19], net damage caused by entanglement with megafauna [20], gear conflicts, and operator error [21].

Regional studies in Indonesia have also begun to highlight the scale of ALDFG. For example, Riyanto et al. [14] estimated annual gillnet losses in Pangandaran at 4,612 pieces or 224,584 meters. However, this study was limited to general estimates and did not provide an in-depth analysis of causal factors. Despite global and regional insights into gear loss and ALDFG impacts, significant gaps remain at the local level. The lack of systematic quantitative data makes it difficult to assess the scale of ALDFG, while causal factors related to fisher practices, port infrastructure, and reporting mechanisms have not been thoroughly investigated.

This study addresses these gaps by providing quantitative estimates of ALDFG and analyzing its primary causes in gillnet fisheries at Cikidang Fishing Port. The objective is to estimate the number of gillnets lost annually and identify the main causal factors of ALDFG in Pangandaran. The findings are expected to provide essential quantitative data and causal analysis to support management strategies and policy recommendations aimed at reducing ALDFG and its impacts at the local level.

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II. METHOD

A. Studi Site

This study was conducted in January 2026 at Cikidang Fishing Port (PP), located in Pangandaran Regency, West Java Province. The site was selected because it is the central hub of gillnet fisheries, with gillnets accounting for 87.5% of fishing gear units [22], or more than 80% of all fishing gear in the Pangandaran region [13][14]. The fisheries at PP Cikidang are dominated by vessels <5 GT operating under a one day fishing system, resulting in high gillnet usage intensity and a significant potential for ALDFG generation.

B. Data Collection

Data were obtained through field observations and direct interviews with gillnet fishers at PP Cikidang. Respondents were selected using purposive sampling based on the following criteria: (1) active fishers with prior experience of ALDFG, (2) use of gillnets as the primary fishing gear, and (3) landing catches at PP Cikidang. Direct interviews were chosen to gain deeper insights into the extent and causes of gillnet losses. A structured questionnaire, adapted from the World Bank and FAO's Gillnets Global Fishing Gear Loss Assessment [23][24], was used as the interview instrument. The questionnaire covered information on gillnet quantity and specifications, frequency of use, technical lifespan of components, experiences of gear loss, causal factors, and reporting mechanisms.

The study population comprised 475 gillnet vessels at PP Cikidang, with one fisher assigned to each vessel [22]. The minimum sample size was calculated according to [25], using a 10% margin of error and a 90% confidence level. This calculation indicated a minimum of 83 respondents, representing 18% of the total population. To improve representativeness and data quality, 90 gillnet fishers were ultimately surveyed.

C. Data Analysis

Data were analyzed using descriptive quantitative methods to estimate annual gillnet losses as ALDFG. Estimations were conducted using Confidence Intervals (CI), which provide a range within which the population

means are expected to lie based on sample data [26]. CI allows the estimation of lost gillnets to be expressed as a range of values, making it more representative of the gillnet fisher population at PP Cikidang. The lower and upper bounds of the 95% confidence interval were multiplied by the total gillnet vessel population to obtain the estimated range of gillnet losses in Pangandaran waters.

Causal factors of gear loss were analyzed descriptively to illustrate each factor (e.g., adverse weather, gear conflicts, operator error, and others). The results were then used to identify the dominant causes of ALDFG.

III. RESULTS AND DISCUSSION

A. Estimations of Gear Losses

1) Fisher's experiences with gear losses

Most gillnet fishers in Pangandaran reported more than five years of fishing experience (Figure 1). Based on this background, all respondents reported experiencing gillnet losses. Of these, 92% reported being unable to recover lost gillnets even when they knew the location of the loss, 2% managed to retrieve lost gear, and the remaining 6% neither knew the location nor were able to recover it (Figure 2).

Gillnet fishers typically marked gear-setting locations using marker buoys and natural landmarks (when fishing grounds were nearshore). In addition, some fishers used the "Fishing Point" application as an alternative to GPS, which only records the user's last location history rather than tracking gear directly. Consequently, if marker buoys were lost, recovering gear became difficult. According to Kanhai et al [27], modern tracking technologies can help prevent or reduce gear losses.

Not all gillnet fishers experiencing ALDFG reported their losses. Approximately 20% did not report, 49% consistently reported, and 31% reported occasionally. More than half of the fishers had reported gear losses, underscoring the importance of reporting mechanisms [28]. Internationally, gear loss reporting is regulated under MARPOL Annex V [29], and nationally by the Ministry of Marine Affairs and Fisheries through Circular Letter No. B.1694/DJPT/HK.410/XII/2024 [30].

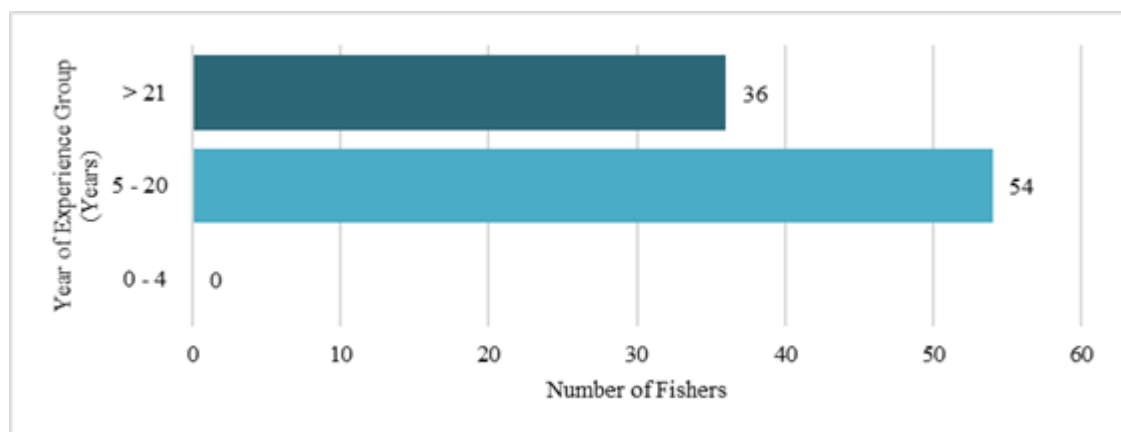


Figure 1. Fishing experience of gillnet fishers.



Figure 2. Fishers' awareness of lost fishing gear locations.



Figure 3. Organizations that receive reports of gear loss from fishers in Pangandaran.

In Pangandaran, lost gear was typically reported to several parties. Most respondents reported losses to fisher associations (37%) and vessel owners (31%), followed by nearby vessels (18%), coast guards (12%), and local government (2%) (Figure 3). Fisher associations and vessel owners were the most common recipients of reports, largely due to financial considerations. Gear loss not only reduced fishing capacity but also decreased catch volume, thereby lowering income. Consequently, fishers often relied on associations or vessel owners for financial support to replace lost gear.

2) Estimated annual gear losses

Gillnet fishers reported several types of gear losses, including entire sets, single units or pieces, marker buoys, small floats, and net fragments. Net fragments were the most frequently lost component (92%),

followed by single units or pieces (64%) (Figure 4). Gillnets are particularly prone to partial or complete loss because they are not actively monitored; their passive operation increases vulnerability [31].

The number of ALDFG incidents in Pangandaran has increased fourfold compared to 2020, as reported by Riyanto et al. [14]. In this study, total gillnet losses were estimated at 16,473–19,648 pieces per year (Table 1), equivalent to 752,528–897,605 meters annually, resulting in financial losses of IDR 8.66–10.33 billion (Table 2). In contrast, losses in 2020 were estimated at 4,612 pieces or 224,584 meters annually [14]. At the individual level, gillnet fishers lost approximately 35–41 pieces per year, or 1,584–1,890 meters, and incurred financial losses of IDR 18.23–21.74 million per fisher annually.

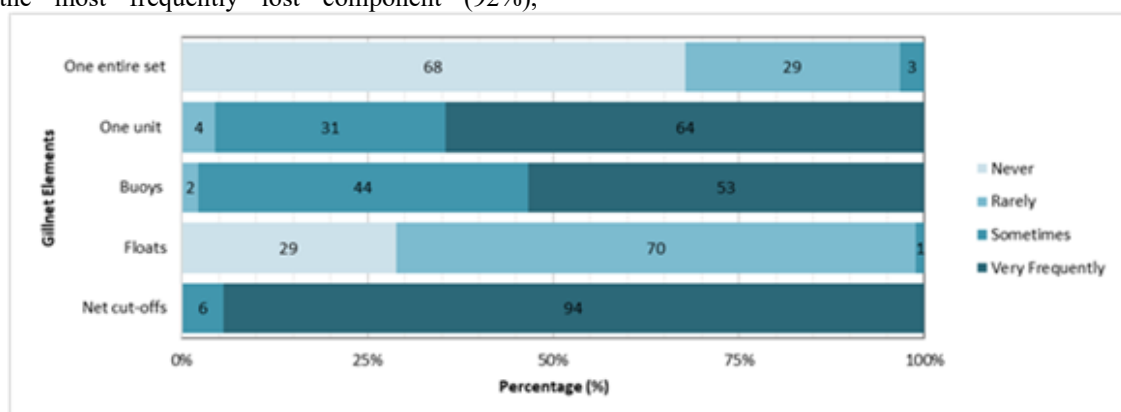


Figure 4. Frequency of gillnet losses by gear components, including a one entire set, a single piece (one unit), buoys, floats or net cut-offs

TABLE 1.
ESTIMATIONS OF THE NUMBER OF LOST GILLNETS ANNUALLY

Period	Vessel (n)	Average Gillnet Loss (pieces)	Standard Deviation (SD)	Margin of Error (95%)	Individual		Estimated Total Population CI Lower (pieces)	Estimated Total Population CI Upper (pieces)
					CI Lower (pieces)	CI Upper (pieces)		
1 year	90	38.02	16.18	3.34	34.68	41.37	16,472.70	19,648.41
1 month	90	3.17	1.35	0.28	2.89	3.45	1,372.73	1,637.37

TABLE 2.
CONVERSION OF THE NUMBER OF LOST GILLNETS ANNUALLY

Average Gillnet Loss (meters)	Individual		Estimated Total Population CI Lower (meters)	Estimated Total Population CI Upper (meters)	Average Gillnet Price (IDR)	Individual		Estimated Total Population CI Lower (IDR)	Estimated Total Population CI Upper (IDR)
	CI Lower (meters)	CI Upper (meters)				CI Lower (IDR)	CI Upper (IDR)		
1 year									
45.68	1,584.27	1,889.69	752,527.85	897,604.91	525,722	18,231,715	21,746,540	8,660,064,495	10,329,606,307
1 month									
45.68	132.02	157.47	62,710.65	74,800.41	525,722	1,519,310	1,812,212	721,672,041	860,800,526

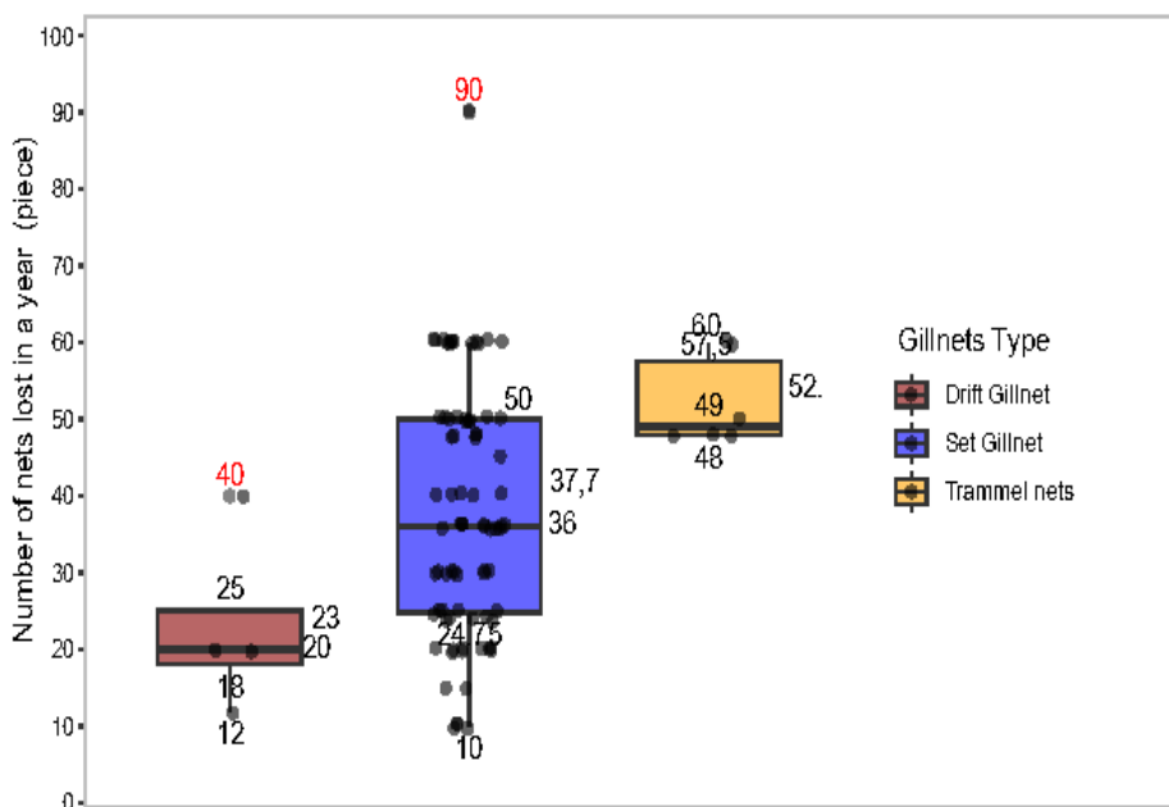


Figure 5. Annual distribution of lost gear units per vessel.

The gillnet types most frequently lost in Pangandaran were drift gillnets, set gillnets, and trammel nets. Figure 5 illustrates the distribution of gillnet losses among these types. Overall, set gillnets exhibited the widest distribution of losses, ranging

from 10 to 90 pieces annually, compared with the other two types. Set gillnets were also the most observed gear type during fieldwork.

B. Causes of Gear Losses and Mitigation Strategies

1) Causes of gear losses

Multiple factors contribute to ALDFG in Pangandaran, including natural, technical, and social aspects. Based on Fisher's interviews, 16 causal factors were identified (Figure 6). Strong ocean currents emerged as the primary factor, with 87% of respondents reporting it as "always occurring" and 13% as "sometimes occurring." Many fishers tend to overlook currents when setting gillnets. Strong currents complicate gear deployment and retrieval, and may also displace gillnets from their original location, both of which contribute to ALDFG [32].

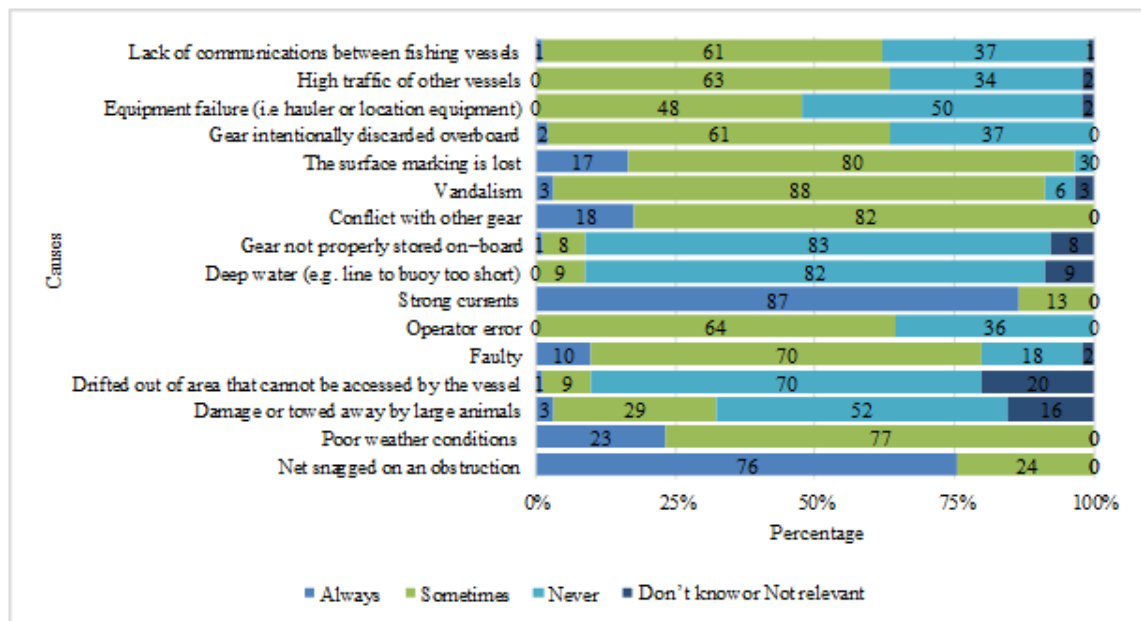


Figure 6. Gear loss causes identified in fisher interviews

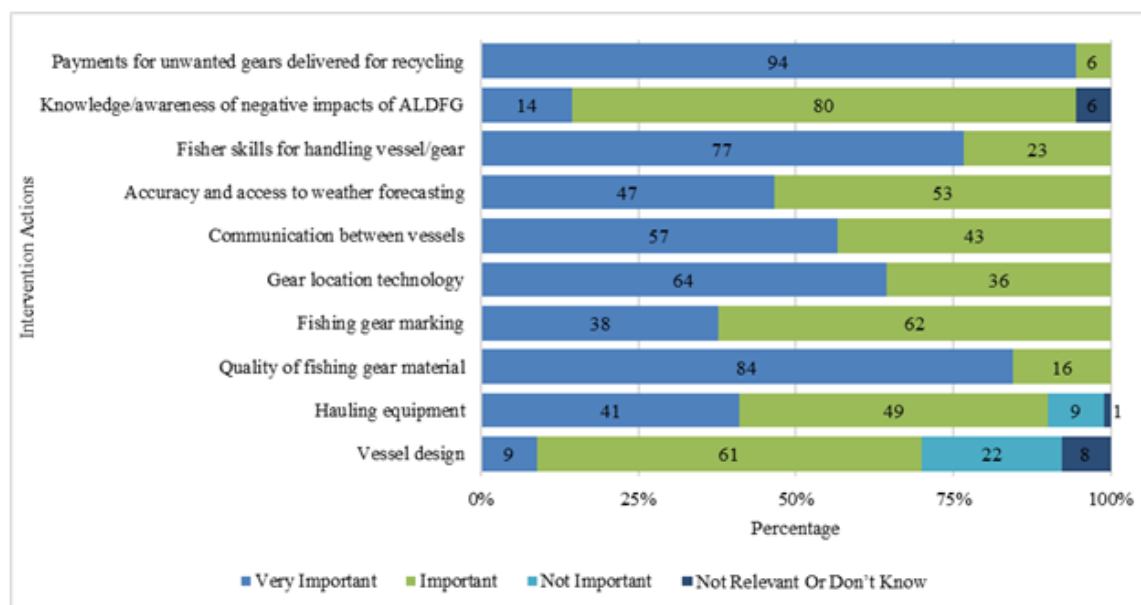


Figure 7. Surveyed fishers' prioritization of measures to reduce ALDFG.

Another major factor is gear snagging on obstructions such as coral reefs or shipwrecks. 76% of fishers reported always experiencing ALDFG as a result of this issue. Pangandaran's coastal waters host healthy coral reef ecosystems [33], which serve as prime fishing grounds by supporting high fish productivity. However, prolonged fishing activity in reef areas increases the risk of gear snagging [34][35]. Adverse weather was also identified as a significant factor (23%), as extreme sea conditions clearly heighten the risk of gillnet loss. Globally, bad weather is recognized as the most common cause of fishing gear loss [18].

2) Mitigation strategies to reduce gear losses

After identifying the causal factors of ALDFG in Pangandaran, it is essential to review applicable mitigation measures. Preventive strategies are key to reducing ALDFG, requiring a combination of technical, economic, and regulatory interventions for sustainable gear management [1][36]. Locally, fisher perspectives provide crucial input for designing relevant and urgent interventions.

Respondents prioritized several measures (Figure 7). The most important, cited by 94% of fishers, was financial incentives for collecting and recycling unused gear. Gillnet fishers in Pangandaran already practice reuse and recycling, with 93% (84 of 90 respondents) reporting consistent collection of damaged nets. Incentives align with gear buyback and Extended Producer Responsibility (EPR) schemes in Europe, which require producers to manage gear throughout their lifecycle, including collection and recycling [37].

Financial support encourages fishers to surrender obsolete gear rather than discard it at sea, thereby reducing ALDFG and supporting circular economy practices.

TABLE 3.
POLICY MEASURES ADDRESSING TO THE ALDFG PHENOMENON IN PANGANDARAN

No.	Policy measures	Preventive	Mitigation	Curative
1	Socialization of the ALDFG	√		
2	Use of modern technology	√	√	√
3	Fishing gear marking	√	√	√
4	Avoid placing fishing gears in areas where it often gets stuck	√		
5	Improving fishermen's skills		√	
6	Using durable materials for fishing gear	√	√	
7	Report of lost fishing gear			√
8	Offer facilities to store discarded fishing gear and provide incentives			√
9	Circular Economy of ALDFG			√

Fishers also emphasized the importance of using higher quality gear materials (84%) and improving operational skills (77%). In practice, however, fishers often purchase new nets rather than repair damaged ones, citing time and labor efficiency. The relatively low cost but poor durability of nets reinforces this tendency, shortening gear lifespans and increasing ALDFG risk [38] highlights that durable gear materials reduce breakage under strong currents or adverse weather conditions. Training programs can also minimize operator errors and poor storage practices, forming part of a comprehensive policy to reduce ALDFG.

Technological support and communication systems were also considered important. Gear-tracking technologies (64%) and effective gear marking systems (38%) were seen as solutions to facilitate retrieval and reduce ghost fishing. Examples include barcode-based gear marking in small-scale fisheries in Pekalongan, Indonesia [39]. Technologies such as GPS, RFID, and AIS can enable real-time gear tracking, though adoption should prioritize simplicity and affordability [1619]. Economic constraints limit adoption, underscoring the need for subsidies or government support to make these technologies accessible to small-scale fishers.

Improved communication among vessels (57%) and access to accurate weather forecasts (47%) were also highlighted. Effective communication reduces conflicts and gear collisions, while reliable forecasts help fishers avoid risky operations. These practices align with recommendations by Gilman et al. [40], emphasizing the importance of information systems and coordination in reducing ALDFG.

Mitigation is not limited to hardware or information systems but also depends on fisher awareness of ALDFG impacts [41]. Although only 14% of respondents considered awareness-raising “very important,” 80% still considered it “important.” This indicates that fishers recognize ALDFG impacts but prioritize more practical interventions. Systematic education can reinforce understanding that gear loss not only causes economic hardship but also ecological damage.

The ALDFG mitigation framework in Pangandaran can be organized into three categories [1]: preventive,

mitigation, and curative. Preventive measures aim to reduce gear loss by promoting awareness, implementing modern technologies, marking fishing gear, and systematically planning fishing grounds. Mitigation measures aim to reduce impacts by enhancing skills, using durable materials, and implementing tracking technologies. Curative measures include reporting, collection facilities, incentives, and circular-economy practices to recover and recycle lost gear. Collectively, these strategies provide a comprehensive approach for managing ALDFG in Pangandaran’s gillnet fisheries (Table 3).

IV. CONCLUSION

Most gillnet fishers in Pangandaran have experienced ALDFG. As many as 92% reported being unable to recover lost gillnets even when aware of their location. Net cuts-offs (92%) and one set (single pieces) (64%) were the most frequently lost components, resulting in an estimated total loss of 16,473–19,648 pieces per year, equivalent to 752,528–897,605 meters annually, with financial losses of IDR 8.66–10.33 billion. At the individual level, fishers lost an average of 35–41 pieces per year or 1,584–1,890 meters, corresponding to financial losses of IDR 18.23–21.74 million per fisher annually. The primary causes of gear loss were strong ocean currents (87%), snagging on obstructions such as coral reefs (76%), and adverse weather (23%). To address these issues, mitigation strategies can be structured into three categories: preventive, including awareness programs, adoption of modern technologies (GPS, RFID, AIS), gear marking, and fishing ground planning; mitigation, involving skill enhancement, use of durable gear materials; and curative, encompassing gear loss reporting, provision of collection facilities and financial incentives, and implementation of circular economy practices for recycling. Together, these measures can reduce gear loss from the outset, minimize ecological and economic impacts, and ensure sustainable management of lost fishing gear in Pangandaran.

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REFERENCES

- [1] G. Macfadyen, T. Huntington, and R. Cappell, *Abandoned, Lost or Otherwise Discarded Fishing Gear*. Rome, Italy: Food and Agriculture Organization of the United Nations, 2009, pp. 1–138.
- [2] FAO, Report of the expert consultation on the marking of fishing gear, FAO Fish. Aquac. Rep. R1157, 46, 2016. [Online]. Available: <https://openknowledge.fao.org/handle/20.500.14283/i5729e>.
- [3] P. Consoli, T. Romeo, M. Angiolillo, S. Canese, V. Esposito, E. Salvati, G. Scotti, F. Andaloro, and L. Tunesi, “Marine litter from fishery activities in the Western Mediterranean Sea: The impact of entanglement on marine animal forests,” *Environ. Pollut.*, vol. 249, pp. 472–481, 2019.
- [4] K. Richardson, R. A. Silvia, J. Drinkwin, K. V. K. Gilardi, I. Giskes, G. Jones, K. O'Brien, H. P. Raasch, L. Ludwig, and K. Antonelis, “Building evidence around ghost gear: global trends and analysis for sustainable solutions at scale,” *Mar. Pollut. Bull.*, vol. 138, pp. 222–229, 2019.
- [6] K. Nagendrasai and G. Sravani, “Ghost fishing: haunting our oceans' sustainability,” *AgriCOs*, vol. 5, no. 1, pp. 32–38, 2024.
- [5] M. Riyanto, R. M. Fajri, D. P. Yuwandana, R. I. Wahju, A. Purbayanto, K. Richardson, H. A. Einarsson, and P. He, “Estimates of gear loss and contributing factors in trap fisheries in coastal waters: A case study from the Seribu Islands, Indonesia,” *Fisheries Research*, vol. 289, p. 107500, 2025. doi: 10.1016/j.fishres.2025.107500
- [7] L. V. Ballesteros, J. L. Matthews, and B. W. Hoeksema, “Pollution and coral damage caused by derelict fishing gear on coral reefs around Koh Tao, Gulf of Thailand,” *Mar. Pollut. Bull.*, vol. 135, pp. 1107–1116, 2018. doi: 10.1016/j.marpolbul.2018.08.033
- [8] M. Morfin, S. Méhault, L. Miquelot, Q. C. Dufau, and D. Kopp, “Using citizen science to inventory and map abandoned, lost, or otherwise discarded fishing gear (ALDFG),” *Mar. Pollut. Bull.*, vol. 220, p. 118418, 2025. doi: 10.1016/j.marpolbul.2025.118418
- [9] A. Adlina, P. Wijayanti, D. Ratnasari, and T. Kodiran, “Economic impact of ghost gear on small-scale fisheries in Java Sea (Case Study: Tegal, Central Java),” *J. Sos. Econ. Mar. Fish.*, vol. 18, no. 2, pp. 141–148, 2023.
- [10] J. McIntyre, K. Duncan, L. Fulton, A. Smith, A. J. Goodman, C. J. Brown, and T. R. Walker, “Environmental and economic impacts of retrieved abandoned, lost, and discarded fishing gear in Southwest Nova Scotia, Canada,” *Mar. Pollut. Bull.*, vol. 192, p. 115013, 2023. doi: 10.1016/j.marpolbul.2023.115013
- [11] Global Ghost Gear Initiative, *Best Practice Framework for the Management of Fishing Gear: June 2021 Update*. Prepared by T. Huntington, Poseidon Aquatic Resources Management Ltd., 2021, pp. 1–94 + appendices.
- [12] I. Syauqi, R. Muningsgar, and W. Oktariza, “The role of Cikidang Fish Landing Base (PPI) in drift gillnet fisheries bussiness,” *Albacore*, vol. 3, no. 3, pp. 321–330, 2019.
- [13] M. A. Ginanjar, I. N. Suyasa, and I. J. P. Dewi, “Characteristics of catch fisheries in Pangandaran District,” *AGRIKAN J. Agribisnis Perikanan*, vol. 15, no. 1, pp. 226–238, 2022.
- [14] M. Riyanto, R. I. Wahju, and G. S. Komarudin, “Rate and causes of lost gillnets in the Pangandaran Waters of Indonesia,” *IOP Conf. Ser.: Earth Environ. Sci.*, vol. 1033, no. 012040, 2022. doi: 10.1088/1755-1315/1033/1/012040
- [15] K. Richardson, B. D. Hardesty, J. Z. Vince, and C. Wilcox, “Global causes, drivers, and prevention measures for lost fishing gear,” *Front. Mar. Sci.*, vol. 8, 2021. doi: 10.3389/fmars.2021.690447
- [16] M. Riyanto, G. D. Prasetyo, R. M. Fajri, and K. Parr, *Field assessment of abandoned, lost, or otherwise discarded fishing gear in Daru and the Forecoast Villages, Western Province, Papua New Guinea. Report on the Arafura and Timor Seas Ecosystem Action (ATSEA) Program*, Bogor, Indonesia: IPB University, 2026, p. 59.
- [17] A. Ayaz, V. Ünal, D. Acarli, and U. Altinagac, “Fishing gear losses in the Gökova Special Environmental Protection Area (SEPA), eastern Mediterranean, Turkey,” *J. Appl. Ichthyol.*, vol. 26, no. 3, pp. 416–419, 2010. doi: 10.1111/j.1439-0426.2009.01386.x
- [18] K. Richardson, R. Gunn, C. Wilcox, and B. D. Hardesty, “Understanding causes of gear loss provides a sound basis for fisheries management,” *Mar. Policy*, vol. 96, pp. 278–284, 2018. doi: 10.1016/j.marpol.2018.02.021
- [19] M. Riyanto, G. D. Prasetyo, R. M. Fajri, and I. M. Thenu, *An assessment of abandoned, lost, or otherwise discarded fishing gear associated with gillnet and purse seine in Fisheries Management Area 718, Indonesia. Report on the Arafura and Timor Seas Ecosystem Action (ATSEA) Program*, Bogor, Indonesia: IPB University, 2025, p. 59.
- [20] Y. Rodríguez, F. Vandeperre, E. M. Duncan, M. Machete, and C. K. Pham, “An index to differentiate megafauna entangled in operational fishing gears from abandoned, lost, or otherwise discarded fishing gears,” *Sci. Total Environ.*, vol. 971, p. 178950, 2025. doi: 10.1016/j.scitotenv.2025.178950
- [21] E. Gilman, F. Chopin, P. Suuronen, and B. Kuemlangan, *Abandoned, lost and discarded gillnets and trammel nets: Methods to estimate ghost fishing mortality, and the status of regional monitoring and management*. FAO Fisheries and Aquaculture Technical Paper 600. Rome, Italy: FAO, 2016. ISBN 978-92-5-108917-0.
- [22] PP Cikidang, *Operational Data Overview of the Cikidang Fishing Port*. Pangandaran, Indonesia: PP Cikidang, 2026. [Online]. Available: https://datastudio.google.com/u/0/reporting/c58ad0d7-4c24-4bd8-ad51-9d5aeb70e2b6/page/p_sno3ldfufd.
- [23] World Bank, *Management, Retrieval and Recycling of End-of-Life and Abandoned, Lost and Discarded Fishing Gear: The Evidence Base from Capture Fisheries*. Washington, D.C.: The World Bank, 2022.
- [24] FAO, *Global Fishing Gear Loss Assessment Quantity, Causes, and Management Options: Gillnets and Entangling Nets*. Rome, Italy: Food and Agriculture Organization, 2021.
- [25] R. L. Scheaffer, W. M. III, R. L. Ott, and K. Gerow, *Elementary Survey Sampling*. Boston, MA, USA: Brooks/Cole, 2012.
- [26] W. Zhang, “Confidence intervals: Concepts, fallacies, criticisms, solutions and beyond,” *Network Biology*, vol. 12, no. 3, pp. 97–115, 2022.
- [27] L. D. K. Kanhai, T. Lovell, H. Asmath, H. Einarsson, E. Keller, I. Richter, and J. Baziuk, “Abandoned, lost and otherwise discarded fishing gear in the Caribbean SIDS of Trinidad and Tobago,” *Mar. Pollut. Bull.*, vol. 224, p. 119139, 2026. doi: 10.1016/j.marpolbul.2025.119139
- [28] M. Beseng, “Managing abandoned, lost, or otherwise discarded fishing gear in Cameroon's marine small-scale fisheries: Perspective of local ecological knowledge,” *Mar. Policy*, vol. 185, p. 107000, 2026. doi: 10.1016/j.marpol.2025.107000
- [29] M. Riyanto, E. S. Wiyono, and M. I. Abdurraman, “Estimation of fishing boats operational waste and its management strategy at Nizam Zachman Ocean Fishing Port,” *AAEL Bioflux*, vol. 16, no. 4, pp. 2124–2132, 2023.
- [30] Ministry of Marine Affairs and Fisheries, *Circular Letter of the Director General of Capture Fisheries No. B.1694/DJPT/HK.410/XII/2024 on measures to address fishing gear left behind, lost or discarded at sea and fishing gear that has reached end-of-life or is damaged*. Jakarta, Indonesia: MMAF, 2024.
- [31] J. Link, B. Segal, and L. M. Casarini, “Abandoned, lost or otherwise discarded fishing gear in Brazil: a review,” *Perspect. Ecol. Conserv.*, vol. 17, no. 1, pp. 1–8, 2019. doi: 10.1016/j.pecon.2018.12.003
- [32] C. M. Frenkel, J. Iacarella, and N. C. Ban, “Predicting factors of fishing gear loss and distribution across Canada's Pacific Ocean,” *Mar. Policy*, vol. 181, p. 106861, 2025. doi: 10.1016/j.marpol.2025.106861
- [33] D. N. Y. P. Kusuma and L. A. S. Wijayanti, “Baseline coral reef condition as preliminary information for coastal management in Pangandaran Regency,” *J. Sumber Daya Hewan*, vol. 7, no. 1, pp. 24–29, 2026. doi: 10.24198/jsdh.v7i1.69815
- [34] K. Richardson, C. Wilcox, J. Vince, and B. D. Hardesty, “Challenges and misperceptions around global fishing gear loss

- estimates,” *Mar. Policy*, vol. 129, p. 104522, 2021. doi: 10.1016/j.marpol.2021.104522
- [35] C. Frenkel, M. Eadie, A. Murphy, J. C. Iacarella, and N. C. Ban, “Why, and where, is commercial fishing gear lost? A global review and case study of Pacific Canada,” *Mar. Pollut. Bull.*, vol. 196, p. 115528, 2023. doi: 10.1016/j.marpolbul.2023.115528
- [36] K. Richardson, B. D. Hardesty, J. Vince, and C. Wilcox, “Global estimates of fishing gear lost to the ocean each year,” *Sci. Adv.*, vol. 8, no. 41, p. eabq0135, 2022.
- [35] WWF, *Extended Producer Responsibility for Fishing Gear: Development of a Blueprint for Implementation*. Rome, Italy: WWF, Oct. 2024.
- [36] OECD, *Towards G7 Action to Combat Ghost Fishing Gear: Policy Perspectives*. OECD Environment Policy Paper No. 25, Paris, France: OECD, 2021. ISSN 2309-7841.
- [37] FAO, *Gear marking pilot study in Indonesian small-scale gillnet fisheries with reference to FAO’s draft guidelines on the marking of fishing gear*. FAO Fish. Aquac. Tech. Pap. No. T632, Rome, Italy: FAO, 2018. [Online]. Available: <https://www.fao.org/3/BU654en/bu654en.pdf>
- [40] E. Gilman, G. Moreno, H. Murua, and M. Chaloupka, *Guidelines for developing plans of action on managing abandoned, lost, and discarded fishing gear*. ISSF Technical Report 2025–07, Pittsburgh, PA, USA: International Seafood Sustainability Foundation, 2025.
- [41] I. Giskes, J. Baziuk, H. Pragnell-Raasch, and A. Perez Roda, *Report on good practices to prevent and reduce marine plastic litter from fishing activities*. Rome, Italy and London, UK: FAO and IMO, 2022. doi: 10.4060/cb8665en