



## Fishermen empowerment and marine conservation based on TURING in tackling ghost fishing

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### ABSTRACT

The natural resources potential of Samas Beach has led to the use of fishing gear. Fishing nets made of nylon take a very long time to decompose. Ghost fishing is a phenomenon where fish are caught by nets that have been lost or abandoned at sea. Ghost fishing has a profound impact on the marine environment. This impact is not only ecological, economic, and social, but also particularly affects small-scale fishermen who experience a decline in income due to reduced fish stocks. The abandoned fishing gear at Samas Beach is a result of the gear's deterioration. Based on the issues and events occurring at the location, the TURING Team from the University of Diponegoro PKM-PM initiated an innovation in the form of a net collection device called TURING. The methods used include interviews and data analysis. The implementation of TURING is expected to benefit coastal communities due to its ease of implementation, readily available raw materials, and cost-effective efficiency. The objective of the PKM-PM initiative is to provide guidance, training, and empowerment to the coastal communities of Samas Beach in addressing ghost fishing and sea turtle conservation through the development of TURING.

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### ABSTRAK

Potensi sumber daya alam di Pantai Samas menimbulkan aktivitas penggunaan alat tangkap. Jaring ikan yang terbuat dari bahan nilon sangat lama untuk menguraikannya. Ghost fishing merupakan suatu keadaan ikan tertangkap oleh jaring yang sudah hilang di perairan laut. Ghost fishing memiliki dampak yang serius pada lingkungan laut. Dampak ini tidak hanya bersifat ekologis, ekonomis dan sosial, terutama bagi nelayan kecil yang mengalami penurunan pendapatan akibat berkurangnya stok ikan. Alat tangkap yang terbenakalai di Pantai Samas disebabkan oleh faktor rusaknya alat tangkap. Berdasarkan permasalahan dan peristiwa yang terjadi di lokasi, Tim TURING Universitas Diponegoro PKM-PM berinisiatif melalui sebuah inovasi alat penampung jaring dengan sebutan TURING. Metode yang digunakan yaitu menggunakan metode wawancara dan analisis data. Penerapan TURING diharapkan dapat bermanfaat bagi masyarakat pesisir dikarenakan konsep yang sangat mudah diimplementasi oleh masyarakat, bahan baku yang mudah ditemukan serta efisiensi biaya yang lebih terjangkau. Tujuan dari gagasan PKM-PM adalah melakukan pendampingan, pelatihan, dan pemberdayaan masyarakat pesisir Pantai Samas dalam upaya mengatasi ghost fishing dan konservasi penyu dengan membuat TURING.

**Kata Kunci:** alat memancing; ghost fishing; pemberdayaan nelayan; TURING

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## INTRODUCTION

*Ghost fishing* is a phenomenon in which fishing gear left or lost in the sea continues to entangle marine life, leading to accidental catches and threatening the sustainability of aquatic ecosystems. Through the *Technology, Utilization, Regulation, Innovation, and Governance* approach, fishers' empowerment can be enhanced by utilizing technology to mitigate the negative impacts of ghost fishing practices. At the same time, regulatory and innovative solutions in marine resource management can foster more sustainable outcomes. This approach not only involves the use of technology to detect and reduce lost fishing gear but also encourages the more efficient and responsible use of marine resources. Additionally, stricter regulations and innovations in fishing methods can help create a more environmentally friendly system while providing incentives for fishers to participate in marine conservation efforts.

The potential of marine natural resources on Samas Beach has led to many activities using fishing gear. Samas Beach is located in Srigading Village, Sanden, Bantul Regency, about 24 km southwest of Yogyakarta. Large waves, strong winds, steep beach lips, and grayish sand characterize this beach. The use of fishing nets has emerged as a new problem for marine ecosystems, particularly on Samas Beach. Fishermen usually repair nets if they have minor damage, but if they can't be repaired, they won't use them anymore. Fishermen immediately threw their used nets into the sea. This practice directly contributes to the increase in fishing gear waste in the sea, which triggers the phenomenon of *ghost fishing*. *Ghost fishing* refers to the passive capture of marine life by nets that have been abandoned or lost (McDonald et al., 2022). In addition to endangering fish, *ghost fishing* also threatens the sustainability of sea turtles and marine mammals, pollutes the environment, and damages the aesthetic appeal of the beach.

*Abandoned, Lost, or Discarded Fishing Gear (ALDFG)* is a significant source of marine debris, with substantial ecological and economic consequences (Hoiberg et al., 2025; Royer et al., 2023). ALDFG drivers, including marine and meteorological conditions, lack of education and awareness among fishermen, and poor waste management facilities both on board and on land (Athukorala et al., 2024; Fronkova et al., 2024). Fishing gear that is abandoned, lost, or otherwise discarded is gaining attention in environmental assessments (He et al., 2024; Lee et al., 2024). ALDFG has a significant impact on marine ecosystems and the species that inhabit them. ALDFGs, including gill nets and traps, continue to catch fish and other marine organisms, despite the absence of further human monitoring. Research by Gilman suggests that abandoned gear contributes to ghost fishing, leading to the uncontrolled deaths of trapped species, including endangered ones such as turtles and marine mammals (Gilman, 2016). This results in significant ecological losses to habitats and reduces marine biodiversity. Some studies suggest that this lost gear can survive in the ocean for years and even decades, leading to the accumulation of microplastic waste in the sea. The fisheries economy also feels a negative impact, as lost fishing gear can reduce the potential catch available to local fishermen (Stevens, 2021).

Various studies have been conducted to mitigate the impact of ALDFG through improved monitoring and more environmentally friendly technologies. For example, previous research has suggested using biodegradable materials to replace conventional fishing gear that is difficult to decompose, thereby reducing the duration of *ghost fishing* (Do & Armstrong, 2023). In addition, Solutions involving new technologies and a collaboration-based approach between countries are needed to address this issue comprehensively. Several studies have also emphasized the importance of local community participation in the cleanup and prevention of ALDFG, which can raise awareness and reduce the amount of gear left at sea (Yang, 2022).

Based on the *existing conditions* of partners and the results of previous research that strengthen the conditions faced by the community, several problem-solving efforts are offered.

## 1. Empowerment of Coastal Communities

Coastal community empowerment is an effort to enhance the quality of life for people in coastal areas by providing access to resources, knowledge, and skills that enable them to become independent and sustainable. Some of these factors must be considered in the empowerment of coastal communities, including the positive impact of innovation on communities, relationships with local cultures, as well as technical implementation mechanisms and development financing (Handoko et al., 2023; Rashid et al., 2024; Susilowati & Mafruhah, 2023). Efforts to realize each program are prepared; through this approach, it can provide implications for the success or failure of the program (Hidayatun et al., 2022).

A participatory approach involves elements of society moving from the initial stage to evaluation (Purnamasari et al., 2020). The partnership approach aims to optimize achievements in terms of social networks (Widodo & Sidiq, 2019). Empowerment is a joint effort, where stakeholders share a responsibility (Tjahjono et al., 2021) in empowering specific groups based on their potential (Rahmat & Mirnawati, 2020). The participatory approach and partnership applied are supported by the strength (self-help) with their ability to rise (Mudjanarko et al., 2020).

## 2. Manufacture of Mesh Holding Barrels (TURING) and Gearline

TURING is an innovation that utilizes 200-liter plastic barrels as storage containers for nets, both those in use and those that are no longer in use. *The gearline* is a concrete pole structure placed next to the TURING, which functions to dry the net so that it remains dry and clean after sea activities, with the aim of minimizing the occurrence of ghost fishing, especially among hatchlings released in the area. Each barrel is equipped with a nameplate that serves to mark the ownership of the net.

Based on the results of observations, direct discussions with partners, and monitoring during the program, it can be found that the condition of partners has decreased optimism and life expectancy. Therefore, in supporting the implementation of the PKM-PM program "Fishermen Empowerment and Marine Conservation based on TURING (Net Container Container) in Efforts to Counter *Ghost Fishing*", the purpose of this service is to provide guidance, training, and empowerment to the coastal communities of Samas Beach in an effort to overcome *ghost fishing* and turtle conservation through the development of TURING (Net Container Container).

## Literature Review

### ***Abandoned, Lost, Discarded Fishing Gear***

*Abandoned, Lost, or Discarded Fishing Gear (ALDFG)*, often referred to as *ghost nets*, is one of the most significant threats to global marine ecosystems. This phenomenon refers to any fishing equipment that is deliberately discarded, lost, or left behind in the aquatic environment, and continues to fish without human control (Gilman et al., 2021). Various types of equipment fall into this category, ranging from gillnets, trawls, fish traps, to ropes and buoys (Ghaouar et al., 2024). The primary sources of ALDFG vary, including accidents during storms or extreme sea conditions, intentional equipment damage, or irresponsible disposal practices by fishermen. The impact is extensive, causing damage to physical habitats such as coral reefs and seagrass meadows, as well as disrupting the seafood chain (Răpă et al., 2024). Additionally, ALDFG is also a source of microplastics that harm marine organisms and has the potential to serve as a vector for invasive species, which can disrupt the balance of local ecosystems.

### ***Ghost Fishing***

*Ghost fishing* is the direct and most damaging consequence of the presence of ALDFGs in the ocean. The term describes a phenomenon in which fishing equipment that has been abandoned, lost, or discarded

continues to passively and relentlessly "catch" marine organisms (Dąbrowska *et al.*, 2021). Nets, traps, and ropes carried by ocean currents become deadly traps for fish, crustaceans, marine mammals, and seabirds, causing them to become entangled, injured, or die from starvation and exhaustion. The ghost fishing process can last for years or even decades, especially for equipment made of synthetic materials that are difficult to decompose (Stevens, 2021). In addition to directly harming animals, ghost fishing also damages populations of target and non-target species, threatens marine biodiversity, and negatively impacts the sustainability of fisheries (Barrett *et al.*, 2021). Efforts to counter ghost fishing involve various approaches, ranging from ghost net harvesting programs to the development of more biodegradable materials, as well as raising fishermen's awareness and implementing stricter regulations to prevent equipment disposal.

## METHODS

This service program is carried out through four interrelated stages, starting with preparation. The preparation stage involves conducting field surveys to gather observations and hold direct discussions with partners, identifying existing problems, determining their priority, and formulating alternative solutions that can be proposed. Additionally, coordination with project partners is conducted to reach agreements, obtain necessary permits, and ensure the smooth implementation of the entire project.

### Program Targets

Fishermen's nets are placed on the beach and stored in sacks, which can result in the potential for ghost fishing. Samas Beach has the highest tides. When there is a tide, nets scattered on the beach will be washed away by sea currents, resulting in ghost fishing. Based on the problems that occurred at the location, the TURING Undip team and Pokmaswas Minosamudro collaborated to create an innovation for net storage and drying of waste nets from barrels and concrete tubs that have been modified accordingly. The placement of TURING and Gearline is in a safe zone where the highest tide occurs.

The target of this community service program is outlined in **Table 1**.

**Table 1.** Program Targets

Pre-Condition	Intervention	Condition After
Partner communities feel the impact of ghost fishing and social inequality	<ol style="list-style-type: none"> <li>1. Presenting the TURING socialization program.</li> <li>2. Introducing the TURING Program to partners.</li> </ol>	The condition of Samas Beach has improved, with the arrangement of nets helping to reduce the occurrence of ghost fishing.
The previous partner community was still manually carrying out the process of drying nets, which were placed around the beach, resulting in ghost fishing.	<ol style="list-style-type: none"> <li>1. Education on handling ghost fishing and the use of net storage bins (TURING) and Gearline</li> <li>2. Invite partner communities to participate in the process of creating TURING and Gearline.</li> </ol>	The partner community enthusiastically accepted the TURING program and contributed to the process of making TURING and Gearline.
Partner communities do not yet understand how TURING and Gearline work	<ol style="list-style-type: none"> <li>1. Hand over the Partner Handbook to the community.</li> <li>2. Simulation of the process of using TURING and Gearline.</li> </ol>	Partner communities have begun to utilize TURING and Gearline.

Source: Service 2024

In implementing this program, several stages must be completed. This program consists of four stages, each with its sub-stages. The method of implementing this program is illustrated in the scheme shown in Figure 1.

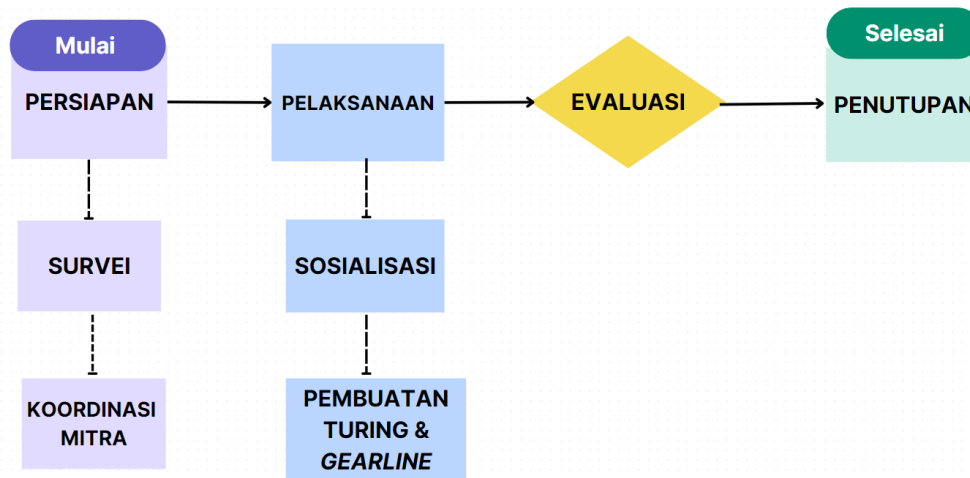


Figure 1. Implementation Method Scheme  
Source. Author Documentation 2024

## Preparation

This stage is carried out by conducting surveys for field observation and, together with partners, identifying existing problems, prioritized problems, and alternative solutions offered. Coordinate with project partners to obtain agreements and prepare necessary permits, ensuring a smooth implementation of the project.

## Implementation

The implementation of activities is carried out with several activities, including the following.

### 1. Socialization of the TURING Program.

This stage is carried out to notify the existence of the TURING program and the TURING implementation plan. The socialization event, "Fishermen Empowerment and Marine Conservation based on TURING (Net Container Containers) in Efforts to Counter Ghost Fishing," was held at one of the residents' houses on June 28, 2024. This socialization was attended by 10-15 residents of RT 63 and 64 Ngepet Hamlet. A discussion session was held with partners to emphasize the importance of efforts to combat *ghost fishing*. The next series involves collecting the names of the barrel owners and distributing partner books.

### 2. Manufacture of Mesh Container Barrels (TURING)

TURING is equipped with an 80mm diameter concrete buoy as a base foundation that is useful for maintaining stability and sturdiness. TURING not only helps minimize *ghost fishing* practices by storing nets safely, but also provides good organization and protection of the coastal environment. An illustration of TURING can be seen in Figure 2.



**Figure 2.** Illustration of the shape of TURING (net container barrel)

Source: Author Documentation 2024

The process of making this barrel begins with the selection of appropriate size dimensions based on the size of the fisherman's net, so that each barrel is expected to accommodate 15 fishing nets. The net container is equipped with a nameplate to mark the ownership of the net. Another material is in the form of concrete buoys on the outside of the barrel to prevent the barrel from being washed away by the waves.

### 3. Gearline Manufacturing

*The gearline* is a concrete pole structure placed next to the TURING. This structure is equipped with bamboo blades that function to dry the nets and clean them after sea activities. *The gearline* has several main components, which can be seen in Figure three.

#### Concrete Pipe

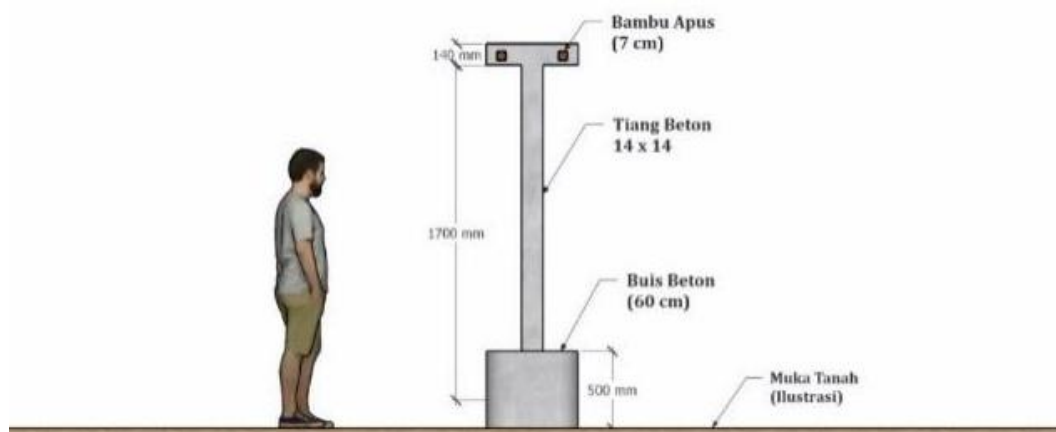
Concrete block is used as the basic foundation for *the Gearline*. This concrete is a type of *precast* that is specially designed to provide strong structural support. This concrete tube has a diameter of 60 cm, which allows optimal stability for the *Gearline*. The use of concrete busters ensures that *the Gearline structure* remains sturdy and resistant to coastal environmental conditions. With a strong foundation, *Gearline* can support the drying of fishermen's nets more efficiently and safely.

#### Support Pole

The support pole is a cast pole that is firmly planted in the ground and placed in a bush. The support pole is made of concrete with a mixture of iron, cement, sand, and stone, with a shape resembling the letter "T". The support pole is designed to be high and strong enough to withstand a heavy net load, measuring 170 cm in height. *The gearline* is made of adapted concrete pillars that withstand the conditions on the beach. The placement of *the Gearline* next to the TURING allows for efficient integration between storage and drying of nets, making it easier for fishermen to set up their equipment.

#### Bamboo

The bamboo blades used to hang the net provide additional flexibility and durability. *The gearline* uses two bamboos arranged in parallel. Bamboo was chosen because it is both lightweight and strong, and it is resistant to humidity and extreme weather conditions. The bamboo bar serves as a place to hang the net, providing good airflow for the optimal drying process.



**Figure 3.** Illustration of the shape of the gearline  
Source: Author Documentation 2024

The gearline in **Figure 3** is placed next to the TURING to improve operational efficiency for fishermen. After returning from the sea, fishermen can immediately hang their nets on the Gearline without needing to dry them on the coast, which has the potential to prevent *ghost fishing*. This saves fishermen time and labor, making the drying process faster and more practical. Proper mesh placement ensures that the mesh is always in a ready-to-use condition. The TURING program can help partners to focus on fishing activities with quality equipment.

## Evaluation

Evaluations are carried out on the programs that have been implemented. This assessment was conducted through interviews with Pokdawris and several coastal communities. In the interview, several questions were asked regarding the satisfaction and usefulness of using TURING and Gearline. Based on the results of monitoring and evaluation, the team received a positive response, that partners and coastal communities of Samas Beach felt satisfied and benefited.

## Closing

At this stage, the project evaluation results report is prepared and then submitted to the stakeholders. This process involves preparing reports that contain information on the project's performance, identified problems, and recommendations for improvement. Furthermore, follow-up is carried out through the implementation of the stage plan based on the recommendations provided.

## RESULTS AND DISCUSSION











The coastal community of Samas Beach hopes that a party will be held to create innovations that empower coastal communities and help overcome the problem of *ghost fishing* on Samas Beach. The Coastal Community Supervisory Group (POKMASWAS) "Minosamudro" is the leading partner in the PKM PM program "Fishermen Empowerment based on TURING (Net Container Container) in an Effort to Overcome *Ghost Fishing*" in the area of Samas Beach, Ngepet Hamlet, Srigading Village, Kapanewon Samas, Bantul Regency, DIY. This group was formed based on public awareness and concern for the preservation of the marine environment and biological resources along the coast of Samas.

Minosamudro is a Supervisory Community Group (Pokmaswas) comprising community members who are actively involved in marine environmental supervision and conservation activities. They possess extensive knowledge and experience regarding the marine conditions on the coast of Samas Beach and have a

strong commitment to supervising activities in the coastal area and maintaining its sustainability. The group also has extensive networks with other seaside communities, which can help disseminate information and raise awareness about the importance of preserving the ocean.

The implementation of the TURING (Net Container Container) program has achieved a 92% success rate, yielding several notable results and outputs, as outlined in **Table 2**.

**Table 2.** Program Outcomes

Program Name	Time	Result	Documentation
Partner Location Survey	May 25, 2024 (360 minutes)	The condition of the beach is full of nets	
Partner coordination	June 26, 2024 (270 minutes)	Partners know the procedures and <i>outputs</i> of activities	
Survey of tools and materials	June 25, 2024 (360 minutes)	Know some of the vendors of tools and materials needed	
Survey of TURING and Gearline Location Points	26 May 2024 (180 minutes)	Knowing the placement points of the TURING (Net Container Bin) and <i>Gearline</i>	
Partner Book Creation	1 June 2024 (300 minutes)	Printing of the partner handbook	
Socialization of the TURING and <i>Gearline</i> programs	June 27, 2024 (150 minutes)	Insight into how to prevent <i>ghost fishing</i> for partners regarding the PKM-PM program.	
Submission of Partner Books	June 27, 2024 (5 minutes)	Partners obtain a handbook that serves as a valuable reference for implementing the TURING program.	
Manufacturing of TURING and <i>Gearline</i>	June 28, 2024 (480 minutes)	The TURING and <i>Gearline</i> are installed at two points of the placement location.	
Practice of Using TURING and <i>Gearline</i>	June 28, 2024 (250 minutes)	Partners practice the use of TURING and <i>Gearline</i>	
Program Evaluation and Satisfaction Interview	07 July 2024 (480 minutes)	Partners feel helped by the implementation of the TURING program	

Source: Service 2024

The results achieved from this program can be seen in the impact of interventions carried out through the TURING program and Gearline, which has a significant effect on fishing gear management and environmental cleanliness at Samas Beach. Analysis of conditions before and after the intervention showed positive changes both visually and based on community testimonials.



**Figure 4.** Activity Intervention  
*Source: Author Documentation 2024*

Based on **Figure 4**, the pre-activity beach conditions indicate that the nets used are left scattered in the sand, resulting in visual pollution and potential harm to marine life. After the intervention in the form of a *gearline*, the net is kept regularly hanging and not touching the sand, as shown in the post-activity image. The use of sacks as a storage place for nets before activities is prone to damage and inefficiency. Intervention through TURING, as shown in the picture, enables more durable, clean, and neater storage of the network. It also reduces plastic waste from damaged sacks. Testimonials from local communities provide qualitative data that strengthens the effectiveness of interventions. The following are the results of a survey of the satisfaction of fishermen and residents around Samas Beach. Mr. FY. stated that the beach is becoming cleaner, and there are no more scattered nets. Mr. S considers TURING to be more durable and able to accommodate a larger number of nets than sacks. Mr. Sr highlighted the role of *gearlines* in preventing nets from being scattered in the sand. Since the 1970s, numerous studies have been conducted on the source, existence, and impact of ALDFG (Richardson *et al.*, 2019).

### Potential Results

The potential results of implementing this program, which partner communities can feel, focus on social, educational, and environmental aspects. According to Aldina *et al.* (2023), approximately 640,000 kg of used nets enter the sea every year. This is due to several reasons, including abandoned, lost, and discarded fishing gear (ALDFG), also known as *ghost gear*. Our collaborative efforts have had a positive impact, not only benefiting our partners but also providing sustainable benefits to the communities surrounding them. Previously, the fishing community still kept nets on the beach, which could result in ghost gear.

### Social Aspects

Based on monitoring, the TURING program can help Pokmaswas improve community welfare through various means, such as increasing community access to natural resources and enhancing the quality of life within the community. The cleanliness of the beach can significantly contribute to the aesthetic appeal of an attractive and well-maintained beach.

## Educational Aspects

The implementation of programs and educational content aimed at increasing awareness of environmental conditions can serve as a reference. The implementation of TURING socialization can help the community understand the importance of preserving the environment and encourage them to take action to protect it.

## Environmental Aspects

An estimated eight million tons of garbage are dumped annually into Indonesia's maritime areas, making it the world's top source of marine litter, after China (Jambeck *et al.*, 2015). Marine debris can come from land activities carried into the sea or the fishing industry (Purba *et al.*, 2019). The TURING program can help Pokmaswas improve the quality of the environment by addressing ghost fishing, reducing environmental pollution, and managing fishing gear responsibly.

## Discussion

Minosamudro is actively involved in the PKM program, playing a role in the installation and maintenance of net containers, as well as conducting patrols along the coast to monitor fishing activities and prevent *ghost fishing*. In addition, Pokmaswas provides education to the public about the dangers of *ghost fishing* and the importance of preserving the sea. Management strategies for ALDFG include regulatory enforcement, promoting sustainable equipment design, implementing expanded producer responsibility policies, and improving waste reception facilities (Edward *et al.*, 2025).

Minosamudro is a clear example of the community's active role in preserving the marine environment. They have successfully cooperated with the PKM program. According to King in the book "*Fishing for litter: A cost-benefit analysis of how to abate ocean pollution*," the problem of being swallowed and entangled by marine debris effectively reduces fish stocks and lowers catches and revenues in the fishing industry. The increasing number of abandoned fishing gear in the global ocean poses a significant threat to corals and marine life (Das *et al.*, 2025; Shankar *et al.*, 2025). This success shows the effectiveness of collaboration between local communities and SMEs in overcoming environmental problems.

The positive results of this program can serve as an inspirational model for other coastal communities by implementing similar measures to protect marine ecosystems. The phenomenon of fish nets scattered on the coast of Samas Beach has become a concerning problem. Coastal communities immediately throw their used nets into the sea. Fishing nets that are intentionally or unintentionally left behind in the sea can cause the phenomenon of *ghost fishing*. The impact of *ghost fishing* is not only limited to marine life, but also harms sea turtles and marine mammals that become entangled in nets. Nets stranded on the beach also damage the beach's aesthetics and endanger tourists. ALDFG represents a significant percentage of global plastic pollution, which is currently considered one of the primary sources of ocean-based activities (Seixas *et al.*, 2024).

The fishermen's empowerment programme at Samas Beach, through the TURING and Gearline initiatives, has shown promising results in overcoming the problem of ALDFG and the phenomenon of *ghost fishing*. The collaboration between the community service team and the Pokmaswas "Minosamudro" demonstrates that a participatory and innovative approach can create fundamental, positive changes. From socialization to the implementation of TURING and *Gearline*, the awareness and participation of the fishing community have increased, resulting in more responsible management of fishing gear, better beach cleanliness, and reduced potential hazards to marine life, including turtles and marine mammals. These results confirm the importance of education, the availability of adequate facilities, and supportive regulations to minimize the significant impact of ALDFG on aquatic ecosystems and fisheries sustainability.

## CONCLUSION

TURING and Gearline are innovative and strategic steps in efforts to mitigate the occurrence of *ghost fishing*. The implementation of TURING, equipped with signage and concrete bollards, ensures that fish nets are stored safely and organized, which can reduce the risk of unused nets becoming ghost catchers that endanger marine life. Gearline 's sturdy and weather-resistant structure, consisting of concrete poles and apus bamboo, provides efficient net drying facilities for coastal communities. The use of proper materials and robust installation methods ensures durability and functionality in the long run. This program still has some limitations that need attention. One of the challenges is ensuring the long-term sustainability of TURING and Gearline, particularly in terms of maintaining community participation and addressing infrastructure maintenance needs. The need for further research evaluating the impact of TURING and Gearline in the medium and long term, including sociological approaches to understanding the dynamics of community participation. It is also crucial to develop sustainable training and socialization programs to enhance local capacity and foster more comprehensive behavioral changes in fishing gear disposal practices. This innovation is not only a technical solution, but also able to form a strong conservation culture among coastal communities.

## AUTHOR'S NOTE

The author declares that there is no conflict of interest related to the publication of this article. The author emphasizes that the data and content of the article are free from plagiarism.

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