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Economic Assessment of Removal of Abandoned, Lost, or Otherwise Discarded Fishing Gear (ALDFG) From Northeastern Mediterranean Sea

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ABSTRACT

Abandoned, lost, or otherwise discarded fishing gear (ALDFG) poses a persistent threat to marine biodiversity and fisheries economies. İskenderun Bay in the Northeastern Mediterranean Sea, an ecologically productive and fishing-intensive region, has been increasingly affected by ghost fishing caused by ALDFG. This study aimed to (1) assess the ecological and economic impacts of ghost fishing, (2) document and retrieve ALDFG using minimally invasive methods, and (3) evaluate the cost-effectiveness of gear removal operations. Between May 2014 and April 2015, ghost nets were located and retrieved in İskenderun Bay using a combination of fishers' interviews, SCUBA, ROVs, and surface-supplied diving. Three key sites were selected for retrieval operations using a balloon lifting method. Seabed types were categorized into four habitat classes based on depth and substrate composition. In total, 565 kg of derelict fishing gear, including purse-seine and trammel nets, was successfully recovered from the survey area. Reusable and recyclable materials amounted to $5,097.72 in theoretical income, resulting in a net economic loss of $18,510. Elongation nets, especially those lost in rocky coastal areas, posed the highest environmental risk due to their persistent ghost fishing activity. This study represents the first large-scale ALDFG retrieval and economic assessment in the Northeastern Mediterranean Sea. The findings emphasize the need for systematic ALDFG monitoring, biodegradable gear use, and community-based education. Balloon-assisted lifting proved to be an effective and ecologically responsible retrieval technique. Establishing reporting mechanisms and policy frameworks is vital for mitigating ghost fishing impacts in Türkiye and similar coastal regions.

INTRODUCTION

Fisheries represent a cornerstone of global food security and economic resilience, providing livelihoods for millions worldwide (Kuczenski et al., 2022; NOAA, 2023; Stuart et al., 2024). Nevertheless, marine ecosystems are increasingly challenged by overfishing, habitat degradation, and pollution-pressures that carry significant environmental consequences (Lokrantz et al., 2009). Given their ecological diversity and productivity, aquatic environments play a critical role in supporting sustainability and must be protected to ensure both ecological integrity and human well-being. In recent years, the degradation of the physico-chemical properties of these environments has posed a serious threat to aquatic life. Although essential from an economic perspective, fishing operations can adversely impact these ecosystems in numerous ways (Gilman et al., 2021; Gilman, 2022).

Among these environmental challenges, the issue of abandoned, lost, or otherwise discarded fishing gear (ALDFG) has drawn increasing scientific and policy attention due to its long-lasting and transboundary impacts (Macfadyen et al., 2009; Stelfox et al., 2016; Drinkwin, 2022; Gallagher et al., 2023; Ssempijja et al., 2024). Fishing gear may be lost at sea due to natural forces such as storms, strong currents, or shipwrecks (Ayaz et al., 2006). In addition, operational failures-such as the improper securing of marker buoys, entanglement with marine megafauna (e.g., dolphins, whales, and seals), or damage to buoy lines caused by seabirds-can also result in gear loss (Worm et al., 2006; Liquete et al., 2013; NOAA, 2023). Furthermore, intentional human actions-such as the deliberate severing of buoy lines due to interpersonal conflicts, entanglement with previously lost gear, or mechanical failures-contribute to this growing problem (Gilman, 2015; FAO, 2016; Richardson et al., 2018, 2019; Goodman et al., 2021). Additional environmental concerns include marine tourism-related debris, stormwater-borne waste, and irregular disposal of refuse from vessels, all of which further exacerbate the problem (Savels et al., 2022).

Lost fishing nets can severely disrupt marine ecosystems by altering the sheltering and foraging behaviors of aquatic organisms and inadvertently causing the death of species such as seals, sea turtles, and seabirds. These derelict nets are often referred to as “ghost fishing” gear, as they continue to entangle and kill marine life long after being abandoned (Macfadyen et al., 2009; Jambeck et al., 2015; Gilman et al., 2016; Kim et al., 2016; Hardesty et al., 2021; Vodopia et al., 2024). The environmental impact of ghost gear varies with the type of fishing equipment; for example, gillnets and traps can continue to capture organisms for extended periods (Erzini et al., 1997; Matsuoka, 1999; Bullimore et al., 2001; Godøy et al., 2003; Nakashima & Matsuoka, 2004; Matsuoka et al., 2005; Richardson et al., 2018, 2021; Hardesty et al., 2021). Consequently, these lost devices contribute to unregulated and uncontrolled marine mortality, resulting in the loss of valuable aquatic resources, declines in biodiversity, and broader ecological degradation (Link et al., 2019).

Globally, it is estimated that approximately 6.4 million metric tons of marine debris enter the oceans annually (UNEP, 2005; Richardson et al., 2021; Kammann et al., 2023), with 8% to 12% of all fishing gear used worldwide lost at sea each year (Macfadyen et al., 2009). In Türkiye alone, an estimated 1,000 to 2,000 kilometers of fishing nets are unintentionally abandoned in marine environments annually. The scale, distribution, and consequences of ALDFG have grown markedly in recent decades, driven by the expansion of industrial fishing and the use of durable, synthetic, and buoyant materials in gear production (Macfadyen et al., 2009). The economic loss associated with lost fishing gear in Türkiye is estimated to be around 6 million $ (Taşlıel, 2008). Moreover, ghost gear contributes to substantial ecosystem damage and species mortality, with an estimated one million seabirds and over 100,000 marine mammals dying annually from entanglement (Ayaz et al., 2010; Gall & Thompson, 2015; Gray & Kennelly, 2018).

Research on ghost nets in Türkiye remains scarce, with only a limited number of studies conducted thus far-primarily in İzmir Bay (Ayaz et al., 2004) and the Karataş and Yumurtalık regions of İskenderun Bay (Taşlıel, 2008). The rich fisheries potential of İskenderun Bay has been acknowledged since the 1940s (Kosswig, 1955). The region harbors a diverse and economically valuable array of marine species.

Given the expansive nature of its fishing grounds, the unintentional loss of fishing gear presents a high risk of widespread dispersal across the seafloor. Fishers have frequently reported the accumulation of abandoned gear in the bay's natural benthic habitats, a situation exacerbated by advancing fishing technologies and increasing harvest intensity. İskenderun Bay hosts various fishing practices, including basket traps, bottom-set gillnets, trawling, and purse seining. Gear loss can result from different operational scenarios: extension nets may drift or become entangled in muddy or rocky substrates, trawl nets may be lost due to fishing errors or rope breakage-especially when buried in sediment-while purse seines are often lost when they become ensnared on rocky seabeds.

The objectives of this study were threefold: (1) to visually document the ecological impacts of lost fishing gear in the Northeastern Mediterranean Sea and to undertake the region's first underwater retrieval operations using an ecologically sensitive balloon lifting technique; (2) to estimate both the economic loss associated with ghost fishing gear and the cost of gear recovery; and (3) to develop a methodological framework that ensures diver safety and cost-efficiency, serving as a foundation for future large-scale retrieval efforts in the area.

MATERIAL AND METHODS

This study was carried out in designated fishing grounds within Northeastern Mediterranean Sea between May 2014 and April 2015. Despite notable advancements in marine survey technologies, the detection and identification of lost fishing nets remain technically challenging. Photographic documentation collected during long-term field studies highlights the detrimental effects of ghost nets on marine life and the broader the Northeastern Mediterranean Sea ecosystem. Figure 1A and 1B, taken in the Northeastern Mediterranean Sea, depict sections of a damaged trawl net entangled on a submerged wreck, with dead fish visibly trapped within the netting.

The methodological approach adopted in this research involved a combination of advanced technologies and local ecological knowledge. Initially, target areas were identified based on information obtained through interviews with local fishers. These areas were then systematically surveyed using a suite of tools, including remotely operated vehicles (ROVs), SCUBA diving, and surface-supplied diving systems (Figure 2). PVC-bodied, parachute-type lifting balloons were used during the lifting operations, each equipped with a single-dump system and a safety valve. Three balloons with capacities of 200 kg, 500 kg, and 1000 kg were employed, all manufactured from high-strength PVC material and designed to provide controlled buoyant lift with overpressure protection for safe underwater handling. In addition, a remotely operated vehicle (ROV) was utilized to support imaging and operational monitoring throughout the fieldwork. The ROV is capable of operating at depths up to 120 m, capturing 720p HD video, and is powered by a propulsion system consisting of two horizontal and one vertical thruster, allowing a maximum speed of 3 knots. With its stable imaging capability, maneuverability, and compact configuration, the ROV played a critical role in object detection, guidance, and real-time monitoring of the lifting balloon operations, thereby enhancing both the safety and efficiency of the underwater activities. Through this integrated approach, the presence, depth, and physical characteristics of abandoned fishing gear were comprehensively documented.

The fishing gear identified in the study area consisted of various types of derelict nets. These included passive gear types, such as trammel nets and cage traps, and active gear types, including purse seines. The condition of the retrieved gear was systematically assessed during diving operations, with particular attention to whether the nets were buried, overgrown with algae, or still functioning as unintended traps for marine organisms.

To support a structured analysis, the seabed environments within the study area were categorized into four distinct habitat types based on depth and substrate characteristics:

- **Type 1:** Shallow rocky and reef areas (≤ 30 meters),
- **Type 2:** Shallow seagrass-dominated areas (≤ 30 meters),
- **Type 3:** Shallow sandy and muddy areas (≤ 30 meters), and
- **Type 4:** Deeper rocky and reef areas (30–60 meters).

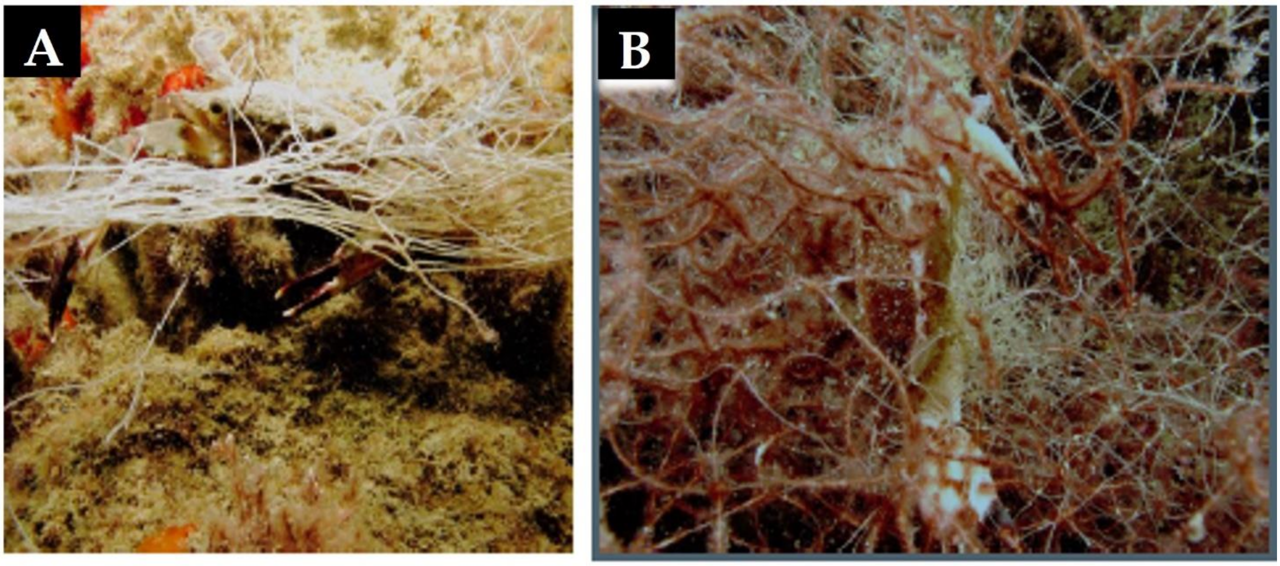

Figure 1. (A) Ghost net identified within the study sites, representing lost fishing gear persisting on the seafloor; (B) Dead fish entangled in a damaged trammel net found snagged on underwater wreckage in the Northeastern Mediterranean Sea (Photographs taken during field operations; original content).

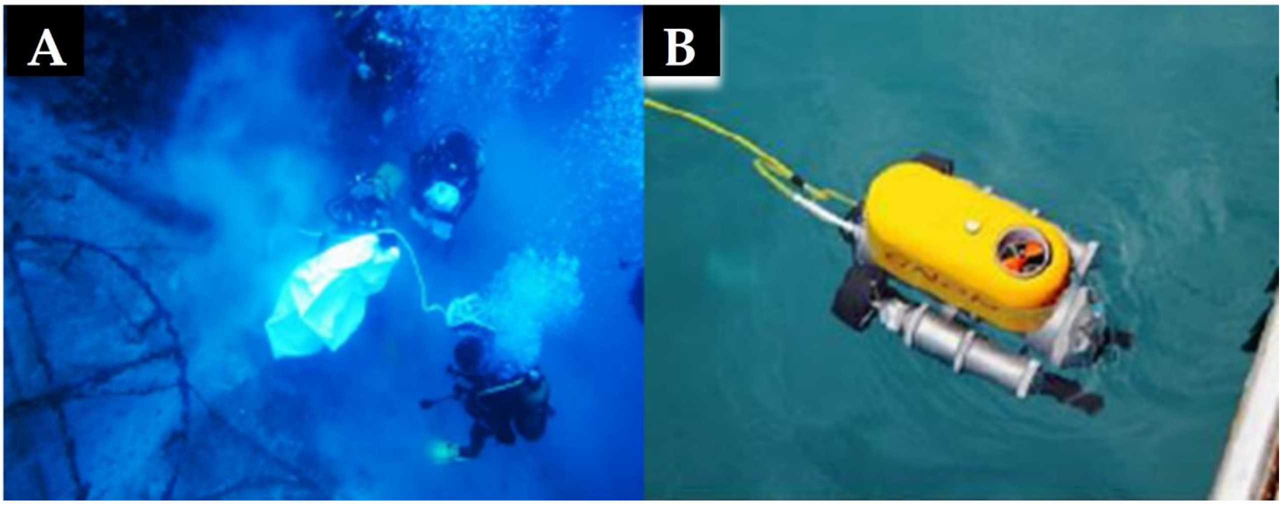

Figure 2. (A) Underwater survey operations conducted by SCUBA divers for the identification and documentation of lost fishing gear; (B) Deployment of a remotely operated vehicle (ROV) to support visual inspection and mapping of submerged ghost nets in the Northeastern Mediterranean Sea (Original field documentation).

In the second phase of the study, three sites within Northeastern Mediterranean Sea were strategically selected based on variability in seabed habitat types and depth profiles. These areas encompassed a diverse array of substrate compositions, including reef, sandy, muddy, pebbly, rocky, and vegetated bottoms. The designated locations (Figure 3) represented ecologically distinct stations across the bay. The structural heterogeneity of these benthic environments allowed for a comprehensive assessment of the spatial distribution of abandoned fishing gear, as well as an evaluation of the effectiveness and adaptability of the balloon-assisted retrieval method under varying environmental conditions (Figure 4).

In the third phase of the study, an analysis was undertaken to identify the most cost-effective method for the retrieval of lost fishing nets from the selected locations. The fourth phase expanded the scope to a comprehensive economic assessment of ghost gear and its associated impacts. From an economic perspective, two principal components were evaluated: (1) the financial loss incurred by fishers as a result of gear loss, and (2) the operational costs involved in locating and retrieving derelict nets from the seafloor. For the purposes of this analysis, "net materials" were defined to include all structural components of the gear, such as netting fabric, ropes, lead sinkers, and floaters. Total economic losses and recovery expenditures were estimated using up-to-date market prices, providing a realistic quantification of the financial burden that ghost fishing imposes on both individual stakeholders and the fisheries sector as a whole.

Figure 3. Map of the study area extending between Konacık and Keldağ in the Northeastern Mediterranean Sea, indicating the locations-marked with solid red circles-where ghost nets were identified and retrieved during field surveys (Geospatial data compiled from dive operations and remote sensing tools) (1)Keldağ-Uzunkaya, (2)Keldağ-Doğruca Burnu, and (3)Konacık-Kale (Modified from Özyılmaz et al., 2024).

Figure 4. Retrieval of lost fishing nets from the seafloor using the balloon lifting method, a technique designed to minimize disturbance to sensitive benthic habitats while enabling the safe extraction of ghost gear to the water surface (Original documentation from field operations).

The economic loss associated with ghost fishing can be formulated as follows:

- **Economic Loss = *Cost of acquiring new fishing gear*** (i.e., expenses incurred by fishers to replace lost nets and continue their operations) **+ *Net removal costs*** (i.e., labor costs + additional operational costs)
- **Economic Income** = ***Reusable materials*** (e.g., lead weights, floaters) **+ *Recyclable materials*** (e.g., nets, ropes)
- **Total Expense = *Economic Loss – Economic Income***

For future research, a more comprehensive cost or cost-effectiveness analysis would benefit from expanded data collection. This should encompass not only the direct expenditures related to gear loss and recovery operations but also potential economic gains from ongoing fishing activities and alternative revenue streams-such as the resale or recycling of retrieved materials-arising from implemented mitigation strategies.

RESULTS

The approach adopted in this study aimed to assess the impact of lost fishing nets across different seabed habitats and to facilitate their removal from the marine environment. Sampling operations were conducted at three locations: Keldağ-Uzunkaya, Keldağ-Doğruca Burnu, and Konacık-Kale. Several ghost nets were identified and successfully retrieved from these sites. Specifically, a 55 kg elongation net was removed from a depth of 35 meters at Keldağ-Uzunkaya, a 400 kg purse seine net was extracted from 40 meters at Keldağ-Doğruca Cape, and a 110 kg purse seine net was retrieved from 45 meters at Konacık-Kale.

Analysis of the collected data indicated that *tongue elongation nets* accounted for the highest proportion of lost gear in the area, followed by *shrimp nets* and other elongation net types. In the Keldağ region in particular, the greatest losses occurred among elongation nets deployed parallel to rocky coastal zones, locally referred to as "big eye" or "rubble" areas. These findings suggest that shrimp and tongue elongation nets-given their structural characteristics, shallow deployment depths, and exposure to strong currents and storms-are less likely to maintain their physical integrity over time. However, when these nets become entangled in rocky substrates, they are less likely to be displaced or degraded, thereby posing a long-term environmental hazard.

Various types of traps were also encountered in the study area. These traps-targeting species such as grouper, sea bream, and coral-are typically deployed in rocky habitats using sardine-like bait. The loss of such gear, particularly due to adverse weather conditions, can lead to uncontrolled fish mortality, exacerbating the ecological consequences of ghost fishing.

The direct cost associated with the retrieval of ghost nets was calculated at $6,970 (Table 1). This estimate excluded expenditures related to balloon lift systems, underwater imaging equipment, and tubing materials, which were not covered within the scope of the project. Moreover, labor costs were largely assumed by the research team, further reducing overall project expenses. The estimated economic income of $5,097.72 (Table 2 and Table 3) represents a theoretical valuation of the reusable and recyclable components recovered from the retrieved nets. In contrast, the $14,060 figure reflects a hypothetical cost for fishers to replace the lost nets with new gear. These figures culminate in a total economic loss estimate of $18,510 (Table 4), representing the projected financial burden to the national economy attributable to ghost gear in the region.

This study also highlighted that elongation nets-particularly those continuing to capture marine organisms' post-loss-pose the highest ecological risk among all identified gear types.

Table 1. Work breakdown and cost analysis ($) for diving operations conducted at selected ghost net retrieval locations in the Northeastern Mediterranean Sea

Location	Work Breakdown and Costs				Grand Total ($)
	Diver's wage*	Superior wage**	Boat rental	Subsistence (Viaticum)	
Keldağ-Uzunkaya (2 days, 5 divers, 1 superior)	1600	400	900	90	**2990**
Keldağ-Doğruca (1 day, 5 divers,1 superior)	800	200	900	90	**1990**
Konacık-Kale (1 day, 5 divers, 1 superior)	800	200	900	90	**1990**
Total cost ($)	**3200**	**800**	**2700**	**270**	**6970**

Note: *Diver wage (person/day) = 160 $. **Superior wage (person/day) = 200 $.

Table 2. Quantity and estimated economic value ($) of reusable and recyclable materials-such as nets, lead sinkers, floats, and ropes-retrieved from ghost fishing gear at different locations in the Northeastern Mediterranean Sea

Location	Fishing Gear Type	Extracted Net Weight (kg)	Net (kg)	Lead (kg)	Float (pcs)	Rope (kg)
Keldağ-Uzunkaya	Trammel Net	55	7.3	31.84	289	4.34
Keldağ-Doğruca	Purse Seine	400	394	6	0	0
Konacık-Kale	Purse Seine	110	97	13	0	0
Total		**565**	**498.3**	**50.84**	**289**	**4.34**

Table 3. Unit prices and total estimated economic value

Material	Unit Price ($)	Total Quantity	Estimated Value ($)
Net (kg)	10	498.3	4983
Lead (kg)	0.5	50.84	25.42
Float (pcs)	0.3	289	86.7
Rope (kg)	0.6	4.34	2.6
Total			**5097.72**

Table 4. Estimated costs ($) associated with operational activities conducted during the study

Description	**Amount ($)**
Fishnets Removal Cost	6970
New Mesh Cost	14060
Total Economic Loss (Removal + New Mesh Cost)	21030
Economic Income	2520
Total Expense	**18510**

The most effective strategy for mitigating ghost fishing is to implement preventative measures that directly address the root causes of fishing gear loss. These efforts should be embedded within a broader framework of integrated coastal zone management and sustainable fisheries governance. One such innovation developed by the fisheries sector involves time-release mechanisms, which are engineered to deploy small surface buoys at preset intervals. These buoys assist in the relocation and retrieval of lost gear, thereby reducing the likelihood of long-term ghost fishing.

In the context of trap fishing, similar systems are employed to link the trap entrance to an escape hatch, which opens automatically after a predetermined period, allowing any captured organisms to escape and rendering the gear inoperative. In Türkiye, multi-panel nets often remain deployed for extended durations, increasing the risk of loss. To minimize these risks, it is essential that the location of deployed fishing gear is clearly marked and visible to other fishers. For example, during nighttime fishing, equipping net buoys with lights can help prevent overlap and potential gear conflict, thereby reducing unintentional losses.

Complementary to technological solutions, comprehensive studies aimed at quantifying the extent and identifying the causes of gear loss in commercial fisheries are critical. Such data are vital for evaluating the magnitude and ecological impact of ghost fishing. In line with regulatory compliance, all ghost nets and fishing gear recovered during this study were formally transferred to the Hatay Provincial Directorate of Agriculture and Forestry, Department of Fisheries, in accordance with the provisions of Fisheries Law No. 1380.

DISCUSSION

This study offers critical insights into the ecological and economic consequences of ghost fishing caused by abandoned, lost, or otherwise discarded fishing gear (ALDFG) across various benthic habitats in the Northeastern Mediterranean Sea. The successful identification and recovery of ghost nets from diverse seafloor types-including rocky reefs, sandy substrates, and seagrass meadows-underscores the widespread and pressing nature of the problem. The findings emphasize the necessity for integrated, habitat-sensitive fisheries management strategies. Notably, elongation nets, particularly those deployed in shallow rocky coastal areas, emerged as the most frequently lost gear type and the greatest ecological threat due to their prolonged capacity to entangle marine life. These results are consistent with global research highlighting the persistent ecological risks associated with passive fishing gear once abandoned (Macfadyen et al., 2009; Gilman et al., 2016; Gajanur & Jaafar, 2022).

Although ALDFG is a recognized concern in marine ecosystems, its full ecological footprint remains underexplored (Wasave et al., 2025). In Türkiye, scientific investigations on ghost fishing have thus far been limited to localized studies in areas such as İzmir Bay (Ayaz et al., 2004), the Sea of Marmara (Uçar & Öztekin, 2023), the Gökova Special Environmental Protection Area (Ayaz et al., 2010), and specific locations in İskenderun Bay (Taşlıel, 2008). These prior efforts largely focused on quantifying lost gear and identifying contributing factors. He & Suuronen (2018) suggests that appropriate gear marking technologies effectively help identify ALDFG sources, track entangled gear on marine organisms, and reduce marine litter. The present study expands upon this foundation by offering a comprehensive assessment of ghost net locations, gear types, and associated economic costs. As the most productive fishing ground in the Eastern Mediterranean, İskenderun Bay supports a broad array of fishing activities, including trawling, purse seining, gillnetting, longlining, and trap fishing. Interviews with local fishers confirmed that gear loss is common, driven by both environmental pressures (e.g., storms, strong currents) and operational constraints (e.g., gear overlap). Extensive field surveys involving SCUBA and ROV-based inspections confirmed the presence of ghost nets across varying depths. To mitigate further ecological damage during retrieval, an environmentally sensitive balloon-assisted recovery technique was employed, marking a notable methodological advancement over conventional gear removal approaches.

This study builds on earlier estimates by Taşlıel (2008) by not only quantifying seasonal gear loss in Karataş and Yumurtalık but also by documenting gear classification, spatial distribution, and retrieval costs. Consequently, this work provides a more holistic understanding of the ghost fishing issue in the region and serves as a scientific foundation for future policy formulation and sustainable fisheries practices.

Extensive national and international research has documented the scale and consequences of ghost fishing. For instance, during the 2006-2007 season, a total of 1,856 nets-including shrimp gillnets and standard gillnets-were reported lost along Istanbul's coastline, with an estimated combined length of 226 kilometers (Yıldız & Karakulak, 2010). Uçar & Öztekin (2023) reported that purse seines constituted 60% of lost gear, followed by gillnets (29%) and bottom-set nets (6%). Historical data indicate that along the Istanbul coast alone, approximately 229.5 km of gillnets, 2.7 km of fishing lines, and 14 traps were lost in 2008, with turbot nets representing the highest proportion. Similar patterns were observed by Samsun (2004), who documented the recurring loss of turbot nets in the Black Sea due to retrieval difficulties.

Ayaz et al. (2004) reported the loss of 200-280 km of gillnets in İzmir Bay in 2002, primarily due to entanglement, adverse weather, and insufficient gear marking. International studies support these trends. For example, lost gillnets in Norwegian waters were found to entangle valuable species such as plaice, while Godøy et al. (2003) observed high mortality rates in ghost crab traps in the Barents Sea, where recovered traps often contained dead crabs or skeletal remains. Similar results were seen in İskenderun Bay, where recovered ghost traps contained both deceased and decomposing marine organisms.

This study further demonstrates that, in addition to gillnets and trammel nets, diverse trap configurations-such as fyke nets-substantially contribute to ghost fishing in the region. Because passive gear is inherently designed to capture marine life even when unattended, its loss represents a persistent ecological hazard (Gilman, 2015). Once lost, such gear can remain active for extended periods, continuing to trap marine organisms until it is either retrieved or naturally degraded-a process that can span several years depending on environmental conditions (Miller, 1990). This long-term entrapment exacerbates the depletion of marine resources and degradation of benthic habitats.

Trammel net fishing in İskenderun Bay occurs year-round and is prevalent in small-scale fisheries. Seasonal depth ranges vary, with operations typically taking place between 10–60 meters from December to May and between 60-125 meters from May to November. According to small-scale fisheries data, approximately 227 vessels engage in trammel net fishing in the region. Their distribution spans Karataş (82), Yumurtalık (47), Gölovası (43), Dörtyol (13), İskenderun (21), Arsuz (14), and Çevlik (7) (Özyurt et al., 2008).

Species composition also influences ghost fishing dynamics. Carr et al. (1992) observed that although net efficiency declines rapidly, the capture rate of crustaceans such as shrimp may actually increase, even in deteriorated gear. The duration of gear functionality is largely influenced by environmental conditions and seabed structure. Studies by Matsuoka et al. (2005) and Nakashima & Matsuoka (2004) found that gear entangled in rocky or reef habitats tends to retain its three-dimensional form for longer periods, enabling prolonged ghost fishing activity.

The mechanical disturbance caused by trawling also contributes to habitat degradation. Jennings & Polunin (1996) noted that trawl doors suspend sediment and generate turbulence that directs fish into nets. The adverse impacts of ghost fishing gear encompass significant environmental damage, such as continued unintended catches and habitat degradation, as well as substantial economic costs, including clean-up efforts and reduced fishery productivity (Macfadyen et al., 2009). Continued mortality caused by lost nets and traps depletes fish stocks and results in unrecorded economic losses. Although the finite nature of marine resources has been recognized since the 1960s (Bingel, 2002), the mortality caused by ghost gear remains largely invisible to stock assessments and economic planning, thereby undermining sustainability goals.

This study holistically evaluated both the environmental impacts of ALDFG and the economic costs associated with gear loss and recovery. Comparable research by McIntyre et al. (2023) in Southwest Nova Scotia revealed that abandoned lobster traps continued to affect biodiversity and fishing productivity long after their loss. The findings of the present study are consistent with these observations and further underscore the multifaceted risks posed by ghost fishing.

The use of ROV technologies and SCUBA in this study aligns with monitoring protocols reported by Liu et al. (2023) in Taiwan's Penghu Islands. The balloon-assisted lifting technique used for gear recovery proved to be a low-impact and ecologically sound alternative, paralleling best practices employed by Royer et al. (2023) in the Hawaiian Islands and Palmyra Atoll.

Community engagement was also central to the present study. Collaboration with local fishers and the promotion of awareness campaigns reflect participatory strategies endorsed by Mengo et al. (2023), who highlighted the importance of local ecological knowledge in designing effective mitigation measures. Furthermore, the study supports the use of biodegradable fishing gear as a long-term solution to ghost fishing, echoing findings from Drakeford et al. (2023), who demonstrated its economic and ecological feasibility in the English Channel.

Finally, addressing ALDFG requires international coordination. Liu et al. (2024) emphasized the importance of trilateral cooperation in the Sulu-Sulawesi Seas, supporting the present study's recommendation to develop cross-border reporting systems and collaborative management frameworks. As ghost fishing is a transboundary issue, only harmonized regional responses will yield sustainable outcomes.

CONCLUSION

This study presents one of the first comprehensive assessments of the ecological and economic impacts of abandoned, lost, or otherwise discarded fishing gear (ALDFG) in the Northeastern Mediterranean Sea. Through the use of ecologically sensitive methods-such as balloon-assisted retrieval-and an interdisciplinary approach integrating field surveys, diver observations, and economic evaluation, the study reveals the magnitude and complexity of the ghost fishing problem in the region. The findings demonstrate that elongation nets, particularly those lost in shallow rocky areas, pose the highest ecological risk due to their prolonged entanglement potential. The recovery of over 565 kg of fishing nets and associated components underscores the persistence of ghost gear and its capacity to continue inflicting environmental damage long after abandonment. In economic terms, the retrieval and replacement costs amounted to $21,030, while the potential recovery income from recyclable materials remained significantly lower, at $5,097.72-resulting in a net loss of $18,510 to the regional fisheries sector. The study also highlights the operational challenges and risks involved in ghost net removal. The success of the balloon lifting method illustrates the feasibility of low-impact gear retrieval in sensitive benthic environments, yet also calls attention to the need for professional safety protocols and pre-removal habitat assessments. Importantly, the research emphasizes that technical interventions alone are insufficient. Reducing the incidence of ALDFG requires a multifaceted strategy, including:

- The promotion of biodegradable fishing gear,
- The implementation of gear marking and tracking technologies,
- The design of habitat-specific recovery protocols, and
- The active involvement of local fishing communities through education and awareness campaigns.

Finally, the findings underline the importance of establishing national and regional frameworks for systematic ALDFG monitoring, reporting, and response. Given the transboundary nature of marine debris, Türkiye's engagement in cooperative Mediterranean-wide initiatives will be critical in addressing the ghost fishing problem at scale.

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Compliance with Ethical Standards

Authors' Contributions

YM : Writing – review & editing, Supervision, Investigation, Data analysis, Conceptualization.

MFC : Data analysis, Writing – original draft, Investigation.

ABB : Sampling, Investigation.

AD : Sampling, Writing – review & editing, Investigation, Data analysis.

MG : Sampling.

EŞ : Sampling, Writing – review & editing, Investigation.

MS : Sampling, Investigation.

NU : Sampling, Investigation.

All authors read and approved the final manuscript.

In Memoriam: Dr. Mevlüt Gürlek

This publication is dedicated to the memory of Dr. Mevlüt Gürlek, whose profound dedication to marine science and invaluable contributions significantly shaped the course of this research. Dr. Gürlek's scientific insight, collegial spirit, and unwavering enthusiasm for the marine environment left a lasting impact on this project and on all who had the privilege of working with him. Although he is no longer with us, his legacy endures through the continued pursuit of scientific knowledge he so passionately championed. He is remembered with deep respect and sincere gratitude.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Disclosure

The authors confirm that no generative AI was used in writing this manuscript or creating images, tables, or graphics.

REFERENCES

Ayaz, A., Acarlı, D., Altinagac, U., Ozekinci, U., Kara, A., & Ozen, O. (2006). Ghost fishing by monofilament and multifilament gillnets in Izmir Bay, Turkey. *Fisheries Research*, *79*(3), 267-271. https://doi.org/10.1016/j.fishres.2006.03.029

Ayaz, A., Ünal, V., & Özekinci, U. (2004). An investigation on the determination of amount of lost set net which cause to ghost fishing in Izmir Bay. *Ege Journal of Fisheries and Aquatic Sciences*, *21*(1), 35-38.

Ayaz, A., Ünal, V., Acarlı, D., & Altınağaç, U. (2010) Fishing gear losses in the Gökova Special Environmental Protection Area (SEPA), eastern Mediterranean, Turkey. *Journal of Applied Ichthyology*, *26*(3), 416-419. https://doi.org/10.1111/j.1439-0426.2009.01386.x

Bingel, F. (2002). *Examining of the fish populations*. Baki Bookshop Press.

Bullimore, B. A., Newman, P. B., Kaiser, M. J., Gilbert, S. E., & Lock, K. M. (2001). A study of catches in a fleet of "ghost-fishing" pots. *Fishery Bulletin*, *99*(2), 247-253.

Carr, H. A., Blott, A. J., & Caruso, P. G. (1992). A study of ghost gillnets in the inshore waters of southern New England. *Proceedings of the MTS'92: Global Ocean Partnership. Marine Technological Society*, USA. pp. 361-367.

Drakeford, B. M., Forse, A., & Failler, P. (2023). The economic impacts of introducing biodegradable fishing gear as a ghost fishing mitigation in the English Channel static gear fishery. *Marine Pollution Bulletin*, *192*, 114918. https://doi.org/10.1016/j.marpolbul.2023.114918

Drinkwin, J. (2022). *Reporting and retrieval of lost fishing gear: Recommendations for developing effective programmes*. FAO and IMO. https://doi.org/10.4060/cb8067en

Erzini, K., Monteiro, C. C., Ribeiro, J., Santos, M. N., Gaspar, M., Monteiro, P., & Borges, T. C. (1997). An experimental study of gill net and trammel net 'ghost fishing' off the Algarve (southern Portugal). *Marine Ecology Progress Series*, *158*, 257-265. https://doi.org/10.3354/meps158257

FAO, (2016). *Abandoned, lost and discarded gillnets and trammel nets. Methods to estimate ghost fishing mortality, and the status of regional monitoring and management*. FAO Fisheries Technical Paper (Vol. 600, Issue January). Food and Agricultural Organization.

Gajanur, A. R., & Jaafar, Z. (2022). Abandoned, lost, or discarded fishing gear at urban coastlines. *Marine Pollution Bulletin*, *175*, 113341. https://doi.org/10.1016/j.marpolbul.2022.113341

Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin*, *92*(1-2), 170-179. https://doi.org/10.1016/j.marpolbul.2014.12.041

Gallagher, A., Randall, P., Sivyer, D., Binetti, U., Lokuge, G., & Munas, M. (2023). Abandoned, lost or otherwise discarded fishing gear (ALDFG) in Sri Lanka-A pilot study collecting baseline data. *Marine Policy*, *148*, 105386. https://doi.org/10.1016/j.marpol.2022.105386

Gilman, E. (2015). Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. *Marine Policy*, *60*, 225-239. https://doi.org/10.1016/j.marpol.2015.06.016

Gilman, E., Chopin, F., & Suuronen, P. (2016). *Abandoned, lost and discarded gillnets and trammel nets: methods to estimate ghost fishing mortality, and the status of regional monitoring and management*. FAO Technical Paper No 600.

Gilman, E., Musyl, M., Suuronen, P., Chaloupka, M., Gorgin, S., Wilson, J., & Kuczenski, B. (2021). Highest risk abandoned, lost and discarded fishing gear. *Scientific Reports*, *11*(1), 7195. https://doi.org/10.1038/s41598-021-86123-3

Gilman, S. L. (2022). *Jews and Science*. Purdue University Press.

Godøy, H., Furevik, D. M., & Stiansen, S. (2003). Unaccounted mortality of red king crab (*Paralithodes camtschaticus*) in deliberately lost pots off Northern Norway. *Fisheries Research*, *64*(2-3), 171-177. https://doi.org/10.1016/S0165-7836(03)00216-9

Goodman, A. J., McIntyre, J., Smith, A., Fulton, L., Walker, T. R., & Brown, C. J. (2021). Retrieval of abandoned, lost, and discarded fishing gear in Southwest Nova Scotia, Canada: Preliminary environmental and economic impacts to the commercial lobster industry. *Marine Pollution Bulletin*, *171*, 112766. https://doi.org/10.1016/j.marpolbul.2021.112766

Gray, C. A., & Kennelly, S. J. (2018). Bycatches of endangered, threatened and protected species in marine fisheries. *Reviews in Fish Biology and Fisheries*, *28*(3), 521-541. https://doi.org/10.1007/s11160-018-9520-7

Hardesty, B. D., Roman, L., Duke, N. C., Mackenzie, J. R., & Wilcox, C. (2021). Abandoned, lost and discarded fishing gear 'ghost nets' are increasing through time in Northern Australia. *Marine Pollution Bulletin*, *173*, 112959. https://doi.org/10.1016/j.marpolbul.2021.112959

He, P., & Suuronen, P. (2018). Technologies for the marking of fishing gear to identify gear components entangled on marine animals and to reduce abandoned, lost or otherwise discarded fishing gear. *Marine Pollution Bulletin*, *129*(1), 253-261. https://doi.org/10.1016/j.marpolbul.2018.02.033

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, *347*(6223), 768-771. https://doi.org/10.1126/science.1260352

Jennings, S., & Polunin, N. V. (1996). Impacts of fishing on tropical reef ecosystems. *Ambio*, *25*(1), 44-49.

Kammann, U., Nogueira, P., Wilhelm, E., Int-Veen, I., Aust, M. O., & Wysujack, K. (2023). Abandoned, lost or otherwise discarded fishing gear (ALDFG) as part of marine litter at the seafloor of the Baltic Sea – Characterization, quantification, polymer composition and possible impact. *Marine Pollution Bulletin*, *194*, 115348. https://doi.org/10.1016/j.marpolbul.2023.115348

Kim, S., Kim, P., Lim, J., An, H., & Suuronen, P. (2016). Use of biodegradable driftnets to prevent ghost fishing: Physical properties and fishing performance for yellow croaker. *Animal Conservation*, *19*(4), 309-319. https://doi.org/10.1111/acv.12256

Kosswig, C. (1955). Zoogeography of the near East. *Systematic Zoology*, *4*(2), 49-73. https://doi.org/10.2307/2411949

Kuczenski, B., Vargas Poulsen, C., Gilman, E. L., Musyl, M., Geyer, R., & Wilson, J. (2022). Plastic gear loss estimates from remote observation of industrial fishing activity. *Fish and Fisheries*, *23*(1), 22-33. https://doi.org/10.1111/faf.12596

Link, J., Segal, B., & Casarini, L. M. (2019). Abandoned, lost or otherwise discarded fishing gear in Brazil: A review. *Perspectives in Ecology and Conservation*, *17*(1), 1-8. https://doi.org/10.1016/j.pecon.2018.12.003

Liquete, C., Zulian, G., Delgado, I., Stips, A., & Maes, J. (2013). Assessment of coastal protection as an ecosystem service in Europe. *Ecological Indicators*, *30*, 205-217. https://doi.org/10.1016/j.ecolind.2013.02.013

Liu, W. H., Chang, H. A., Jhan, H. T., Lin, C. C., Chen, L. S., Liu, C. L., & Ting, K. H. (2023). Monitoring and management of abandoned, lost and discarded fishing gear (ALDFG) in Penghu Islands, Taiwan. *Marine Pollution Bulletin*, *195*, 115344. https://doi.org/10.1016/j.marpolbul.2023.115344

Liu, W. H., Fabilane, J. A., & Hsu, W. K. K. (2024). Mitigating marine debris: Addressing abandoned, lost, and discarded fishing gears (ALDFGs) in the Sulu-Sulawesi Seas through trilateral cooperation between the Philippines, Indonesia, and Malaysia. *Marine Pollution Bulletin*, *208*, 116913. https://doi.org/10.1016/j.marpolbul.2024.116913

Lokrantz, J., Nyström, M., Norström, A. V., Folke, C., & Cinner, J. E. (2009). Impacts of artisanal fishing on key functional groups and the potential vulnerability of coral reefs. *Environmental conservation*, *36*(4), 327-337. https://doi.org/10.1017/S0376892910000147

Macfadyen, G., Huntington, T., & Cappell, R. (2009). *Abandoned, lost or otherwise discarded fishing gear*. UNEP Regional Seas Reports and Studies No.185; FAO Fisheries and Aquaculture Technical Paper, No. 523. UNEP/FAO.

Matsuoka, T. (1999). Ghost fishing by lost fish-traps in Azuma-cho water. *Mini Review and Data File of Fishries Research*, *8*, 64-69.

Matsuoka, T., Nakashima, T., & Nagasawa, N. (2005). A review of ghost fishing: Scientific approaches to evaluation and solutions. *Fisheries Science*, *71*(4), 691-702. https://doi.org/10.1111/j.1444-2906.2005.01019.x

McIntyre, J., Duncan, K., Fulton, L., Smith, A., Goodman, A. J., Brown, C. J., & Walker, T. R. (2023). Environmental and economic impacts of retrieved abandoned, lost, and discarded fishing gear in Southwest Nova Scotia, Canada. *Marine Pollution Bulletin*, *192*, 115013. https://doi.org/10.1016/j.marpolbul.2023.115013

Mengo, E., Randall, P., Larsonneur, S., Burton, A., Hegron, L., Grilli, G., Russel, J., & Bakir, A. (2023). Fishers' views and experiences on abandoned, lost or otherwise discarded fishing gear and end-of-life gear in England and France. *Marine Pollution Bulletin*, *194*, (Part A), 115372. https://doi.org/10.1016/j.marpolbul.2023.115372

Miller, R. J. (1990). Effectiveness of crab and lobster traps. *Canadian Journal of Fisheries and Aquatic Sciences*, *47*(6), 1228-1251. https://doi.org/10.1139/f90-143

Nakashima, T., & Matsuoka, T. (2004). Ghost-fishing ability decreasing over time for lost bottom-gillnet and estimation of total number of mortality. *Bulletin of the Japanese Society of Scientific Fisheries (Japan)*, *70*(5), 728-737.

NOAA. (2023). *Derelict fishing gear, marine debris program*. Retrieved on February 25, 2025, from https://marinedebris.noaa.gov/types/derelict-fishing-gear

Özyılmaz, A., Şimşek, E., Demirci, S., & Demirci, A. (2024). Macroelement and microelement compositions in the liver of smooth-hound *Mustelus mustelus* in fall and spring from Iskenderun Bay, Northeastern Mediterranean Sea. *Marine Science and Technology Bulletin*, *13*(2), 111-117. https://doi.org/10.33714/masteb.1412927

Özyurt, C. E., Kiyağa, V. B., & Akamca, E. (2008). Sole catching with trammel nets in İskenderun Bay. *Ege Journal of Fisheries and Aquatic Sciences*, *25*(3), 233-237. (In Turkish)

Richardson, K., Wilcox, C., Vince, J., & Hardesty, B. D. (2021) Challenges and misperceptions around global fishing gear loss estimates. *Marine Policy*, *129*, 104522. https://doi.org/10.1016/j.marpol.2021.104522

Richardson, K., Asmutis-Silvia, R., Drinkwin, J., Gilardi, K. V., Giskes, I., Jones, G., O'Brien, K., Pragnell-Raasch, H., Ludwig, L., Antonelis, K., Barco, S., Henry, A., Knowlton, A., Landry, S., Mattila, D., MacDonald, K., Moore, M., Morgan, J., Robbins, J., van der Hoop, J., & Hogan, E. (2019). Building evidence around ghost gear: Global trends and analysis for sustainable solutions at scale. *Marine Pollution Bulletin*, *138*, 222-229. https://doi.org/10.1016/j.marpolbul.2018.11.031

Richardson, K., Gunn, R., Wilcox, C., & Hardesty, B. D. (2018). Understanding causes of gear loss provides a sound basis for fisheries management. *Marine Policy*, *96*, 278-284. https://doi.org/10.1016/j.marpol.2018.02.021

Royer, S. J., Corniuk, R. N., McWhirter, A., Lynch IV, H. W., Pollock, K., O'Brien, K., Balagso, K. B., Oyafuso, Z. S., Kawelo, H. K., Vroom, P.S., Boland, R. C., Donohue, M. J., & Lynch, J. M. (2023). Large floating abandoned, lost or discarded fishing gear (ALDFG) is frequent marine pollution in the Hawaiian Islands and Palmyra Atoll. *Marine Pollution Bulletin*, *196*, 115585. https://doi.org/10.1016/j.marpolbul.2023.115585

Samsun, N. (2004). *The research on the determinates of some biological characteristics of the turbot (Scophthalmus meaoticus Palla, 1811) caught in the Sinop region*. [Ph.D. Thesis. Ondokuz Mayıs University].

Savels, R., Raes, L., Papageorgiou, M., & Speelman, S. (2022). *Economic assessment of abandoned, lost and otherwise discarded fishing gear (ALDFG) in the fishery sector of the Republic of Cyprus*. Global Marine and Polar Programme, IUCN.

Ssempijja, D., Einarsson, H. A., & He, P. (2024). Abandoned, lost, and otherwise discarded fishing gear in world's inland fisheries. *Reviews in Fish Biology and Fisheries*, *34*(2), 671-683. https://doi.org/10.1007/s11160-024-09843-5

Stelfox, M., Hudgins, J., & Sweet, M. (2016). A review of ghost gear entanglement amongst marine mammals, reptiles and elasmobranchs. *Marine Pollution Bulletin*, *111*(1-2), 6-17. https://doi.org/10.1016/j.marpolbul.2016.06.034

Stuart, L., Hobbins, M., Niebuhr, E., Ruane, A. C., Pulwarty, R., Hoell, A., Anderson, W., Brown, M. E., Chen, M., Funk, C., Gerlak, A. K., Harrison, L., Ingram, K. T., Korytina, D., Leng, G., Liu, Y. Y., McNally, A., Sheffield, J., Svoboda, M., Tadesse, T., Van den Berg, M., Verdin, J. P., White, D. H., Wit, A. J. W., Zaitchik, B. F., & Farrar, M. (2024). Enhancing global food security: Opportunities for the American Meteorological Society. *Bulletin of the American Meteorological Society, 105*(4), E760–E777. https://doi.org/10.1175/BAMS-D-23-0073.1

Taşlıel, A. S. (2008). *Determination of amount of lost fishing gear on Karataş and Yumurtalik (Iskenderun Bay) during a fishing season.* [M.Sc. Thesis. Çukurova University].

Uçar, F., & Öztekin, A. (2023). Study for the detection of ghost nets in the Sea of Marmara (Kapıdağ Peninsula and Islands Region). *Journal of Anatolian Environmental and Animal Sciences*, *8*(4), 787-794. https://doi.org/10.35229/jaes.1228180

UNEP. (2005). *Marine litter: An analytical overview*. United Nations Environment Programme. Retrieved on October 9, 2025, from https://www.unep.org/resources/report/marine-litter-analytical-overview

Vodopia, D., Verones, F., Askham, C., & Larsen, R. B. (2024). Retrieval operations of derelict fishing gears give insight on the impact on marine life. *Marine Pollution Bulletin*, *201*, 116268. https://doi.org/10.1016/j.marpolbul.2024.116268

Wasave, S., Kamble, S., Kazi, T., Wasave, S., Sreekant, G. B., & Sharma, A. (2025). A bibliometric review on ghost fishing: Impacts on marine environment and governing measures. *Marine Pollution Bulletin*, *212*, 117604. https://doi.org/10.1016/j.marpolbul.2025.117604

Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folke, C., Halpern, B. S., Jackson, J. B. C., Lotze, H. K., Micheli, F., Palumbi, S. R., Sala, E., Selkoe, K. A., Stachowicz, J. J., & Watson, R. (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science*, *314*(5800), 787-790. https://doi.org/10.1126/science.1132294

Yıldız, T., & Karakulak, F. S. (2010). Technical characteristics of pelagic set nets, used in Istanbul artisanal fisheries. *Ege Journal of Fisheries and Aquatic Sciences*, *27*(1), 25-29. http://doi.org/10.12714/egejfas.2010.27.1.5000156488