

Marine Pollution by Lost, Abandoned and Discarded Fishing Gear

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1. Introduction

Marine pollution caused by plastic waste has become a topic of social concern in recent years. However, while “single-use plastics,” such as plastic bags and beverage containers, attract a great deal of attention, another kind of plastic waste—namely, fishing gear such as fishing nets, ropes, and the like—is not as widely recognized by the public. The same is true of efforts to tackle the problem. While considerable progress has been made to deal with single-use plastics—measures such as charging for plastic shopping bags and urging beverage manufacturers to use recyclable containers are examples—progress has been scant with respect to fishing gear.

Lost, abandoned and discarded fishing gear (ALDFG) has various environmental and socio-economic negative impacts. Fishing gear left in the sea can drift ashore and spoil the scenery. It poses a hazard when it becomes entangled in the propellers of passing ships. It can reduce fishery resources as it continues catching fish in the sea (a phenomenon known as “ghost fishing”). And it can kill marine life, including sea turtles, seabirds, and other endangered species, if they swallow it or become entangled in it. In general, fishing nets, ropes and other types of equipment are durable and do not decompose easily in the sea, although they eventually break up into small pieces and become microplastics that pollute the environment. In the case of fishing line made of nylon, for example, it is estimated that the time for natural decomposition is particularly long among plastics at over 600 years.¹ On the other hand, materials such as Styrofoam, which is brittle and crumbles easily, quickly turn into particles called microplastics that pollute the marine environment.² Moreover, ALDFG accounts for a relatively high percentage of marine plastic waste. These reasons make it necessary to target ALDFG with special countermeasures within efforts to tackle plastic waste as a whole.

¹ NOAA Marine Debris Program, Ocean Conservancy, SC Sea Grant. “Marine debris is everyone’s problem” (<https://www.who.edu/files/server.do?id=107364&pt=2&p=88817>)

² Kusube, T., Baba, Y., Kitano, S., Yachi, T., Takatsuki, H. (2019). Waste survey of microplastics on the coast in Ishikawa Prefecture. *Bulletin of Ishikawa Prefectural University*, 2, 27-35.

2. How Much Fishing Gear is Lost in the Ocean?

No accurate information is available on how much plastic fishing gear is left behind in marine environments (in this paper, the term "fishing gear" refers to not only fishing nets but also all equipment used in fishery and aquaculture). A 2009 report³ by the UN Environment Programme (UNEP) and the UN Food and Agriculture Organization (FAO) estimated that between 0.02% and 30% of fishing gear is lost, with the rate of loss varying depending on the location and fishing method. Looking at this in terms of fishing type, gillnets have a low percentage of 0.02 to 0.5%, while traps have a high share around 20 to 30%. From this, it is estimated that around 640,000 tons of fishing gear may be lost into the environment worldwide each year.⁴ Additionally, a meta-analysis of gear loss surveys undertaken between 1975 and 2017 that was conducted as part of a recent study by Richardson *et al.* of the University of Tasmania estimated that 5.7% of fishing nets, 8.6% of traps, and 29% of fishing lines were lost.⁵ From these same surveys there was found a large geographical bias, as past surveys on fishing gear loss were concentrated in Europe and North America (Figure 1). Surveys focusing on Asia, Africa, and South America were scarce, and not a single one was conducted in Japan. Another survey conducted in 2015 produced an estimate indicating that ALDFG comprise at least 46% of the 79,000 tons of plastic waste that has accumulated in the Great Pacific Garbage Patch.⁶

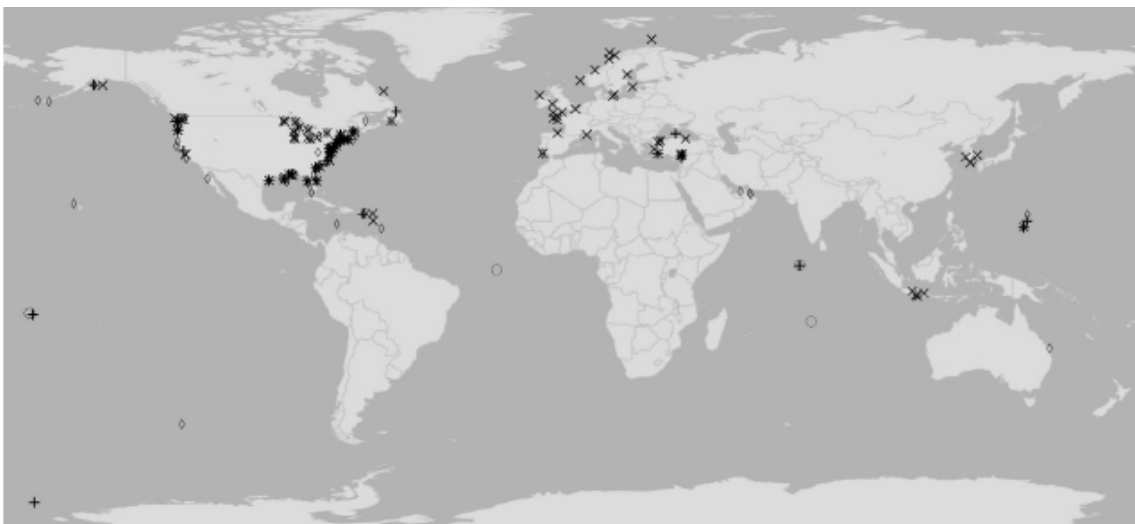


Figure 1: Geographical distribution of past studies on lost fishing gear that were reviewed by Richardson *et al.* (Source: Richardson *et al.*, 2019)

³ Macfadyen, G., Huntington, T., & Cappell, R. (2009). Abandoned, lost or otherwise discarded fishing gear.

⁴ 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.

⁵ Richardson, K., Hardesty, B. D., & Wilcox, C. (2019). Estimates of fishing gear loss rates at a global scale: A literature review and meta-analysis. *Fish and Fisheries*, 20(6), 1218-1231.

⁶ Lebreton, L., et al., 2018. Evidence that the Great Pacific garbage patch is rapidly accumulating plastic. *Sci. Rep.* Vol. 8, 4666.

On the other hand, fishing gear accounts for a significant percentage of the plastic waste that washes ashore on coasts throughout Japan. It is estimated that about 20,000 tons of plastic is manufactured in the forms of fishing nets, ropes, buoys, and other fishing gear items in Japan each year (accounting for about 0.2% of total plastic production).⁷ Moreover, a survey of beach litter conducted by the Ministry of the Environment found that fishing gear makes up a large percentage of waste collected on beaches, accounting for 59.3% by weight, 52.6% by volume, and 37.8% by number of pieces⁸ (Table 1). Of course, not all of the fishing gear that washed ashore originated in Japan, as some of it came from neighboring countries. Nevertheless, with such a high percentage of fishing gear washing ashore on Japanese coasts, it is easy to surmise that a considerable amount is drifting in the seas around Japan. Given that Japan is one of the world's most prominent fishing nations, it has a particularly urgent need to grasp how much fishing gear is actually being lost at sea and to implement countermeasures.

Table 1: Percentages of beach litter surveyed at 10 coastal locations in Japan

Category		By weight (%)	By volume (%)	By number of pieces %
Disposable plastics	Beverage bottles	7.3	12.7	38.5
	Other plastic bottles	5.3	6.5	9.6
	Containers (condiment containers, trays, cups, etc.)	0.5	0.5	7.4
	Plastic bags	0.4	0.3	0.6
	Cutlery (straws, forks, spoons, knives, stirrers)	0.5	0.5	2.7
	Total	14	20.5	58.8
Fishing gear	Fishing nets, ropes	41.8	26.2	10.4
	Buoys	10.7	8.9	11.9
	Styrofoam buoys	4.1	14.9	3.2
	Other fishing gear	2.7	2.6	12.3
	Total	59.3	52.6	37.8
Other	Other plastics	26.7	26.9	3.3

(Source: Prepared by the author based on Ministry of the Environment [2018], "Chuo Kankyo Shingikai Junkan-gata Shakai Bukai Purasuchikku Shigen Junkan Senryaku Shoi'inkai (Dai-san Kai) Gijishidai-Haifu Shiryō" (Plastic Resource Recycling Strategy Subcommittee, Recycling Society Subcommittee, Central Environment Council [third meeting] agenda and distributed document) reference material 1 "Purasuchikku wo torimaku kokunaigai no jokyō [dai-san shiryōshu]" (domestic and international circumstances surrounding plastic [third collection of documents]))

⁷ Gyogyo ni okeru Purasuchikku Shigen Junkan Mondai Taisaku Kyogi-kai (council on measures to address the problem of plastic resources recycling by fisheries) (April 2019), "Gyogyo ni okeru purasuchikku shigen junkan mondai ni taisuru kongo no torikumi" (future initiatives for addressing the problem of plastic resources recycling by fisheries).

(https://www.jfa.maff.go.jp/j/sigen/action_sengen/attach/pdf/190418-5.pdf)

⁸ Ministry of the Environment (2018), "Chuo Kankyo Shingikai Junkan-gata Shakai Bukai Purasuchikku Shigen Junkan Senryaku Shoi'inkai (Dai-san Kai) Gijishidai-Haifu Shiryō" (Plastic Resource Recycling Strategy Subcommittee, Recycling Society Subcommittee, Central Environment Council (third meeting) agenda and distributed document) reference material 1 "Purasuchikku wo torimaku kokunaigai no jokyō [dai-san shiryōshu]" (domestic and international circumstances surrounding plastic [third collection of documents]). (<https://www.env.go.jp/council/03recycle/y0312-03/y031203-s1r.pdf>)

3. The Impacts of Lost Fishing Gear

As was mentioned above, ALDFG does not decompose easily and can continue to catch fish and other forms of marine life for decades or even centuries. In one example, the remains of 32,000 organisms were found in 870 fishing nets that were recovered in the state of Washington, USA. Among the dead organisms were seabirds and marine mammals.⁹ In addition, Stelfox *et al.*¹⁰ reviewed 76 publications and found references to more than 5,400 individuals of 40 species that were victims of “ghost fishing.” However, there was little information in the reviewed literature concerning the Arctic Ocean, Antarctic Ocean, and Indian Ocean, in particular. Moreover, the medical treatment records of a wildlife rehabilitation facility in California, USA, indicated that about 10% of the wildlife the facility treated had injuries related to fishing gear.¹¹ Among the animals treated were brown pelicans, seagulls, and pinnipeds that included California sea lions and harbor seals. Fishing gear-caused damage to coral reef ecosystems has also been reported in the Hawaiian Islands¹² and Thailand.¹³ Thus, the effects of fishing gear on wildlife and ecosystems are being reported in various pieces of literature. However, as the majority of animal deaths and injuries occur in the wild where they cannot be witnessed by humans, it is almost impossible to fully understand the impacts of lost fishing gear on wildlife. And, of course, it is not only fish hooks and lines left by commercial fishery operators that threaten wildlife; those left by amateur or recreational fishermen pose a threat as well.

It must be noted that the socioeconomic impacts of ALDFG are also significant. For instance, many maritime accidents are caused by drifting ALDFG that gets entangled with ship propellers. One of the worst such accidents occurred in South Korea in 1993, when a nylon rope became wrapped around the propellers of a large ferry, causing it to sink with the loss of 292 precious lives.³ There are other costs associated with ALDFG. They include the costs that fishery operators must bear to repair or reacquire lost fishing gear, the costs of recovering fishery gear, and the economic loss brought by decreased fishery resources attributable to ghost fishing. To give an example, in the Chesapeake Bay in the US, where blue crab fishing with pots flourishes, it is estimated that 900,000 crabs die and \$300,000 worth of fishery resources are lost annually due to crab pots that were not recovered and

⁹ Good, T.P., June, J.A., Etnier, M.A., Broadhurst, G., 2009. Ghosts of the Salish Sea: threats to marine birds in Puget Sound and the Northwest Straits from derelict fishing gear. *Mar. Ornithol.* 37, 67–76.

¹⁰ 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.

¹¹ Dau, B. K., Gilardi, K. V., Gulland, F. M., Higgins, A., Holcomb, J. B., Leger, J. S., & Ziccardi, M. H. (2009). Fishing gear-related injury in California marine wildlife. *Journal of Wildlife Diseases*, 45(2), 355-362.

¹² Donohue, M. J., Boland, R. C., Sramek, C. M., & Antonelis, G. A. (2001). Derelict fishing gear in the Northwestern Hawaiian Islands: diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. *Marine pollution bulletin*, 42(12), 1301-1312.

¹³ Ballesteros, L. V., Matthews, J. L., & Hoeksema, B. W. (2018). Pollution and coral damage caused by derelict fishing gear on coral reefs around Koh Tao, Gulf of Thailand. *Marine pollution bulletin*, 135, 1107-1116.

abandoned in the ocean.¹⁴

4. Tackling the Problem of Lost Fishing Gear

The following is a list of the possible measures for dealing with losses of fishing gear.^{3, 15}

- Marking fishing gear to indicate its owner
- Tracking the locations of fishing gear
- Prohibiting the use of fishing gear beyond its useful life
- Regulating places and times for fishing
- Strengthening legal regulations
- Cracking down on illegal fishing
- Providing economic incentives
- Recovering used fishing gear
- Recovering lost fishing gear
- Providing training for new fishermen
- Raising public awareness and education
- Improving materials, shapes, etc., to make fishing gear less likely to be lost
- Developing fishing gear with biodegradable materials

The marking of fishing gear is internationally recommended, and guidelines for it were prepared and issued by the FAO in 2019.¹⁶ Included in the guidelines are recommendations that fishery organizations take the initiative in introducing and monitoring fishing gear marking systems, and that the gear marking system is implemented in a participatory process that includes fishermen and other stakeholders. Various methods are available for marking fishing gear. They range from relatively simple methods, such as color-coding and tagging, to more sophisticated methods, such as using devices that emit radio waves, have GPS functions, or can be detected acoustically.¹⁷

As for government-led initiatives in Japan, the Fisheries Agency set up a “council on measures to address the problem of plastic resources recycling by fisheries” in 2019 that prepared a document detailing “future initiatives for addressing the problem of plastic resources recycling by fisheries.”¹⁸ Additionally, the Ministry of the Environment prepared

¹⁴ Bilkovic, D. M., Havens, K., Stanhope, D., & Angstadt, K. (2014). Derelict fishing gear in Chesapeake Bay, Virginia: Spatial patterns and implications for marine fauna. *Marine Pollution Bulletin*, 80(1-2), 114-123.

¹⁵ Gilman, E. (2015). Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. *Marine Policy*, 60, 225-239.

¹⁶ FAO. (2019). *Voluntary Guidelines on the Marking of Fishing Gear*. Rome. 88 pp.

¹⁷ 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.

¹⁸ Fisheries Agency, “Gyogyo ni okeru purasuchikku shigen junkan mondai ni taisuru kongo no torikumi’ no kohyo-to ni tsuite” (regarding the public announcement, etc., of “future initiatives for addressing the problem of plastic resources recycling by

"marine litter prevention guidelines" in 2013 that provide a guide for public awareness and education by local governments for fishery operators, voluntary collection of used fishing gear by manufacturers, and other activities.¹⁹ The ministry also revised its "guidelines for fishing-related waste disposal" in May 2020 to ensure more correct waste disposal practices.²⁰ As the government's efforts to tackle this problem have only just begun, it is hoped that the initiatives mentioned here will be vigorously promoted going forward.

Efforts are also underway to collect and recycle abandoned ALDFG. Iceland is actively tackling the problem of marine plastic waste, and it is promoting efforts to recycle discarded fishing nets by establishing a fund for this purpose. In Japan, too, a company called Refinverse, Inc. has developed a technology for recycling discarded fishing nets and ropes into carpet tiles and other products.²¹

Research on biodegradable alternative materials is also proceeding in Japan through industry-government-academia collaboration. In 2019, Minister of the Environment Yoshiaki Harada, Professor Tadahisa Iwata of the University of Tokyo's Graduate School of Agricultural and Life Sciences, and Atsushi Okubo, an executive officer with Chukoh Chemical Industries, Ltd., exchanged views on applications for biodegradable plastics in fishing gear.²² In addition, a research group led by Professor Kozo Ito of the University of Tokyo²³ and a research group led by Professor Kenichi Kasuya of Gunma University²⁴ are conducting research under the "Moonshot Research & Development Program," an initiative of the government's Cabinet Office and other organizations, to develop new biodegradable materials that can be applied to fishing gear. And Nichimo Co., Ltd and Kuraray Co., Ltd. are jointly developing pipes made of biodegradable plastic for use in oyster farming.²⁵ This is a response to a long-standing problem whereby large amounts of plastic pipe from oyster farming drift away and end up washing ashore in various parts of the Seto Inland Sea.²⁶

fisheries). <https://www.jfa.maff.go.jp/j/press/sigen/190418.html>

¹⁹ Office of Marine Environment, Water Environment Division, Environmental Management Bureau, Ministry of the Environment (2013), "Kaigan hyochaku-butsu ryushutsu boshi Gaidorain" (marine litter prevention guidelines).

https://www.env.go.jp/water/marine_litter/umigomi/guideline.pdf

²⁰ Ministry of the Environment, "Gyogyo-kei haikibutsushori gaidorain no kaitei ni tsuite" (regarding revisions to the guidelines for fishing-related waste disposal). <https://www.env.go.jp/press/108065.html>

²¹ Refinverse, Inc. <https://www.r-inverse.com/>

²² *The Suisan-Keizai Daily News* (dated April 12, 2019), "Gyogu ni seibunkai pura de kaiyo gomi taisaku, Harada kankyo-sho-ra iken kokan" (a discussion by Environment Minister Harada and others on addressing marine litter by using biodegradable plastic in fishing gear).

²³ *The Chemical Daily* (dated December 22, 2020), *Todai nado, kaiyo pura mondai kaiketsu e munshotto shido, fukusu no shigeki de seibunkai*" (moonshot started to resolve the marine plastic waste problem; biodegradation with multiple stimuli).

²⁴ *Asahi Shimbun Digital* (dated March 8, 2021), "Kaiyo osen boshi e gyakkyo to nintai; seibunkai-sei pura kaihatsu ni torikumu" (adversity and perseverance in preventing marine pollution; striving to develop biodegradable plastic).

<https://www.asahi.com/articles/ASP376W0XP2RUHNB008.html>

²⁵ *Minato Shimbun* (dated August 30, 2019), "Datsu-umi pura gomi gyogu kaihatsu: Nichimo to Kurare; tokushu sozai, kaiteido-chu de seibunkai" (developing fishing equipment that does not become marine plastic waste; Nichimo and Kuraray; special materials and biodegradation in seabed soil).

²⁶ Fujieda, S. (2011). Drifting and grounding of plastic pipes used in oyster farming in the Seto Inland Sea. *Nippon Suisan*

Thus, research to develop alternative materials is moving forward. However, there are still various challenges, such as durability and high cost, that must be overcome before such materials can enter practical use.

5. Future Prospects

The causes of lost fishing gear are varied, ranging from intentional dumping or abandonment to bad weather and other unintentional and unavoidable circumstances.³ For instance, a survey conducted in the United Kingdom found that the majority (46%) of fishing gear losses were caused by bad weather conditions,³ while an Australian survey revealed that most losses were caused by snagging on seafloor rocks or other features (78%) or conflict with other gear (19%).²⁷ As can be seen, the seemingly simple notion of “fishing” involves an extremely diverse range of environments (which include aquaculture), types of fishing gear used, and methods of operation. This makes it very difficult to comprehend the problem. Thus, it is considered essential to first confirm the actual situation of fishing equipment losses—namely, what causes fishing gear to be lost, where it is lost, and how much of it is lost. From there, attention should be given to studying cost-effective measures, including fishing gear marking. Other issues that deserve consideration include how to expand the recycling of abandoned fishing nets and ropes, a matter discussed above, and how to increase fishing gear recovery and recycling rates.

The problem of ALDFG is also inextricably linked to sustainable fisheries. As mentioned above, there are concerns that ghost fishing will reduce the stocks of fishery resources. Fewer resources can induce a negative loop: decreased resource availability leads to intensified competition, which in turn leads to more fishing gear losses due to operations in undesirable weather conditions or gear entanglements by fishermen aggregating in small fishing areas. Currently, MSC,²⁸ MEL,²⁹ and other ecolabel certification systems are in place to promote sustainable fisheries. Adding such items as “Are measures being taken to prevent fishing gear losses?” and “Is marked fishing gear being used?” to these systems’ certification criteria would certainly be an effective step forward. Not only is it important for fishery operators themselves to take the initiative in preventing fishing gear losses by changing their mindset and taking innovative steps, but also the society as a whole must address this issue by, for example, purchasing recycled products and environment-friendly fisheries products.

Gakkaishi, 77(1), 23-30.

²⁷ 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.

²⁸ Ocean ecolabel “certification by the Marine Stewardship Council (MSC)”

²⁹ Marine Eco-Label Japan (MEL)