Status, Trends and Best Management Practices for Abandoned, Lost or Otherwise Discarded Fishing Gear (ALDFG) in Asia and the Pacific

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Abstract

Marine debris derived from Abandoned, Lost or Otherwise Discarded Fishing Gear (ALDFG) is considered as one of the most serious threats to marine ecosystems and fisheries, and thus warrants strong international cooperation and effective national responses to properly address. This paper examines international and national legal approaches that seek to address ALDFG, either directly or within the wider framework of fisheries or marine litter management. It analyzes the development of principles and standards in dealing with ALDFG and specifically examines the status and trends of ALDFG in Asia Pacific while surveying its causes and impacts. Building on the analysis of the region's response, the paper looks at the issues and challenges specific to developing Asian and Pacific Island countries. Best management practices and corresponding implementation mechanisms as applied to local conditions are identified and discussed, with a particular focus on prevention measures as well as applicable mitigation and curative interventions. Accordingly, the study investigates case studies in the region, which include appropriate regulations and civil society initiatives. Finally, the paper provides recommendations for potential adoption in developing countries of specific rules, economic incentives and research pathways to support enabling environments for ALDFG management. This research supports the overarching framework for combating marine litter through behavioral, regulatory and system changes, to address marine pollution specifically originating from the fisheries sector.

Key words

ALDFG, fisheries, ghost gear, marine debris, marine pollution, plastic pollution

I. Introduction: Marine Plastic Pollution

Plastic has tremendously grown in usage over recent decades owing to its broad utility, durability and resistance to biological processes of degradation. However, this latter quality has also made it a key pollutant in the natural environment, with plastic material persisting even long after its useful life has come to an end[1]. Plastic has been identified as the most abundant type of marine debris, with average proportions varying between 60 to 80% of the total and with some areas reaching as much as 90 to 95%[2]. Worryingly, global estimates of plastic litter in the oceans

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[1] Alsopp, M., Walters, A., Santillo, D., Johnston, P. Plastic Debris in the World's Oceans. Greenpeace International (2006).

[2] Derraik, J.G.B., The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin, 44: 842-852 (2002). See generally Velis, C.A.,. Plastic waste in marine litter: action now and at the source. Waste Manag. Res. 32 (4), 251–253 (2014).

range from around 27 to 66.7 million tons, with 12.2 million tons entering the marine environment every year[3].

It is difficult to identify the sources of marine debris as the oceans are faced with such a staggering magnitude of plastic pollution[4]. However, sources of litter can generally be identified from either land-based or oceanic activities. Land-based inputs contribute the majority of marine litter with annual estimates of 4.8–12.7 million metric tons being dumped to the sea based on 2010 data[5]. On the other hand, oceanic pollution may be attributable to waste generated from shipping, fisheries, aquaculture and offshore platforms[6]. Such activities contribute to approximately 10% of global marine debris[7].

Marine plastic litter accumulates in the five ocean gyres areas, forming extensive floating garbage patches[8]. Furthermore, plastic buildup is known to occur in remote coastal areas[9], with small islands particularly vulnerable as they have higher plastic debris accumulation rates compared to continental areas[10]. Field data suggest that plastic pollution in many islands is primarily of non-local origin[11], and are commonly from continental sources or wastes from ship and fishing vessels[12]. In addition to the adverse impacts to the marine ecosystem, plastic pollution poses a significant threat to food safety, tourism, and is an identified contributor to climate change[13]. Of particular concern is the breakdown of plastic debris into microplastic which can enter the food web, thereby presenting a risk to environmental and human health. Alarmingly, human intake of microplastics from seafood has been estimated to range from 1 particle to 30 particles per day[14].

As such, addressing marine pollution is considered as a matter of high international priority and the United Nations Sustainable Development Goals specifically call for a significant reduction of marine pollution of all kinds, including marine debris, by 2025[15].

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[3] Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., Plastic waste inputs from land into the ocean. Science 347 (6223), 768–771 (2015). See also EUNOMIA. Plastics in the Marine Environment. June 2016. 13pp (2016).

[4] Jones, M.M., Fishing debris in the Australian marine environment. Mar. Pollut. Bull. 30, 25–33 (1995).

[5] Jambeck et al., *supra.*

[6] Ocean Conservancy, Trash travels: From our hands to the sea, around the globe, and through time. International Coastal Cleanup Report (2010).

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

[8] Perez-Venegas, D., Paves, H., Pulgar, J., Ahrendt, C., Seguel, M., Galban-Malagon, C.J., Coastal debris survey in a Remote Island of the Chilean Northern Patagonia. Marine Pollution Bulletin 125 530–534 (2017).

[9] Perez-Venegas et al, *ibid*.

[10] Corcoran, P.L., Biesinger, M.C., Grifi, M., Plastics and beaches: a degrading relationship. Mar. Pollut. Bull. 58 (1), 80–84 (2009).

[11] 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. Mar. Pollut. Bull. 42 (12), 1301–1312 (2001).

[12] Ingraham Jr., W.J., Ebbesmeyer, C.C., Surface current concentration of floating marine debris in the North Pacific Ocean: 12-year OSCURS model experiments. In: Proceedings of the International Conference on Derelict Fishing Gear and the Ocean Environment (2001).

[13] See International Union for the Conservation of Nature (IUCN). Accessed at https://www.iucn.org/resources/issues-briefs/marine-plastics (visited Sep 24, 2020)

[14] Lusher, A.L., Hollman, P.C.H., Mendoza-Hill, J.J., Microplastics in fisheries and aquaculture: Status of knowledge on their occurrence and implications for aquatic organisms and food safety. FAO Fisheries and Aquaculture Technical Paper. No. 615. Rome, Italy (2017).

[15] United Nations Sustainable Development Goals Target 14.1

This paper focuses on reviewing the status, trends and issues of plastic pollution derived from the fisheries sector, with a primary focus in the Asia Pacific region. The findings are built on a combination of desktop research and interviews for identified case studies. The review also seeks to provide a thorough inventory and analysis of the legal instruments and management measures which have evolved in response to the challenges surrounding waste from the fisheries sector. Based on the global and regional trends on pollution from the fisheries sector, this study identifies existing best management practices with recommendations for potential adoption in Asia and the Pacific.

II. Global Status and Trends: Marine Plastic Pollution from the Fisheries Sector

The fisheries sector contributes a substantial amount of plastic pollution in the oceans. Marine debris derived from Abandoned, Lost or Otherwise Discarded Fishing Gear (ALDFG) has been identified by the UN Environment Programme (UNEP) as one of the most significant threats to marine ecosystems[16], and can be especially damaging to sensitive coastal habitats. Although fishing gear have been abandoned, lost or discarded ever since humans started to fish, the issue of ALDFG has become more problematic in recent decades due to the increase in magnitude of fishing operations and innovations in fishing technologies. These developments have led to an unprecedented growth in fishing capacity and effort, leading to fishing operations in more distant and deeper parts of the oceans[17].

The pervasive use of plastic as a low-cost and durable synthetic material for fisheries gear has exacerbated the impact of ALDFG to the marine environment. Plastic is considered an excellent material for use in aquatic environments as it is highly resistant to abrasion, rust and is recognized for its longevity. It is also lightweight which reduces handling and associated costs[18]. Because of these characteristics, plastic-based fisheries equipment has greatly accelerated since the 1960s[19]. It is employed not only for netting materials, but also for traps, floats, dredges and lines, as well as for boat construction and maintenance, fish hold insulation and fish crates[20].
ALDFG comprises a significant amount of global marine plastic pollution, with an estimated 640,000 tons introduced to the marine environment each year[21]. Although at a global scale, ALDFG is estimated to compose less than 10% of total marine debris by volume, the degree of occurrence can be highly variable at smaller spatial scales and based on locality[22]. ALDFG are regularly reported in surveys of marine debris on beaches, at the seafloor and floating on surface

[16] United Nations Environment. Accessed at https://www.unenvironment.org/news-and-stories/press-release/research-highlights-true-impacts-plastics-our-planet-ecosystems (visited Sep 23, 2020)
[17] Global Ghost Gear Initiative, A Response to the Best Practice Framework for the Management of Fishing Gear: 2017 Results from a consultation with the fishing industry and other stakeholders. Accessed at https://static1.squarespace.com/static/5b987b8689c172e29293593f/t/5bb64b6a71c10baf92d653ba/1538673516254/wap_gear_bp_framework_consultation-doc-2017.10.25-web.pdf (2017)
[18] Huntington, T., Marine Litter and Aquaculture Gear – White Paper. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council. 20 pp plus appendices (2019).
[19] Macfadyen, *supra.*
[20] *Id.*
[21] Richardson, K., Gunn, R., Wilcox, C., Hardesty, B., Understanding causes of gear loss provides a sound basis for fisheries management. Marine Policy 96 278–284 (2018).
[22] Gilman, E., Chopin, F., Suuronen, P. and Kuemlangan, B., Abandoned, lost and discarded gillnets and trammel nets: methods to estimate ghost fishing mortality, and the status of regional monitoring and management, FAO. FAO Fisheries and Aquaculture Technical Paper No. 600. Rome. Italy (2016).

waters[23]. Studies suggest that fisheries activities contribute a large proportion of the marine debris on UK beaches, particularly in areas situated near or adjacent to fishing grounds[24]. Moreover, marine debris from coastal states surrounding the North Sea, such as Germany, the Netherlands and Belgium, has been largely attributed to shipping and fishing activities[25]. The impacts of marine debris derived from fisheries are particularly concerning in remote areas and islands, where the fishing and shipping industries are typically responsible for approximately 50% to 90% of marine debris[26]. For example, reports from Northern Pacific Patagonia show that majority of plastic pollution come primarily from industrial fisheries and aquaculture activities in the surrounding area[27]. Similarly, other remote locations such as the Faroe Islands have seen ALDFG representing more than 75% of marine debris[28].

When fishing gear is lost, abandoned or discarded in the ocean, it can continue to capture or entangle marine organisms which may come in its way. This attribute has made ALDFG to be more commonly known as 'ghost gear', or as engaged in 'ghost fishing'. In general, most ALDFG will float because the density of plastics is less than seawater. This is evident in the rafts of assorted debris in the ocean gyres or convergence zones where ALDFG tend to accumulate[29]. A study from the 'Great Pacific Garbage Patch' in the North Pacific Ocean revealed that ALDFG represented 46% of the 79,000 tons of plastic observed within the 1.6 million km^2 area surveyed[30]. However, derelict fishing gear can also be entangled in the seabed where they are more likely to ghost fish. Studies on marine debris on the seabed of the Mediterranean Sea and Northeast Atlantic, for example, estimated that 34% of debris consisted of ALDFG, second only to assorted plastics which comprised of 41% of the total[31].

Aside from ghost fishing, microplastic from fisheries due to fragmentation caused by direct ultraviolet light, wave action and abrasion also pose a threat to the environment and human health[32]. Numerous studies have shown high levels of plastic contamination of fish caught, and certain forms of microplastic have been linked to local fisheries sources such as ingested synthetic fibers similar to those typically used in fishing gears[33]. With the extent of occurrence of ALDFG expected to increase in the future, especially in light of climate change-induced extreme weather events, the adverse impacts of ALDFG are projected to further intensify.

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[23] Lusher *et al.*, *supra.*
[24] Unger, A, Harrison, N., Fisheries as a source of marine debris on beaches in the United Kingdom. Marine Pollution Bulletin 107 52–58 (2016).
[25] Galgani, F., Leaute, J.P., Moguedet, P., Souplets, A., Verin, Y., Carpentier, A., Goraguer, H., Latrouite, D., Andral, B., Cadiou, Y., Mahe, J.C., Poulard, J.C., Nerisson, P., Litter on the sea floor along European coasts. Mar. Pollut. Bull. 40 (6), 516–527 (2000).
[26] Faris, J. & Hart, K., Seas of Debris. A Summary of the Third International Conference on Marine Debris. Alaska Fisheries Science Center, Seattle, Washington, USA. 54 pp (1994).
[27] Hinojosa, I.A., Thiel, M., Floating marine debris in fjords, gulfs and channels of southern Chile. Mar. Pollut. Bull. 58, 341–350 (2009).
[28] Pham, C.K., Ramirez-Llodra, E., Alt, C.H., Amaro, T., Bergmann, M., Canals, M., Davies, J., Duineveld, G., Galgani, F., Howell, K.L. & Huvenne, V.A., Marine litter distribution and density in European seas, from the shelves to deep basins. PLoS One, 9(4) (2014).
[29] Macfadyen *et al*, *supra*
[30] Lebreton, L.C.M. & Borrero, J.C., Modeling the transport and accumulation floating debris generated by the 11 March 2011 Tohoku tsunami. Mar. Pollut. Bull., 66(1): 53-58 (2013).
[31] Pham et al., *supra.*
[32] Lusher *et al.*, *supra.*
[33] *Ibid*.

A. Sources of Waste

Although its abundance is highly variable, ALDFG is considered as the main source of marine debris and plastic pollution from the fisheries sector. For the purpose of this paper, the term ALDFG encompasses capture fishing gear, Fish Aggregating Devices (FADs), and associated packaging and other fisheries equipment.

In terms of capture fishing gear, passive types such as gillnets, trammel nets and fishing traps/pots are the most common type of ALDFG[34]. These gears are often used by artisanal and small-scale fishers. Approximately one fifth of global marine fisheries landings comes from gillnet and trammel net fisheries[35]. Passive gear has been identified to be more problematic in terms of ghost fishing, as the capture process and design of the gear itself relies on the movement of organisms into the equipment. However, ghost fishing has also been observed in ALDFG from active gears, such as seine nets and trawls[36].

Fish Aggregating Devices (FADs), which are permanent, semi-permanent or temporary structures designed to attract and aggregate pelagic fish such as tuna, also contribute to ALDFG. These artificial objects can either be anchored or set adrift on ocean currents. They are usually made of synthetic material and buoys with subsurface netting or palm fronds. FADs are frequently lost to a fishery and may occasionally be deliberately abandoned in the oceans[37].

Lastly, fish packaging material and other related equipment may also be a source of marine debris. These include discarded plastic fish boxes and industrial packing crates on vessels for transportation and distribution of catches. Other fisheries equipment such as avoidance devices, pingers and streamer lines[38] may also become a source of marine litter if not properly managed or disposed of.

While beyond the scope of this paper, aquaculture is important to note for future study on plastic pollution. Although the present contribution of aquaculture to global plastic debris is not of the same magnitude as that from fisheries, it is expected to become a significant source of plastic pollution in the future given its accelerated pace of growth worldwide.

B. Causes of Abandoned, Lost or Otherwise Discarded Fishing Gear (ALDFG)

There may be different reasons why fishing gear are abandoned, lost or otherwise discarded. This ranges from unintentional, to deliberate but unavoidable acts[39]. This section describes the key causes of ALDFG as follows:

1. Enforcement factors. Illegal, unreported and unregulated (IUU) fishing vessels are known to abandon gear to avoid apprehension. As such, hotspot areas for IUU fishing can yield higher amounts of ghost gear. In particular, fishing gear may be abandoned

[34] Macfadyen *et al*, *supra.*
[35] Gilman, *supra*
[36] *Ibid.*
[37] Macfadyen et al, *supra.*
[38] Lusher et al, *supra*.
[39] Macfadyen *et al, supra.*

to destroy evidence, evade inspection, conceal illegal gear, and to avoid denial of entry to ports[40]. Illegal operations during the night and improper fishing methods may also provide difficult work conditions which are likely to cause ALDFG[41]

2. Operational conditions. Operational factors may provide an economic reason to discard fishing gear. Gear are sometimes abandoned when there are time constraints in fishing operations and are inadvertently left. They may also be discarded because of lack of space in vessels and as the preferred alternative to onshore disposal. Although the substantial investment on fishing gear provides disincentives for the loss of gear[42], some fishers may opt to discard if it proves too difficult to retrieve them.

3. Spatial pressure. Spatial issues arise when multiple marine users compete to operate in an area, which results in damaged or misplaced gear due to gear conflicts. Consequently, damaged gear are often discarded while misplaced gear are lost. ALDFG incidence due to spatial pressure ordinarily happens when passive gear conflicts with passing vessels or active gear. This commonly happens to static traps and pots which are accidentally or intentionally towed away by trawlers.

4. Environmental conditions. Poor seabed conditions and extreme weather events contribute to the loss of fishing gear. A common cause for lost gear is a combination of rough bottom environments and strong currents which result to snagging of gear[43]. Tsunamis and typhoons have been reported to cause tremendous losses of fishing gear which may be dangerous or otherwise difficult to retrieve. For example, substantial amounts of coastal fishing gear were lost during the Indian Ocean tsunami in 2004[44].

C. Ecosystems Impacts

ALDFG as a serious threat to marine ecosystems is mainly attributed to its physical damage to sensitive habitats and ghost fishing. However, it causes several other ecological impacts, from the benthic environment up to coastal areas. The impacts are further described as follows:

1. Continued catch of target and non-target species. Ghost fishing is one of the most significant impacts of ALDFG. Its ability to capture marine organisms depends on the gear type and state of the gear lost and the physical conditions such as currents or depth. It is reported that passive gear such as gillnets and pots/traps are the most likely gear to ghost fish. However, other gear such as trawls and longlines may also cause entanglement of marine organisms[45]. Aside from target species, ALDFG can attract and entangle non-target groups such as sharks. A recent global review shows that

[40] See Global Ghost Gear Initiative. Accessed at https://www.ghostgear.org/news/2017/5/31/iuu-and-ghost-gear-what-are-the-links (visted Sep 23, 2020)
[41] Gilman, E., Chopin, F., Suuronen, P. and Kuemlangan, B., Abandoned, lost and discarded gillnets and trammel nets: methods to estimate ghost fishing mortality, and the status of regional monitoring and management, FAO. FAO Fisheries and Aquaculture Technical Paper No. 600. Rome. Italy (2016).
[42] Macfadyen et al, *supra*
[43] *Ibid.*
[44] *Id.*
[45] *Id.*

ALDFG constitutes 74% of entanglement incidents of sharks and rays[46]. Entangled species usually die from starvation, cannibalism, infection, or prolonged exposure to low dissolved oxygen in water[47]. Dead marine organisms in ALDFG are also known to attract scavengers which are further trapped[48], resulting in a vicious cycle of entanglement and mortality.

2. Interactions with threatened species. ALDFG can impact marine organisms through entanglement, where the gear entraps marine organisms; and ingestion, where ALDFG or its components are intentionally or inadvertently consumed[49]. Many species which can be adversely affected may be threatened or endangered. Studies have shown ALDFG as a significant source of entanglements on a wide range of marine fauna such as sea birds, turtles, seals, cetaceans and other marine mammals. Notably, it is estimated that over one million birds die each year because of ALDFG[50], mostly from entanglement but also due to ingestion of offal which contain hooks, thereby causing esophageal damage or heavy metal poisoning[51].

3. Physical alteration of benthic environment. ALDFG causes changes in the physical benthic environments through smothering, abrasion, and the translocation of seabed features. Dragged ALDFG can scour bottom communities, with sensitive habitats such as coral reefs and seagrass beds particularly at risk. Furthermore, ALDFG may cause the accumulation of fine sediment that cover benthic communities and obstruct water flow. This has been known to create anoxic areas or "dead zones"[52] in the oceans, setting off areas of substantial mortality.

4. Introduction of synthetic material into the marine food web. Synthetic compounds, including microscopic plastic material and toxic chemicals derived from fishing gear, can accumulate in marine food webs[53]. Alarmingly, a study examining the levels of plastic archived in plankton collected regularly since the 1960s found a significant microplastic which may be partly attributed to ALDFG[54].

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[46] Parton, KJ, Galloway, T., Godley, B., Global review of shark and ray entanglement in anthropogenic marine debris. Endangered Species Research, 39 (2019).

[47] Van Engel, W.A., Blue crab mortalities associated with pesticides, herbicides, temperature, salinity, and dissolved oxygen. In H.M. Perry & W.A. Van Engel, eds. Proceedings Blue Crab Colloquium, pp. 187–194. Gulf States Marine Fisheries Commission Publication 7 (1982).

[48] Macfadyen *et al.*, supra

[49] Shomura, R.S. & Yoshida, H.O., eds., Proceedings of the Workshop on the Fate and Impact of Marine Debris, 26–29 November 1984, Honolulu, Hawaii, USA, NOAA Technical Memorandum NMFS, United States Department of Commerce (1985).

[50] Laist, D. & Liffman, M., Impacts of Marine Debris: Research and Management Needs. In N. McIntosh, K. Simonds, M. Donohue, C. Brammer, S. Manson and Carbajal S., 2000. Proceeding of the International Marine Debris Conference on Derelict Fishing Gear and the Ocean Environment, 6-11 August 2000, Honolulu, HI. Hawaiian Islands Humpback Whale National Marine Sanctuary, US Department of Commerce: 344-357 (2000)

[51] Macfadyen, *supra.*

[52] Gilman, *supra.*

[53] *Id.*

[54] Lusher et al, *supra..*

5. Redistribution of litter. As some ALDFG are washed ashore, it can pollute beaches and coastal zones with plastic litter[55]. ALDFG may smother organisms living on the seashore, especially in remote areas and islands. Moreover, ALDFG can provide the nuclei for sand dune formation[56] in coastal areas, thus changing their natural structure and processes.

6. Transport of invasive alien species. ALDFG can serve as a vector of marine invasive species, as they provide solid platforms for species to attach. Invasive species may then be transported to new distributions where such introduction may disrupt the community structure[57].

D. Socioeconomic Impacts

Aside from impact on ecosystems, ALDFG also has a number of socioeconomic impacts on marine users such as navigational hazards and associated safety issues in coastal and offshore areas. Perhaps the seminal case of risks caused by ALFDG occurred in the Republic of Korea (ROK) in 1993, when the propellers of the passenger ferry Seo-Hae was entangled in a 10 mm derelict nylon fishing rope. This caused the vessel to capsize and sink, with 292 persons onboard perishing[58]. More recent studies reveal that from 2010 to 2015, the ROK navy recorded approximately 170 incidents associated with propeller entanglement by ALDFG on their ships[59]. Other socioeconomic impacts are further described as follows:

1. Direct economic costs. Aside from the direct costs of marine accidents and navigational hazards, these include the cost of time spent disentangling and clearing the debris from vessels, engines, propellers, shafts or rudders, as well as the corresponding maintenance or replacement costs. Public cost can also be entailed for government-led or assisted retrieval consisting of expenses for divers and equipment for emergency rescue operations, fuel for searching, etc.[60] Such hazards also directly result in less fishing time for fishing vessels.

2. Indirect economic costs. Catch mortalities due to ALDFG cause wastage, thereby reducing the sustainable production of resources and depriving further economic opportunities from the fishery[61]. Fishers may lose revenue from catching target species which are often affected by ghost fishing. ALDFG can also endanger specific fisheries down the line if the mortality comprises a significant fraction of the population. This

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[55] Food and Agriculture Organization (FAO), Report of the 2019 FAO Regional Workshops on Best Practices to Prevent and Reduce Abandoned, Lost or Discarded Fishing Gear in Collaboration with The Global Ghost Gear Initiative. (Port Vila, Vanuatu, 27–30 May 2019, Bali, Indonesia, 8–11 June 2019, Dakar, Senegal, 14–17 October 2019. Panama City, Panama, 18–23 November 2019). FAO Fisheries and Aquaculture Report FIAO/R1312 (2019).

[56] Macfadyen *et al*, *supra.*

[57] Gilman, *supra*.

[58] Cho, D., Case Study of derelict fishing gear in Republic of Korea. Paper presented at the APEC Seminar on Derelict Fishing Gear and Related Marine Debris, 13–16 January 2004, Honolulu, Hawaii, USA (2004).

[59] Hong, S., Lee, J., Lim, S., (2017). Navigational threats by derelict fishing gear to navy ships in the Korean seas. Marine Pollution Bulletin 119 10.1016/j.marpolbul.2017.04.006 (2017).

[60] Poseidon (2008). As cited in Abandoned, lost or otherwise discarded fishing gear by Macfadyen, G., T. Huntington and R. Cappell 2009. Rome, UNEP/FAO (2008).

[61] Gilman, *supra.*

exerts pressure on the sustainability of the fishery which adversely affects dependent fishing and coastal communities[62]. Individual fishery studies of ALDFG economic impacts are usually calculated either as the percentage of the catch of commercially valuable species in an area, or the proportion of the commercial catch of specific species[63]. These losses range from 4–5% of commercial fish catches in the Baltic Sea[64], to 20-30% of Greenland halibut catch in Norway[65]. Aside from fisheries, particularly affected are areas where ALDFG impacts coral reefs, beaches and coastal zones that are the basis for ecotourism economies. Indirect costs also include reduced income and the negative multiplier effects due to decreased spending. Other costs consist of the disruption to enjoyment of coastal recreational areas[66], and research expenses for the prevention and recovery of ALDFG[67].

3. Social costs. ALDFG contributes to decreased catch levels which in turn may reduce employment in fishing communities[68]. Other impacts include diminished tourism or diving value of coral reefs and coastal areas, reputational risk of erring fishers, and heightened safety risks for fishers and the public[69].

III. The Asia Pacific Context: Status and Trends

The high levels of plastic pollution in Asia and the Pacific pose significant threats for the regional and global marine environment. Using 2018 data, an estimated 11.1 billion pieces of ocean plastic trash are caught in coral reefs alone across the region, and this is projected to increase to 15.7 billion by 2025[70]. The spike in plastic pollution levels in recent decades has been attributed to various factors such as rapid economic development and increased coastal population, combined with unsustainable plastic production and consumption patterns, poor awareness of proper disposal behaviors, and weak waste management systems[71]. The region is therefore considered as a major hotspot for marine debris and plastic pollution, hosting 8 out of the top 10 countries with mismanaged plastic waste polluting the ocean[72].

In terms of ALDFG, there is very little information available in the regional seas of Asia. Data from onboard observer programs yield that ALDFG appears to have increased in the Pacific from 1992 to 2002[73]. However, there are few studies attempting to quantify the magnitude and study the causes of ALDFG in the developing countries of Asia and the Pacific. Moreover, among

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[62] NOAA Marine Debris Program, Report on the impacts of "ghost fishing" via derelict fishing gear. Silver Spring, MD. 25 pp. (2015).
[63] *Ibid.*
[64] Tschernij, V., and Larsson, P. O., Ghost fishing by lost cod gill nets in the Baltic Sea. Fisheries Research 64, 151–162 (2003).
[65] Humborstad, O.-B., Løkkeborg, S., Hareide, N.-R., and Furevik, D. M., Catches of Greenland halibut (Reinhardtius hippoglossoides) in deepwater ghost-fishing gillnets on the Norwegian continental slope. Fisheries Research 64, 163–170 (2003).
[66] Macfadyen *et al*, *supra.*
[67] Poseidon, *supra.*
[68] FAO, *supra.*
[69] Poseidon, *supra*
[70] United Nations Environment Program, Plastics and shallow water coral reefs. Synthesis of the science for policy-makers. Sweet, M; Stelfox, M. Lamb, J. (Authors) (2019).
[71] Jang, Y.C., Hong, H., Lee, J., Lee, J.S., Hong, S.S., Shim,W.J., Thiel, M., Shigeru, F., Chang, T.-d., Kosavisutte, K., Ha, T.T., (2014). Results and lessons learned from joint beach debris surveys by Asian NGOs. PICES, Yeosu, Korea (2014).
[72] Jambeck *et al*, *supra*
[73] Macfadyen *et al, supra.*

the research clusters reviewed in a recent gap analysis on science, legal and policy efforts of marine debris in Southeast Asia, one of the weakest research clusters identified was the contribution of plastics from marine fisheries[74].

Within the region, studies on ALDFG have been conducted mostly in the Republic of Korea (ROK), Japan and Australia, where ALDFG has been identified as a significant marine pollution issue[75]. Most of these studies examined the extent of ALDFG recorded from coastal areas, with a few seeking to identify their origins[76]. In Australia, studies have been conducted in the Gulf of Carpentaria, where more than 85% of nets are presumed to originate from foreign fishing vessels operating outside the country, specifically those operating within Indonesian waters[77]. It is estimated that up to 1,000 tons of ALDFG are recovered every year from the Sea of Japan, which are predominantly pots and gillnets of apparent non-Japanese origin[78]. Surveys in the ROK reveal that 83% of marine litter in certain fishing grounds was composed of fishing nets, ropes and related materials[79]. Furthermore, there are several reports reviewing the Korean government's efforts to remove derelict fishing gears from the seabed of the East Sea through bottom trawling, which is characterized by its inefficiency and high risk for the recovery crew[80]. Beyond these countries and especially among developing countries in the region however, there is a paucity of research on the status and extent of occurrence of ALDFG.

There are also studies showcasing positive developments in the reduction and management of ALDFG in the same countries. The Northern Prawn Fishery in Australia is considered a model in terms of implementing fisheries management measures which have also addressed ALDFG through a combination of spatial closures and restrictions on certain gear, coupled with improvements in waste management practices and education among fishing crew[81]. In ROK, the Ministry of Maritime Affairs and Fisheries (MOMAF) has been purchasing fishing gear waste returned to port by fishers through the Waste Fishing Gear Buy-back project since 2003 to a considerable success. The government pays approximately 10 USD per 100-liter bag to encourage fishers to bring collected litter ashore, with the budget for the program shared between the local and central governments[82]. From the period of 2004 to 2008, the program collected a total of 29,472 tons of ALDFG at a cost of 19,417 USD[83]. Evaluations of the program backed the cost-effectiveness of the intervention. Comparative analyses reveal that the cost entailed was substantially lower relative to projected expenses if the litter were recovered directly by the

[74] Lyons, Y., Neo, M.L., Lim, A., Tay, Y. L. and Vu Hai, D. Status of Research, Legal and Policy Efforts on Marine Plastics in ASEAN+3: A Gap Analysis at the Interface of Science, Law and Policy, COBSEA and NUS (2020).
[75] Raaymakers, S., (2007). Regional Review: Marine Litter in the East Asian Seas region. Report to the East Asian Seas Regional Coordinating Unit, United Nations Environment Programme. 34 pp. plus appendices (2007).
[76] Macfadyen *et al, supra.*
[77] Richardson, *supra*
[78] Inoue, K. & Yoshioka, S., Japan's approach to the issue of derelict and drifting fishing gear and marine debris. In Derelict Fishing Gear and Related Marine Debris: An Educational Outreach Seminar Among APEC Partners. APEC Seminar on Derelict Fishing Gear and Related Marine Debris, 13–16 January 2004, Honolulu, Hawaii, USA (2002).
[79] Cho, *supra.*
[80] Cho, D., Removing derelict fishing gear from the deep seabed of the East Sea. Marine Policy 35 (2011) 610–614 (2011).
[81] Richardson, *supra*
[82] Cho, *supra.*
[83] Morishige, C. (ed.), Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports. NOAA Technical Memorandum NOS-OR&R-36 (2010).

government, which typically entail fleet of vessels, equipment and fuel costs[84]. Furthermore, the program also provides supplementary income to fishers.

The FAO along with the Global Ghost Gear Initiative (GGGI), a cross stakeholder alliance of fishing industry, private sector, NGOs, academia and governments, has been conducting a series of workshops for southeast Asia and the southwest Pacific on best practices to prevent and reduce ALDFG, the last of which was held in 2019. Workshop results in southeast Asia show that gillnets, traps and FADs as the significant contributors to ALDFG, while trawls cause substantial losses due to gear conflict with passive gear such as crab pots[85]. It is important to note that specifically in Southeast Asia, artisanal small-scale fisheries were identified as the most significant source of ALDFG, with lack of education opportunities on its prevention and impacts cited as a contributing factor[86]. Major causes for ALDFG include entanglement with bottom features such as corals, and severe weather conditions. Operational issues including difficulty of retrieval were also recognized, as well as the practice of discarding to avoid enforcement against IUU fishing. For both southeast Asia and the southwest Pacific, the lack of disposal facilities for recovered or end-of-life gear was considered as a major challenge in the proper management and disposition of ALDFG[87]. Notably in the Pacific Small Island Developing States (SIDS), the lack of port reception facilities for fishing operations, of which 90% are foreign-flagged, is considered a primary environmental issue[88]. This led the Secretariat of the Pacific Regional Environment Programme (SPREP) to conduct studies for the provision of adequate regional waste reception facilities for foreign ship and fishing vessels[89], which have yet to be fully scaled up in the region.

There is an acute lack of specific country research on ALDFG from developing countries in Asia Pacific, but further studies have been supported in recent years through the assistance of environmental NGOs and global networks such as the GGGI. In Myanmar, a series of expeditions in the Myeik archipelago was undertaken in 2019 that led to the retrieval of 1,821 kgs of ALDFG and its documentation at 95% of the 80 dive sites surveyed. An unsettling finding from the expeditions is the relatively elevated levels of ALDFG found in the Langann Locally Managed Marine Area (LMMA), signifying challenges in enforcement even for marine protected areas. In contrast to many studies that identify weather conditions as the predominant reason for gear loss, the Myanmar expeditions revealed that deliberate discarding to save on boat space and fuel before returning to port as the major cause in addition to gear conflict. Furthermore, observations from previously cleaned dive sites indicate rapid rates of accumulation and quick replacement of ALDFGs which range from four to five weeks[90]. In Thailand, a study on coastal debris distribution demonstrated that prevalence of ALDFG in beaches is related to economic activities in the vicinity,

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[84] *Ibid*.
[85] FAO, *supra*.
[86] *Ibid*.
[87] *Id*.
[88] Kiessling, I., Finding Solutions: Derelict fishing gear and other marine debris in Northern Australia. Charles Darwin University, National Oceans Office, Australia. 58 pp (2003).
[89] See Secretariat of the Pacific Regional Environment Programme (SPREP). Accessed at https://www.sprep.org/attachments/Publications/WMPC/reception_facilities_plan_final.pdf (visited Sep 24, 2020)
[90] Myanmar Ocean Project, Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG) report in Myeik Archipelago, Myanmar. Report In partnership with Global Ghost Gear Initiative, Ocean Conservancy, Fauna and Flora International, Department of Fisheries and Istituto Oikos (2020).

specifically in the area of Angsila where fisheries and aquaculture activities are common[91]. Government data also uncovered that ALDFG caused up to 89% of deaths of dugongs and 50% of deaths of sea turtles in 2018[92], highlighting the threat that ALDFG poses to threatened species under the International Union for the Conservation of Nature (IUCN) red list. In Malaysia and the Philippines, there have been efforts by the government to establish a national inventory of fishing gear, but the effectiveness of such measures in relation to the incidence of ALDFG have not been studied. There has been very little research and baseline studies on the trends and status of ALDFG in the Pacific Island countries, which is unfortunate as fisheries and coastal tourism are important sectors of many Pacific Island economies.

A study comparing ALDFG and fishers' behavior in Australia and Indonesia found that most Australian fishers repair or replace their nets at a minimum of once annually, as opposed to Indonesian fishers which did so less frequently and reported more frequent incidents of loss[93]. This important finding bolsters the need to address economic factors that affect the underlying causes of ALDFG in the region. Furthermore, ALDFG threatens important industries that support the local livelihoods of many communities in the developing countries[94], specifically small-scale fisheries and marine ecotourism. It is therefore important to conduct further baseline studies on the occurrence of ALDFG, as well as its ecosystems and socioeconomic impacts, to provide a basis of sound fisheries and waste management measures. Promisingly, there are initiatives since 2019 to assess annual rates and levels of global marine capture fisheries being supported by the IUCN[95]. This could fill in the gaps of many data-deficient areas and provide much-needed evidence for future programs and policies.

IV. Issues and Challenges in Asia Pacific

The management of ALDFG in Asia Pacific remains complex and is characterized by its ties to local conditions that link to development issues. Oftentimes, the magnitude largely depends on the socioeconomic status of fishing sectors involved[96]. Although ALDFG are commonly caused by environmental and extreme weather conditions, there is much more incidence of ALDFG related to economic and social equity factors in the region. Notably, major issues include illegal fishing and operational issues to save on costs. In comparison to developed countries, the lack of infrastructure and enabling environment are major challenges as well. The issues are further detailed as follows:

1. IUUF and enforcement issues. Although there are numerous international and regional conventions that seek to prevent and deter ALDFG, enforcement mostly lies within the ambit of the fishing vessels' flag state, and in some cases the coastal and port state authorities. Violators often avoid apprehension mainly because states do not have the

[91] Thushari, G., Chavanich, S., Yakupitiyage, A., Coastal debris analysis in beaches of Chonburi Province, eastern of Thailand as implications for coastal conservation Marine Pollution Bulletin 116 (2017) 121–129 (2017).
[92] Data from the Department of Marine and Coastal Resources (Thailand) (2018)
[93] Richardson, *supra.*
[94] Myanmar Ocean Project, *supra.*
[95] See IUCN. https://www.iucn.org/news/commission-ecosystem-management/201812/derelict-fishing-gear-worlds-marine-capture-fisheries (visited at Sep 23, 2020)
[96] Matsuoka, T., Nakashima, T., and Nagasawa, N., A review of ghost fishing: scientific approaches to evaluation and solutions. Fisheries Science 71, 691–702 (2005).

resources to patrol and monitor their waters. Furthermore, without measures such as gear marking it is very difficult to trace ALDFG back to a specific fisher or vessel[97].

2. Overallocation of licenses. Overallocation of licenses has been identified as a driver of diminishing fisheries resources that lead to reduced catches. The overcapacity effectively pushes fishers to increase fishing effort to maintain at least the same level of catch, resulting in overcrowding of fishing grounds and higher incidence of gear conflict[98]. Moreover, increased competition may also push vessels to go farther to riskier grounds, where loss of gear is more likely due to physical and environmental conditions.

3. Operational issues. ALDFG occurrence in developing countries are often related to the socioeconomic conditions of the fishing sector, and in particular, the artisanal small-scale subsector. In developing country contexts, fishers may be economically unable to invest in upgrades or repairs, and thus the use of old or damaged gear may contribute to an increased prevalence of ALDFG. Furthermore, fishing gear are also deliberately discarded to save on vessel space or weight, and therefore fuel costs.

4. Lack of waste management infrastructure. Port reception and disposal facilities entail costs to build and maintain, which may prove challenging to developing countries. Many small ports have limited space or logistical limitations for handling waste. Moreover, prohibitive costs to access such facilities would encourage illegal disposal of litter into the sea instead, especially if there are no existing incentives in place[99].

5. Lack of policy framework. There are no enabling policy environments to address ALDFG in many developing countries. This includes the lack of clear rules or guidelines for gear marking, reporting, proper marine spatial planning and mechanisms for port reception. There is also a dearth of market-based mechanisms such as economic incentives for gear manufacturers, buy-back schemes, as well as local waste management policies that seek to prevent and reduce ALDFG.

6. Lack of human and technological capacity. When fishing operators do not make money due to overcapacity of fishing grounds, it is often difficult to maintain well-trained crew and reliable fishing technologies[100]. Many developing countries also lack capacity to implement tracking systems or electronic means of gear marking which would simplify and expedite the reporting and recovery processes.

7. Difficulty of monitoring. There are no standards of monitoring and reporting ALDFG that could be comparable within and between regions[101]. There is a need to standardize fishing gear units, reporting methodologies and minimum data requirements to ensure proper data analysis and responsive action. There are also substantial costs

[97] Unger, *supra.*
[98] Richardson, *supra.*
[99] Carpenter, A., MacGill, S.M., Charging for port reception facilities in North Sea ports: putting theory into practice. Mar. Pollut. Bull. 42 (4), 257–266 (2001).
[100] Richardson, supra
[101] Huntington, supra

involved in patrolling and monitoring across huge areas, which may prove challenging in countries with limited resources.

V. Legal and Policy Framework of ALDFG

As in most marine environmental issues, the occurrence of ALDFG is a transboundary problem which warrants strong international and regional cooperation to properly address. The issue has been raised at the level of the United Nations General Assembly (UNGA) on several occasions[102], with resolutions issued calling for more action to address ALDFG and related marine debris. As such, the international and regional legal regimes on the environment and fisheries have developed competencies that seek to address ALDFG, either directly or within the wider framework of fisheries or marine litter management.

A. International Legal Regime of ALDFG

1. Marine Pollution Governance Framework

Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL)[103] prohibits certain discharges of ship-generated garbage, including from fishing vessels. This has further been revised in 2013 to generally prohibit the discharge of all garbage into the sea and particularly identifies plastic waste to include synthetic ropes and fishing nets[104]. MARPOL Annex V also requires adequate port reception facilities and governments to ensure its provision at ports and terminals. The International Maritime Organization (IMO) has published accompanying guidelines for the application of MARPOL Annex V, the latest version of which was adopted in 2017. The guidelines include provisions requiring fishing vessel operators to record the discharge or loss of fishing gear in the Garbage Record Book or the ship's official log-book, and the reporting of accidental loss or discharge of fishing gear which poses a significant threat to the marine environment and navigation[105]. Furthermore, IMO adopted the Action Plan to Address Marine Plastic Litter from Ships [106] in 2018, which includes provisions linking the marking of fishing gear with the IMO Ship Identification Number, as well as the development of best management practice for recovery and port reception facilities of ALDFG, in cooperation with the Food and Agriculture Organization (FAO).

The International Maritime Organization (IMO) London Dumping Convention[107] or the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter specifically requires preventative action to be taken when there is reason to believe that wastes introduced into the marine environment are likely to cause harm[108].

2. Fisheries Governance Framework

[102] These include Resolution A/RES/60/30 of 2005, Resolution A/RES/60/31 of 2005, A/RES/61/222 of 2006 and Resolution A/RES/61/105 of 2006
[103] Entered into force in 1988
[104] Regulation 3.2, Revised MARPOL Annex V (entered into force in 2013)
[105] 2.2.1 Resolution MEPC 295 (71). (Adopted on 7 July 2017)
[106] Resolution MEPC.310(73) (adopted on 26 October 2018)
[107] Entered into force in 1975
[108] Article 3, 1996 Protocol to the Convention

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) provides the universal framework for marine environmental protection which largely reflects customary international law. Under Part XII on the 'Protection and preservation of the marine environment', the general obligation is that states have to protect and preserve the marine environment[109]. It also requires states to take, individually or jointly as appropriate, all measures consistent with UNCLOS which are necessary to prevent, reduce and control pollution of the marine environment from any source[110].

Since UNCLOS, there have been a multitude of international legal instruments and initiatives to manage fisheries and combat IUUF. Instruments focused on curbing IUUF are particularly important to arrest ALDFG because of the strong association between them. Among the first binding agreements that cover gear management is the United Nations Fish Stocks Agreement (UNFSA)[111] or the Agreement for the Implementation of the UN Convention on the Law of the Sea (UNCLOS) relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. The UNFSA identifies the marking of fishing vessels and fishing gear as a flag state responsibility, and as a measure to reduce the incidence of ALDFG. The agreement includes reference to reducing the impact of fishing gears, gear marking and the retrieval of ALDFG.

More recently, numerous states have acceded to the FAO Port State Measures Agreement (PSMA)[112]. The PSMA promotes measures to counter illegal, unreported and unregulated (IUU) fishing committed by foreign vessels by preventing them from using ports and landing catches. This covers IUU vessels and those employing prohibited gear, which are more susceptible to abandon or discard their fishing gear.

Aside from the foregoing binding agreements, there are also a number of voluntary or soft law instruments which cover ALDFG. The FAO Code of Conduct of Responsible Fisheries (CCRF)[113], which aims to promote responsible fishing practices and encourage states to address issues on fisheries with adverse impacts on the marine environment is among the first codes of conduct that encourages states to take appropriate measures to minimize waste, discards, catch by lost or abandoned gear. It also encourages states to ensure that fishing gear should be marked in accordance with national legislation. Furthermore, it contains provisions concerning marine litter with reference to MARPOL requirements on garbage management[114], and the development of technologies, materials and operational methods that minimize the loss of fishing gear[115].

To further implement the gear marking requirement, the Commission on Fisheries (COFI) recommended exploring cost-effective technologies and practices for marking, and subsequently the FAO convened an Expert Consultation on the Marking of Fishing Gear to develop the Draft Guidelines for the Application of a System on the Marking of Fishing Gear. The resulting final

[109] Art. 192, UNCLOS
[110] Art. 194, *ibid.*
[111] Entered into force in 2001
[112] Entered into force in 2016
[113] Issued 1995
[114] 8.7.1, CCRF
[115] 8.4.6, CCRF

FAO Voluntary Guidelines for the Marking of Fishing Gear (VGMFG)[116] was issued in 2019 and is an important tool to guide States in preventing and reducing ALDFG through gear marking. The guidelines provide the necessary steps to implement the system, including details on reporting, recovery and disposal. It also contains provisions on capacity building for developing states and small-scale fisheries. The VGMFG also complements other voluntary instruments such as the International Guidelines on Bycatch Management and Reduction of Discards[117] which seeks to reduce the impacts of lost fishing gear. Such non-binding instruments have been incorporated as part of the CCRF to provide guidance for states, regional fisheries bodies and stakeholders to implement measures to address ALDFG.

B. Regional Instruments

The UNEP, as part of the Global Partnership on Marine Litter, includes ALDFG in the development of regional action plans in the 18 existing UN Environment Regional Seas Programs. Programs publish documents on the state of marine litter and develop Regional Action Plans on Marine Litter[118], and secretariats are established to monitor, assess and undertake outreach and activities on marine litter at the regional level.

Regional Fisheries Bodies (RFBs) and Regional Fisheries Management Organizations (RFMOs) also play a key role in the management of ALDFG. RFMOs, are particularly important, as these intergovernmental regional fishery bodies are empowered to establish binding conservation and management measures, usually over straddling fish and highly migratory fish stocks. Some RFMOs have enacted measures that address ALDFG, including spatial and temporal restrictions, prohibition of gillnet and trammel net gear, and gear marking, among others[119].

Lastly, Regional Plans of Action (RPOA) on Illegal, Unreported and Unregulated Fishing (IUUF) which aim to strengthen regional fisheries management by providing guidance and support for responsible fishing practices, scientific research and management of capacity also provide sound bases for regional collaboration on issues that underlie the causes of ALDFG[120].

C. Review of the International Legal Regime for ALDFG

The international regime for ALDFG management has been an important driver of national interventions that seek to improve the framework from waste disposal and pollution to fisheries management. Notably, soft law through voluntary guidelines and action plans have been key in the development of best management practices for ALDFG. However, international law, guidelines and frameworks for marine pollution and fisheries governance require further translation into implementation mechanisms to ensure effective rollout into national initiatives. More importantly, guidance and best management practices need to be further made into tailor-made actions which would depend on the conditions of different localities such as the source of marine debris, industries involved, etc.

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[116] Endorsed for adoption in 2018, published in 2019
[117] Issued 2011
[118] Macfadyen *et al, supra.*
[119] Gilman, *supra.*
[120] Richardson, *supra*

The evolution of the legal regime has also addressed the lack of global standards for ALDFG management. Aside from the binding agreements such as the UNFSA and PSMA which provide general mandates for national governments to act against illegal and destructive fishing practices, the most impactful legal instruments have been non-binding soft-law instruments. The VGMFG, in particular, seeks to fill in the gaps in the global marine pollution and fisheries governance framework by providing technical guidance and adaptive management measures in order for national governments to effectively implement gear marking practices. The VGMFG takes cue from the development of many national fisheries regulations and legislative reforms to address IUU fishing, which have been guided by FAO International Plans of Action (IPOA) such as the IPOA- IUUF. Soft law instruments such as the VGMFG not only complement the general legal frameworks for ALDFG, i.e., UNCLOS and MARPOL, but further implement other voluntary guidelines such as the CCRF, specifically on the provisions referring to reduction of discards[121], minimizing loss of gear[122], among others.

However, there is a pressing need for these instruments to be incorporated into national law and implementing regulations. In the case of ALDFG, voluntary guidelines such as the VGMFG as well as IPOAs and RPOAs provide a clear advantage in assisting states, regional fisheries bodies as well as industry itself as the guidelines are designed not to be overly prescriptive. Such instruments resort to providing minimum criteria for implementation. As such, national governments and regional authorities have the flexibility to implement stricter regimes, in accordance with the prevailing situation in the fishery. To illustrate, the VGMFG contains provision on risk assessment, and applicability to needs of the reality on the ground for each locality. This ensures that gear marking implementing mechanisms are appropriate and interventions are proportional with the risks involved. Specifically, such guidelines provide authority and technical guidance for policy makers to decide on the suitability of the system, its applicability on specific fisheries and gear, as well as conditions or exemptions, when necessary. Overall, the binding agreements and voluntary instruments form part of the legal regime which seeks to provide guidance as well as flexibility within which states and other stakeholders may act and tailor fit necessary action. In practice, it is important for governments to implement the legal mandates and guidance for the effective management of ALDFG not just through legislation and regulation, but also through incentives and national action plans that would provide the pathways for better means of implementations such as market-based instruments, certifications etc. to reduce ALDFG. Furthermore, collaboration with other states and key stakeholders and relevant organizations will also be helpful in ensuring that there are coordinating and monitoring mechanisms in place to measure compliance.

VI. Best Management Practices

In order to address the issue of ALDFG, best practices must be put in place and firmly implemented. Such practices may be categorized into three main categories, along with the last set of initiatives on awareness and education. The first group of measures seek to prevent the occurrence of ALDFG in the first place. These interventions are preferable as against all other measures that are predicated on ALDFG's introduction in the environment. Mitigation measures

[121] 8.4.5, CCRF.
[122] 8.4.6, CCRF.

aim to reduce the impact of ALDFG, while curative measures target their recovery, removal and disposition. It is important to note that some measures may be best supported by regulatory tools, while for others voluntary arrangements and market-based instruments may suffice. The implementation mechanisms are further discussed in the succeeding section.

A. Prevention Measures

1. Gear Traceability

Gear marking consists of placing a unique identifier in fishing gear that allows relevant authorities to discern responsible parties for fishing gear. It is a good practice to clarify ownership and avoid intra-fishery conflict and is particularly important for recovery efforts[123]. International standards for gear marking are found in the FAO VGMFG, and common gear tag material used include metal, plastic or wood, while bamboo and other biodegradable tags have been explored[124]. Gear marking effectively provides a disincentive for the deliberate abandonment and discarding of fishing gear, while promoting reporting[125]. It can also increase the visibility of passive gear that would reduce navigational risks of other marine users, thereby avoiding accidental gear loss. Marking may be integrated in the supply chain process to involve gear designers and manufacturers to streamline the requirement.

Gear location technology also ensures traceability of fishing gear. Such technology entails the installation of GPS or tracking devices on fishing gear, thus reducing the likelihood of loss while improving its subsequent recovery. The use of transponders on gear has become more accessible as more tracking technologies are introduced for fisheries monitoring processes. Notably, ALDFG can be better managed through electronic tracking along with marking as a prerequisite for registration[126]. However, the use of location technology by small-scale fishers may prove challenging due to cost and technological constraints.

2. Port Interventions

The weakness of port state control has been identified as one of the contributory factors in IUU fishing[127]. Effective port state measures and inspections pursuant to the PSMA or regulations of the port state are known to deter IUU fishing vessels utilizing a port state's facilities. A thorough examination of nets to verify compliance with relevant conservation and management measures, especially those preventing ALDFG, may reduce further incidence of abandonment.

Furthermore, onshore reception is a vital measure among port interventions. Appropriate collection facilities can reduce the chances of fishers discarding gear at sea. However, there must be appropriate incentives through convenient access or recycling buy-back schemes for fishers to

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123 Macfadyen *et al*, *supra.*

124 Dixon, C., Satria, F., Wudianto, Nurdin, E. Utama, A., Mahiswara, Toole, J. He, P., Gear marking pilot study in Indonesian small-scale gillnet fisheries with reference to FAO's draft Guidelines on the Marking of Fishing Gear Committee on Fisheries. Draft Fisheries and Aquaculture Technical Paper. FAO COFI/2018/SBD.18 (2018).

125 Gilman, *supra*.

126 Huntington, *supra.*

127 Macfadyen *et al*, *supra.*

participate. To be deemed more practical for fishers to dispose unwanted gear, the onshore facility should strive to be free of costs or already integrate minimal costs into general landing charges[128]. This may be supported by other programs such as mandatory deposit on new gear to be returned upon delivery to the facility.

3. Spatial Management

Spatial management that allocates zones for marine users are particularly helpful to avoid gear conflict. A zoning scheme would better ensure that users are aware of the presence of fishing gear in specific areas which have been established through agreements or consultations among fishers[129]. Separating passive and mobile gear through spatial management, as well as disallowing certain fishing methods and gear in high-risk areas where snagging may be likely, would significantly reduce gear loss.

4. Design and Manufacturing Interventions

Involvement of gear manufacturers and designers, where they bear responsibility in facilitating the responsible disposal of their products, ensures a circular approach in the disposition of ALDFG. This may be possible through buy-back schemes of old gear to be recycled into new ones, alongside deposit schemes to incentivize their return. Manufacturers may also support the implementation of responsible gear disposal programs and designers may reduce risk of losses through better design[130]. A more practical approach to reduce gear loss is to require fishing vessels to have on-board storage facilities, where gear retrieval, packaging and waste storage solutions are incorporated in the fishing vessel design[131].

To promote longevity and reuse of fishing gear, it is important to maximize reuse of plastic. High specification materials are preferable, as opposed to cheaper single-use alternatives. Fishing operators may also educate crew to refit fishing gear while at sea and conduct circular planning in procurement of materials for fisheries equipment and packaging[132].

5. General Fisheries Management Measures

The overall fisheries management regime can determine the likelihood of ALDFG occurrence in a given fishery. Management measures that prevent the overallocation of fishing licenses and overcrowding of fishing grounds would reduce incidence. In addition to seasonal closures and spatial restrictions, quotas and limitations of licenses per area or fish stock may also prevent gear losses as a subordinate effect[133]. ALDFG may also be prevented by reducing the amount of gear left in the water (soak time), and by monitoring the number of soak time hours. Improved transparency is also an important deterrent for IUU fishing and consequently gear abandonment or discarding. Stronger flag state measures such as vessel monitoring systems and more comprehensive observer coverage for fishing vessels may help in reducing its occurrence.

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128 *Id.*
129 *Id.*
130 Huntington, *supra.*
131 *Id.*
132 Huntington, *supra* (2019).
133 Richardson, *supra.*

B. Mitigation Measures

Biodegradable gear may be promoted to ensure gear decompose when lost at sea. Some synthetic gear materials such as polyhydroxyalkanoates (PHAs) have been developed to be completely biodegradable and capable of being broken down by microbes and ultraviolet light when submerged in water[134]. Other innovations include low-risk FADs that use biodegradable cloth attractors instead of mesh panels, and biodegradable escape panels in traps that may reduce incidence of ghost fishing[135].

Some technologies may also be used to reduce ghost catch. Acoustic beacons, pingers and reflectors can be used to reduce capture of certain non-target species, particularly marine mammals and sea turtles, even when the gear is abandoned, lost or discarded[136].

C. Curative Measures

1. Reporting

Direct reporting from the gear operator should provide a more accurate picture of the circumstances of the loss. Reporting to publicly available gear recovery programs which are facilitated through online reporting, apps or hotlines, are especially effective in reaching out to wider stakeholders. Such reporting complements adoption of location services for ALDFG to accurately determine their position.

2. Recovery

Gear recovery programs usually utilize creeper or grapnel to remove ALDFG from the oceans or seabed. These may involve local dive clubs and coastal communities for coordinated information sharing on the quantity, magnitude and likely locations of ALDFG, Sensitive habitats and biodiversity-rich sites should be prioritized, and targeted surveys in coordination with government and other stakeholders may prove to be effective. This includes using patrol or fishing vessels chartered by fishers' organizations for recovery operations[137], or voyages led by the government in collaboration with industry.

Land and sea-based surveys to locate ALDFG may also be tapped. Existing technology consists of towed-diver surveys, Side Scan Sonar and sea-bed mapping programs[138]. Traps and other static gear in particular can be easily located through remote sensing. Studies identifying hotspots for likely locations where ALDFG are situated may also be conducted through similar technology[139].

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134 Gilman, *supra.*
135 Huntington, *supra* (2017).
136 Gillman, *supra.*
137 Inoue and Yoshioka, *supra.*
138 Huntington, *supra.*
139 Macfadyen, *supra.*

3. Collection and Recycling

Collection and clean-up drives are important activities to remove ALDFG from the marine environment. The sensible next step to the systematic collection of ALDFG in collection facilities would be to recycle them for other productive uses. Other "upcycled" products made from ALDFG components include fencing for agriculture and aquaculture, fillers for roads and coastal tracks, soccer nets, masks and keychains[140]. Upcycling and value adding to products derived from ALDFG also create economic incentives to collect, and may be a valuable source of livelihood in coastal communities.

D. Awareness, Education and Research Initiatives

In general, fishers are aware of their role in conserving the marine environment and managing fisheries to ensure the sustainability of their livelihoods. Due to the investments involved, they also typically exert effort to recover lost gear where possible. However, further education could expand fishers' and other relevant stakeholders' knowledge on the issue of ALDFG and guide them on the implementation of best management practices[141]. Research initiatives must also be prioritized in response to the paucity of quantitative data, especially in the developing parts of Asia and the Pacific. This would help in baselining and providing science-based evidence for future programs on ALDFG in the region.

Specifically, training opportunities for good gear design and appropriate fishing methods to reduce the likelihood of gear loss are expected to improve management of ALDFG[142]. Awareness raising of, and knowledge sharing between, government officials and policymakers are beneficial to elevate and mainstream best management practices and successful cases.

For mandatory regulations such as zoning schemes, the government must involve all relevant stakeholders that would be directly affected, particularly those within the fishing sector itself. The engagement of a broader range of users is crucial to ensure the effectiveness of any intervention, and users' inputs are valuable in designing proposed policy. Moreover, regulations are generally more accepted and easily implemented with high engagement from involved stakeholders[143].

Fisheries observer programs may also be tapped to determine the magnitude of ALDFG as they are most exposed to the extent of its occurrence at sea. Integrating gear reporting, research and recovery processes (e.g. logbook recording and informing local navy or coastguards) in observer program trainings may be beneficial for recovery efforts[144].

Moreover, engaging interested citizen scientists, scuba divers and snorkelers to collect data and report incidence of ALDFG can be a potent tool in putting together a clearer picture of the extent of its occurrence. Collaborating with different organizations such as diving organizations

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[140] Macfadyen, *supra.*
[141] Huntington, *supra.*
[142] Gilman, *supra.*
[143] Huntington, *supra.*
[144] FAO, *supra.*

and marine mammal rescue centers to access data about ALDFG and its impacts may also be useful to fill knowledge gaps[145]. User-friendly and innovative apps that provide avenues for reporting and recording data on ALDFG may reveal important information on the scope and magnitude of ALDFG. Apps are also capable of reaching out to a wider range of stakeholders that could be engaged to combat ALDFG.

E. Review of Management Measures

It should be noted that as far as practicable, the above measures are best taken in combination with each other to form a suite of effective schemes for ALDFG management. Among the three categories, prevention measures are generally considered to be most cost-effective. Therefore, in the range of possible interventions, priority should be given to ensuring the avoidance of gear waste being introduced to the marine environment. Moreover, some mitigation methods such as alterations in gear may compromise economic viability and practicality through increased costs and reduced gear effectiveness[146]. On the other hand, curative measures tend to be less effective and entail greater expenses in comparison to avoidance. However, recovery may still be cost-effective using efficient approaches; and from an economic lens, mitigation or curative measures would still be preferable due to its positive effects rather than inaction. Importantly, such measures should be introduced within the broader fisheries and waste management frameworks to spur behavioral change across all relevant stakeholders.

In terms of avoidance measures, it is necessary to design the intervention to target the commercial operators and small-scale fishers through different methods. Artisanal fisheries will require measures that consider social equity considerations. The disparity in costs involved (e.g. gear marking and tracking) make it even more important to have customized strategies for each subsector. As such, the best management practices provide a general guide for authorities to adopt best applicable measures for different types of fisheries. On the other hand, most mitigation and recovery efforts benefit the whole fisheries industry, as well as related activities in coastal zones such as tourism and community-based recycling projects. Thus, implementing such measures can be more easily scaled up.

Another important note is the importance of investing more into research and awareness for ALDFG management. The dearth of data in global assessments for ALDFG, and particularly in Asia Pacific, highlight the pressing need for supporting research to provide the evidence required as basis for decision making. Such data is necessary to craft and implement appropriate policy and responsive measures to adapt to specific conditions of a locality or fishery. Furthermore, a challenge that will have to be surmounted is the how to work with different stakeholders across the value chain and related industries, from fishers, consumers to recyclers, in order to implement appropriate action and fill gaps in ALDFG management.

Lastly, management measures implemented nationally should be consistent with technical guidance and further enforce the mandates provided for in the legal regime governing ALDFG management. For instance, binding instruments such as the PSMA and voluntary guidelines such as the VGMFG provide important interventions that would tremendously help in improving

[145] Richardson, *supra.*
[146] Gilman, *supra.*

fisheries management and reducing lost gear. Other soft instruments such as plans of action on marine litter and fisheries management are also instrumental for governments to craft national actions plans and provide a potent starting point for which governments may act to ensure proper management of ALDFG.

VII. Implementation Mechanisms

Best management practices are not mutually exclusive and would ostensibly work well in combination with other compatible measures. However, some measures may be best introduced through differing mechanisms, such as regulation or market-based instruments, depending on the goal and actors involved. Accordingly, implementing ALDFG measures can take the following forms:

1. Voluntary actions. Voluntary arrangements for fishing management measures can be an effective means to forward action on ALDFG. In such cases, the fishers' direct involvement may fuel their incentives to act. Voluntary actions can cover spatial measures, gear and vessel design, gear marking, and employing mitigation measures, among others[147].

2. Third-party fisheries certification. Ecolabelling and accreditation provide incentives such as better market access or price premiums which can spur improvements in fisheries management. It is an established market-related tool that seeks to fill gaps in regulation, such as measures that address ALDFG[148]. Third-party certification can include participation in onshore disposal facilities, gear and vessel design, mitigation measures and best practices for reporting and recovery of ALDFG[149].

3. Regulation or legislation. Conventional command and control measures can effectively change fishers' and other stakeholders' behavior to better manage ALDFG. As this approach requires compliance under pain of punishment for violation, it may be difficult to implement without sufficient enforcement systems and may possibly be counterproductive. However, if properly executed, it can effectively control spatial management, gear marking, port state and general fisheries management measures, as well as gear design and onshore facilities. It can also include the range of mitigation and recovery measures, particularly the process of reporting and recovery of ALDFG[150].

4. Information, education and communication campaigns. Improved stakeholder awareness is crucial in ALDFG management. Thorough information dissemination campaigns can promote rules and best management practices for proper avoidance, mitigation or recovery. Strategies can be employed to target specific groups such as fishers and manufacturers, as well as the general public or coastal communities at large.

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147 Huntington, supra.
148 *Id.*
149 Unger, *supra.*
150 Huntington, *supra.*

These activities can also bring about more engagement especially on reporting and recovery of ALDFG[151].

The effectiveness of different implementation schemes largely depends on ensuring that they are applicable to the context in which they are applied. As such, a contributing factor to the success of an intervention is tailoring solutions to the needs of the different subsectors in capture fisheries. It is therefore recommended to adopt and implement distinct management practices to address the issues and challenges of small scale and commercial fisheries, respectively, particularly on avoidance measures.

VIII. Case Studies: National Initiatives

A. Prevention: Fishing Gear Marking in Indonesia

The FAO and GGGI conducted a pilot project on gear marking in Indonesia in 2017 to support the then-draft Voluntary Guidelines for Marking of Fishing Gear. The project focused on small-scale gillnet fisheries, and the aim was to test low-cost and easily applicable methods of marking gillnets. Gillnets were marked using various methods such as metal, plastic, bamboo, coconut shell and fibrecode tags, and the study concluded that small-scale fishers were generally cooperative although there is a need to better understand the linkage of marking and retrieval of ALDFG. Issues identified include the limited incentive to retrieve lost nets due to its low cost and the existence of a government subsidy program, as well as the cost and technical constraints of applying certain types of technology to small-scale fisheries. Another challenge cited was the availability of eco-friendly materials for markers and their attachments.

The Indonesian experience shows that gear marking in small-scale gillnet fisheries is possible provided that a holistic implementation plan is in place. This should encompass data collection, capacity building, fisher education, as well as incentives. The issues on costs may be partly addressed through marking at the point manufacture and adding value to end-of-life gear, which can be achieved through increased collaboration among government, fishers and the private sector. As to the availability of marking materials, further guidance within the gear marking guidelines itself may be useful. Overall, gear marking must be carried out within the context of broader fisheries management measures, as marking on its own may be insufficient to address ALDFG. Moreover, raising awareness and capacity are vital for future interventions on gear marking. As such, findings from this case study apply to gear marking interventions as applied to small scale fisheries, while commercial fisheries may explore other established marking technology.

B. Prevention: FAD Location Technology in Vanuatu

Pacific Island countries have recently started to invest more in anchored FADs, which are designed to enable artisanal fishers to harvest in nearshore areas. While these FADs are designed to be stationary, reports of breaking free from the moorings are not unusual, causing them to drift farther offshore and become marine debris. In response, the Vanuatu Fisheries Department (VFD) pilot-tested low-cost technology to track the location of anchored FADs that break free from their

[151] *Id.*

moorings and allow for their speedy retrieval. This is particularly important for Pacific Island countries as the main issue deterring the use of tracking devices is costs. Most monitoring technology in the market are priced higher than most fishers and government agencies can afford. The project aimed to assess an effective tracking device that would amount to less than 10% of the cost of anchored FADs, which typically cost up to 2,000 USD. No location tracking devices have been deployed in Vanuatu prior to the project.

The case showcases the reliability of tracking devices in providing accurate and real-time location data, provided that the anchored FAD remains within cellular range. In cases of FADs breaking away and drifting, it is important to promptly deploy retrieval vessels before the lost FADs are able to drift beyond the network range. Available technology such as cellular data, satellite networks, or any other compatible and reliable data system may be tapped. The specifications must require the device to be waterproof and solar-powered with a long-lasting battery life. Development of further low-cost tracking technology options is critical, as numerous available alternatives would also drive costs for technology down to cater to small island developing states and small-scale fisheries. Furthermore, agreements with local fishers and other stakeholders to retrieve lost FADs may be entered into for their quick and timely recovery. Overall, findings from this case study could benefit both commercial and artisanal subsectors which rely on FADs for pelagic fisheries.

C. Prevention and Mitigation: Forecasting and Biodegradable Fishing Gear

ALDFG is an emerging issue in Philippine fisheries. However, the existing policy framework in response to the problem mostly involves general fisheries management and does not directly address ALDFG. The suite of measures employed by the Philippine government, primarily through the Bureau of Fisheries and Aquatic Resources (BFAR), include: (1) gear swap programs which promote biodegradable or hybrid materials such as *buri* palm fronds; (2) cash incentives for local governments implementing good fisheries and waste management programs; (3) spatial management through "no FAD" and closed zones, and marine protected areas (MPAs). The main challenge identified was weather disturbances, as some coastal areas suffer from several typhoons a year; while gaps cited were the absence of clear processes for reporting and the need to coordinate with local governments for small scale fisheries projects.

Lessons from the implementation of the above measures highlight the pressing need to improve forecasting capacity and invest in early warning systems at the local government level to address weather-related challenges. Pilots for early warning systems could be explored to assist small scale fisheries in storing gear in anticipation of extreme weather events. Second, a combination of spatial planning and promotion of biodegradable or hybrid fishing gear are effective to prevent and reduce ALDFG. However, better coordination between the BFAR and local governments for rollout and zoning of municipal waters is warranted. Third, although the general solid waste management law requires the establishment of materials recovery facilities, most ports do not have them; and thus, such investments must be prioritized. Learnings from the Philippine case could benefit the whole fisheries sector in terms of preparedness to extreme weather events, while biodegradable gear and local government coordination are targeted towards small-scale fisheries.

D. Curative: Gear Recovery in Myanmar

ALDFG poses a threat to Myanmar's budding marine tourism and diving sector centered around the Myeik Archipelago on the southern coast. As quantitative data about ALDFG do not exist, divers from the NGO Myanmar Ocean Project (MOP) conducted the first systematic underwater surveys that seek to determine locations where ALDFG accumulate and examine the extent and types of gear involved. The expeditions revealed that 31% of sites surveyed can be classified as hotspots, which is defined as areas where regular intentional discarding of old nets by resting boats were recorded, or where multiple layers of lost nets covered reefs or were found to be ghost fishing. Issues that arose from the surveys consist of the difficulty in identifying potential hotspots due to the lack of information and reporting, and the challenges in accessing sites where lost gear accumulate for recovery operations.

The Myanmar case highlight the importance of focused efforts to remove ghost gear from identified hotspots are crucial, and that priority operations should be undertaken in sensitive habitats and sites where marine megafauna are known to frequent[152]. The identification of hotspots could involve both fishers and the diving industry to provide information on discard locations for targeted clean-up initiatives[153]. Because of difficulty of access to most hotspots, immediate gear loss reporting by local fishers through a clear and expedient system for communicating incidents should be promoted. Reporting systems could be piloted across the fisheries and tourism sectors, with fishers' accounts to be shared with dive shops, liveaboards and sailing boat companies with capacity for easier retrieval of ALDFG. Proper coordination across relevant government agencies for quick response assistance and grants of permits for surveying and retrieval would also be advantageous[154]. Lessons from this case study show that recovery efforts benefit the whole fishing, tourism and other related industries in coastal areas, and are easily scalable with collaborative action and use of technology.

E. Curative: Recycling and Value Adding in Thailand

The Net Free Seas Project of the Environmental Justice Foundation (EJF) Thailand aims to encourage local fishing communities to properly collect and recycle end-of-life gear and ALDFG, with a view of eventually integrating them in the market supply chain. The project trains communities to collect and clean nylon gillnets for recycling partners that "upcycle" them into new products. EJF has partnered with the design brand Qualy to produce face shields, bottle openers, push-sticks and headbands, with the products typically commanding a price premium. The project's main challenge is how to make the business model profitable by reducing costs of production such as logistics and transport from far-flung areas. There are also current technological limitations on recycling nets consisting of mixed materials as each type of plastic has a different melting point.

The Thai experience uncovers the need to improve efficiency in technology, specifically on the recycling facilities' capability to compress materials. Future interventions must seek to fill technological gaps and remove the limitations for mixed materials, which cover the vast majority

[152] Myanmar Ocean Project, *supra.*
[153] *Ibid.*
[154] *Id.*

of ALDFG beyond gillnets. The next steps would be to expand from artisanal crab gillnets to eventually include other commercial fishing gear ALDFG such as purse seine nets and trawls. To further build a successful business model, measures must be put in place to minimize costs in terms of logistics, cleaning and transport. Linkages with recyclers and logistics companies should also be expanded, while the corporate sector may be tapped for collection activities such as recovery dives and beach cleanups. The Thai experience advises against subsidizing the cost for fishers to replace nets as it reduces incentives to reuse and recover nets. Instead, other options intangible benefits may be offered, such as membership to groups and preferential access to renewal of licenses and permits. This case shows that recycling efforts benefit across industries in coastal zones and are highly scalable in coastal communities with the proper policy support and an enabling environment.

IX. Recommendations

ALDFG presents a major threat to the marine environment and global fisheries through a range of ecosystems and socioeconomic impacts. Consequently, urgent measures need to be taken to address the problem. Interventions will largely seek to change human behavior as well as promote innovations in technology[155]. For policy formulation, steps forward would involve translating best practices into appropriate implementation mechanisms to build the enabling environment for ALDFG management.

Governments evidently play a key responsibility on the success of any intervention. However, stakeholders such as fishers and related industries wield considerable influence in the outcome in terms of voluntary action and certification. Overall, support should be galvanized across various sectors, including but not limited to fisheries regulators and managers, port authorities and operators, the fishing industry and seafood companies, as well as fishing gear manufacturers and designers. Interested third parties such as ecolabelling programs and NGOs also hold crucial roles in monitoring and sustaining gains, whereas support for scientists and researchers is vital for the development and innovation of technology solutions for ALDFG.

A. Global and Regional Responses

Relevant international organizations must develop a coordinated response to ALDFG. The international response framework should include relevant members agencies of the UN such as the FAO, IMO and UNEP, Regional Fishery Bodies (RFBs) such as RFMOS and advisory councils, and regional bodies which implement ALDFG-inclusive marine litter action plans.

For international initiatives, governments must work with stakeholder networks which include NGOs and fisher groups for a more holistic approach in responding to ALDFG. Organizations such as the GGGI can be tapped for support and technical advice. The FAO, IMO and RFMOs should collaborate in implementing a clean harbors program for small-scale ports, particularly targeting ALDFG, fishing sector waste, and providing onshore reception facilities. International cooperation at all levels should be further strengthened, including in multi-stakeholder initiatives such as the Global Partnership on Marine Litter, to deliver programs under action plans for marine litter.

[155] Macfadyen *et al*, *supra.*

Importantly, efforts must be taken to promote international legal instruments, including soft law measures such as the FAO Voluntary Guidelines on the Marking of Fishing Gear, albeit non-binding. This requires a collaboration among regional environment programs and fisheries bodies to ensure such management practices are incorporated into national action plans for marine litter and fisheries, as well as rules for implementation.

B. National Management Measures for Asia Pacific

The Asia Pacific region is characterized by its unique local conditions which could largely influence the effectiveness of interventions to manage ALDFG. Thus, interventions should be tailor-fit to enable the reduction and disposition of ALDFG considering local conditions. These measures can be undertaken through voluntary arrangements, strong regulatory frameworks, or effective market-based instruments. Actions can be carried out through mandatory or voluntary means, or through a combination of both. Education and awareness initiatives are vital to complement policy instruments and spur behavioral change.

The following recommendations are identified from best management practices and the lessons learned from case studies which respond to issues on ALDFG within the region as a lens for suggesting management measures. Such recommendations for potential adoption in Asia and the Pacific comprised of specific rules, economic incentives and research pathways that would support enabling environments for ALDFG management in the region.

1. Prevention Measures

a. Gear Traceability

Asia Pacific countries must enact regulation for gear marking and unique identification by integrating the requirement as a condition for the grant of fisheries licenses. The system should be consistent with the FAO Voluntary Guidelines for the Marking of Fishing Gear. The process of adoption may be facilitated further by making gear marking and unique identification an intrinsic feature of gear at the point of manufacture. Guidance on recommended eco-friendly materials for gear marking may also be included in future guidelines and options to scale the requirement for small scale fisheries should also be explored.

Requiring tracking devices on fishing gear must also be developed, possibly through a phase-in arrangement as practical options are introduced to cover more fishing vessels. Location and tracking data of fishing gear should be regularly transmitted to relevant authorities to ensure proper disposition.

b. Port Interventions

States must conduct regular port inspection of fishing gear in accordance with the procedures set out in the Port State Measures Agreement (PSMA) or by specific regulations from the port state. In line with this, states should be encouraged to accede to the PSMA as one of the deterrent measures against IUUF and consequently, ALDFG.

Investing in green ports that provide adequate and accessible reception facilities for fishing gear is also vital to properly manage ALDFG. Where cost recovery is necessary, charges should be included in general fees rather than as a stand-alone payment. For small-scale fisheries, collection points can be established at village landing sites where the local government can provide in terms of staffing and space. Onshore disposal of fishing gear may be supported through intangible benefits such as preferential access to renewal of licenses or better port access.

c. Spatial Management

Implementing spatial management measures is critical to avoid gear conflict. Such interventions must be undertaken through rigorous consultations of different stakeholders and zoning schemes strictly enforced by them . Conversely, coordination between fisheries agencies and local governments must be ensured for proper zoning of near-shore waters.

d. Manufacturing and Design Responsibility

Gear manufacturers may buy back old gear for recycling or facilitate responsible gear disposal and end-of-life refund programs. In this regard, manufacturers should be capacitated to conduct life cycle analyses of gear and seek to include responsible use and disposal in its corporate and social responsibility. Vessels may also be designed or reconfigured to have more on-board storage facilities for gear to discourage discarding.

e. Incentives for Gear Maintenance

Incentives that promote gear maintenance in low socioeconomic and developing fisheries may be introduced. This includes retooled government subsidies for recycling old gear and supporting gear recovery, instead of giving payments to simply replace them or providing money for new gear.

f. Early Warning Systems

An early warning system for weather disturbances must be developed, especially in calamity-prone areas. This includes improving forecasting capacity at the local government level to address weather-related challenges.

g. Improved Fisheries Management

Fisheries conservation and management measures that positively affect management of ALDFG must be implemented, such as restrictions in soak time and days at sea. Monitoring, Control and Surveillance (MCS) systems of fisheries operations may be strengthened by requiring vessel monitoring systems, expanded observer programs, and enhanced enforcement operations from sea to ports.

2. Mitigation Measures

Mitigation measures in the region may include promoting the use of biodegradable fishing gear and FADs and conducting pilot tests of new innovations in eco-friendly gear. Initiatives for gear innovation and encourage industry efforts may be supported though incentives and inclusion in certification schemes.

3. Curative Measures

a. Reporting

Easily understandable reporting systems for ALDFG and gear deployed without gear marking must be established. The reporting process should be clearly communicated to government enforcers and across stakeholders in the fisheries and tourism sectors. Moreover, extending the reporting of ALDFG to existing reportorial requirements such as catch documentation systems and observer programs may be helpful.

b. Recovery

Concentrated efforts to remove ghost gear from identified hotspots must be undertaken. Priority sites should cover sensitive habitats such as coral reefs and seagrass beds, as well as areas where marine megafauna are found. Relevant government agencies must coordinate to allow for quick response assistance and permits to survey and retrieval areas. Marine tourism businesses such as dive shops may be involved to expeditiously report ALDFG in existing and potential dive sites. The corporate sector may also be tapped for collection activities such as clean-ups.

c. Collection and Recycling

Local recycling should be promoted, and linkages facilitated for local communities to connect with recyclers and logistics companies. The business cases for ALDFG recycling through measures that minimize costs in terms of logistics, cleaning and transport must be further developed to enable scaling up success stories.

4. Awareness, Education and Research

Awareness and education activities include information campaigns through workshops for spatial management and seminars on ALDFG causes and impacts open to all interested marine users, particularly those with gear conflict, e.g. trawlers and trap/pot operators. Gear marking and other relevant guidelines must be translated and localized for outreach and communications materials to raise awareness among fishing stakeholders. Templates for policymakers, especially at the local level, for the implementation of international and national fisheries guidelines or regulations may be helpful to facilitate the implementation process. This may include providing outlines and sample wording that can be translated into policy instruments such as legislation, ordinances, or fisheries management plans.

Other activities include trainings for fishing vessel crew on proper gear storage and disposal methods, maintenance of record books and formulation of waste management plans; general coastal community waste management trainings and seminars, which include ALDFG as a key issue; and integrating ALDFG management practices into professional maritime and observer program trainings, with priority to government bodies which enforce fisheries and environmental laws and regulation.

As to research initiatives, priority themes and topics in relation to ALDFG include quantification of the extent, magnitude, and characteristics of ALDFG beyond gill nets, the review of ecosystems and socioeconomic impacts, including valuations of impact focused on the local fisheries and tourism sectors for baselining and policy support at the local and national level, and a gap analysis of existing legislation and regulations to determine further policy needs in relation to ALDFG. Scientific research to identify hotspots, sensitive habitats, key biodiversity areas through modelling and simulations using best available technologies are also important for recovery activities.

Research and development on technology and innovation may focus on developing low-cost and practical methods for gear marking and tracking, especially for small-scale fisheries; recycling technology and efficiency improvements, specifically on compressing capability and limitations for mixed materials; cost-effective and practical biodegradable and eco-friendly materials for fishing gear, as well as survey and remote monitoring systems to locate ALDFG.
The applicable implementation mechanism for each of the above measures, along with the responsible parties, costs entailed, subsector applicability and notes on implementation are further detailed in Annex I.

C. Specific Policy Developments

In light of the foregoing recommendations, governments must prioritize the establishment of an enabling legal and regulatory framework to implement management measures for ALDFG. This includes developing specific rules or guidelines on best management practices adapted for local conditions and types of fisheries. Economic incentives to reduce, mitigate and recover ALDFG and industry incentives to require gear marking at the point of manufacture and spur innovation in technology for mitigation and recovery methods must also be promoted. Furthermore, a national reporting mechanism using a standard framework that is compatible across the region should be developed and where applicable, plans of action on marine litter which should include measures that seek to address ALDFG.

Overall, governments must adopt policies promoting the circular economy approach that seek to achieve behavioral and system changes on marine litter. These include promoting sustainable production and consumption patterns, as applied to the fisheries sector.

X. Conclusion

ALDFG poses a major threat to the marine environment and global fisheries. Consequently, urgent measures need to be taken to address the problem. Interventions seek to change human behavior as well as promote innovations in technology. There are a number of

international binding and soft law instruments that seek to help governments and relevant stakeholders manage ALDFG, and the legal regime has been instrumental in developing management measures for states and regional bodies to take, particularly through voluntary instruments which provide flexibility and capabilities for adaptive management in implementing appropriate interventions. However, the steps forward would involve translating best practices into appropriate implementation mechanisms to build the enabling environment for ALDFG management.

The government, industry and civil society all play a major part in creating enabling policy and regulatory frameworks to implement management measures for ALDFG. This can be achieved by developing specific rules or guidelines, economic incentives for management, industry incentives to involve manufacturing and supply chains, and research and development for cost-effective technology and recycling processes. Ultimately, these recommendations would contribute to the overarching circular economy framework on marine litter. Through behavioral and system changes, such policies are envisaged to contribute to addressing marine pollution originating from the fisheries sector in Asia and the Pacific.

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