

**Opportunities and challenges in reducing
abandoned, lost, or discarded fishing gear: Lessons
from Taiwan**

**by
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Abstract

With oceans projected to carry more plastic pollution in volume than fish by 2050, various countries have stepped up clean-up, mitigation, and prevention efforts. Abandoned, lost, and/or discarded fishing gear (ALDFG), which causes ghost fishing and other environmental harm, has been one of the most abundant and problematic types of plastic pollution to marine environments to date. One way to combat ALDFG is to develop a circular economy for marine plastics, and this study focuses on one world leader in this effort: Taiwan. By “following the plastic” through the circular economy, this study examines the effectiveness of Taiwan’s state initiatives. Overall, this study finds that while the Taiwanese state has been responsive to civil society lobbying and includes extensive policies to mitigate and prevent ALDFG, current policies fail to include market linkages and incentives for recycling companies and businesses. This has caused bottlenecks in the movement of ALDFG through the circular economy system, namely in the costly, labor-intensive phases of sorting and cleaning retrieved ALDFG, ultimately preventing Taiwan from closing the circular economy loop.

Keywords: circular economy; marine debris; abandoned, lost, or discarded fishing gear; Taiwan; recycling

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List of Acronyms

ALDFG	Abandoned, lost, or discarded fishing gear
EPA	Environmental Protection Administration
EPA	Extended Producer Responsibility
ESG	Environmental Social Governance
FA	Fisheries Agency
IUU Fishing	Illegal, Unreported and Unregulated Fishing
MARPOL 73/78	Annex V of The International Convention for the Prevention of Pollution from Ships
NGO	Non-governmental organization
OAC	Ocean Affairs Council
OCA	Ocean Conservation Administration
UNEP	United Nations Environment Programme
UNFAO	United Nations Food and Agriculture Organization

Chapter 1. Introduction

Each year, 4.8-12.7 million tons of plastic enter marine environments worldwide (Jambeck et al., 2015). Macroplastics, defined as plastic pieces measuring larger than 5mm, can damage marine ecosystems by breaking corals and contributing to the accidental entrapment of marine life, also known as ghost fishing. Once broken down into microplastics, they can bioaccumulate within marine life. Although the long-term health risk this poses to marine life and humans has yet to be fully understood, studies so far show negative impacts on reproductive health and growth (Lusher et al., 2017; Napper & Thompson, 2020; Jambeck et al., 2020). Although 80% of this plastic comes from land-based sources in the form of discarded plastic bags and cutlery, sea-based sources of plastic, comprised mainly of abandoned, lost, or discarded fishing gear (ALDFG) make up the remaining 20% (Jambeck et al., 2015; Juan et al., 2021; UNIDO, 2019; UNEP, 2009).

Due to degradation and the variety of materials retrieved from ocean clean ups, both land and sea-based plastics are often discarded in landfills despite being made of reusable materials. However, within many countries, support is growing for the development of a “circular economy for marine plastics”. Within a circular economy, materials at the end of their life as one product would be redirected from landfills and back into supply chains as a recycled raw material ready to be reused in new products. Plastics in particular has been a material garnering significant interest, with various countries and international organizations having published guidelines, best practices, and lessons learned to guide countries pursuing the development of circular plastic systems (see Chapter 2 for details on this).

Many countries have made notable progress in the development of a circular economy through their commitments to phasing out and replacing low-quality and difficult to recycle single-use plastics with higher quality or low-waste materials (Dilkes-Hoffman et al., 2019). Taiwan¹ in particular has set aggressive goals, publicly

¹ Since Taiwan has complete autonomy in jurisdiction over its economic activity related to the fishing industry and fishing activities, for the purposes of this study Taiwan will be referred to as a country.

announcing the phase out all single-use plastics by 2030 as a first step to developing a circular economy (Chang, 2019). Presently, Taiwan has the world's second highest recycling rate and is one of the few countries in the world to have successfully attempted the development of a circular economy nation-wide on an industrial manufacturing level. This foundation has led scholars to believe that Taiwan has sufficient systems in place for the plastics industry to transition to a full circular economy (Wu et al., 2021).

While Taiwan is well positioned to expand their circular economy initiatives to include plastics, most initiatives so far are limited in scope to land-based sources of plastic (Chang, 2019). Although some recycling companies recycle items such as plastic bottles retrieved from the ocean, ALDFG has been identified by non-governmental organizations (NGOs) and scholars as the most urgent sea-based circular economy system failure given its volume in comparison to other materials. Various NGOs in Taiwan are currently working on establishing industry links for the reuse and recycling of ALDFG into new products (Circular Taiwan Network, 2019). Preliminary research by these NGOs shows that if sufficient and steady supplies of ALDFG are available to be remade into raw materials, the market for ALDFG in circular economy development is of interest to investors and shows promise in growth. However, in general, sea-based sources of plastic have only recently begun to be included in circular economy development plans.

Amidst the growing concerns about marine pollution, scholars and NGOs have begun to identify missing enabling factors in circular economy development plans for ALDFG and marine debris. In response, the Taiwanese government has begun to take measures to address these gaps, first focusing on issues such as missing industry linkages and inconsistent supplies of materials (Chen, 2015; Chen et al., 2018; Chung et al., 2022; Hung et al., 2022; Kuo & Huang 2014; Liu et al, 2014; Lu et al, 2006). Examples of these new policies and regulations include gear marking and the implementation of a new trial run gear buy-back program to establish an efficient and widespread retrieval system to divert ALDFG out of landfills and into a circular economy (Taiwan Fisheries Agency, 2021). Many of these initiatives are new or in the early stages of development or deployment.

In order to understand the effectiveness of these initiatives, this thesis study adopts a "following the plastic" approach through the new circular economy pathway

currently in place. By interviewing the relevant stakeholders at each stage of the circular economy system, overall, this study found that while Taiwan's action on marine debris has been responsive to civil society lobbying and includes extensive policies to mitigate and prevent ALDFG from initially entering marine environments, a lack of market linkages and incentives has prevented Taiwan from achieving a full circular economy. The buy-back program in place currently lacks market links with recycling companies to incentivize work with ALDFG. Currently, the monetary disincentives for recycling companies to work with ALDFG has created bottlenecks in the movement of ALDFG through the circular economy system, namely in the costly, labor-intensive sorting and cleaning phases. Additionally, loopholes in marketing regulations have allowed businesses to publicly report inaccurate levels of recycled content in their products. The higher price for businesses to utilize recycled materials coupled with these marketing loopholes has resulted in an overall lower demand for recycled raw materials. This has created further disincentives for recycling companies, whom businesses directly purchase recycled raw materials from, to participate in circular economy development.

Chapter 2. Literature Review

2.1. The Creation of ALDFG: How and why fishing gear is abandoned, lost, or discarded

First, it is useful to understand how and why fishing gear is abandoned, lost, or discarded because while countries negatively affected by ALDFG have developed policies and programs tailored to their own unique political, social, and environmental contexts, the methods in which gear is abandoned, lost, or discarded are relatively universal. This chapter breaks down how fishing gear is abandoned, lost, and discarded, and discusses the complications in preventing and mitigating against these causes.

In general, overcrowded fisheries, excess fishing capacity, and illegal, unreported, and unregulated (IUU) fishing are the three main overarching reasons fishing gear may become abandoned, lost, or discarded (Greenpeace Germany, 2019). Most case studies on ALDFG cite specific factors that occur as a result of these overarching issues and can be broken down into two categories: 1) intentional abandonment, and 2) discard and accidental loss. Most intentionally abandoned or discarded fishing gear is related to illegal fishing activities; but some case studies point to fishermen leaving gear at sea due to limited boat space or to avoid paying recycling fees onshore (Macfadyen et al., 2009). In these instances, it appears education around the environmental consequences of abandoned or discarded gear is low (Hong et al., 2018). Moreover, fishing gear is also accidentally lost due to severe weather events breaking or moving gear; gear snagging on underwater rocks, corals, or other objects; towed gear conflicting with static gear in crowded fisheries; and general gear breakage and malfunction which may or may not be due to poor gear maintenance and/or degradation (Drinkwin, 2017; Ellen MacArthur Foundation, 2020; European Union, 2020; Jambeck et al., 2015; Macfadyen et al., 2009).

In preventing ALDFG, there are some universally experienced difficulties regarding the monitoring and enforcement of policies and regulations. First, due to the illicit nature of IUU fishing, perpetrators easily evade penalties by seeking refuge in international waters (Stefanus & Vervaele, 2021; Tai et al., 2020). Additionally, while the monitoring of territorial waters is usually done by the Coast Guard, it is difficult,

especially for countries with large coastlines, to effectively monitor and enforce rules and regulations along the entire coastline 24/7 (Macfadyen et al., 2009).

Second, as gear is often accidentally lost rather than intentionally abandoned or discarded, many of the best practice solutions which are promoted by large NGOs have been remedial and can at best, only partially mitigate against ALDFG (Macfadyen et al., 2009). While some prevention measures exist, to date, no measures have been absolutely fool-proof. Additionally, some policies have been critiqued for targeting those fishermen who already follow the rules, rather than addressing those taking part in, for example, IUU fishing (Macfadyen et al., 2009). Gear marking for example, is an inexpensive and easily enforceable policy that ensures fishermen take responsibility for their own gear. However, those who abide by gear marking rules tend to be those who already properly report lost gear, rendering the overall effectiveness of this policy to correct irresponsible behavior low.

2.2. Why Taiwan?

Taiwan is an ideal case to study ALDFG because it is home to one of the largest fishing industries in the world with an annual worth of 60 billion NT (\$1.95 billion USD) and is the third largest producer of tuna globally. Moreover, Taiwan has a unique history in government responsiveness to civil society lobbying on environmental protection. While the call to establish a circular economy is the most recent of public requests of the government, their success in creating legislative change to address previous environmental issues provides momentum for circular economy development for marine debris. Efforts to specifically address ALDFG into a circular economy has gained significant bottom-up traction from citizens and NGOs as knowledge around marine protection grows (Hung et al., 2022). So far, Taiwan's progress in developing a circular economy has been well-noted within the literature (Young, 2009; Wu et al., 2021; Chang et al., 2019), and in particular, efforts to include ALDFG and other marine debris is on the rise (Chen et al., 2018; Walther et al., 2021). This section will discuss Taiwan's unique bottom-up mobilization in lobbying for the development of a circular economy for marine debris and ALDFG. Additionally, this section will also outline the new policies and regulations Taiwan has implemented so far in response to public requests.

2.2.1. Pollution Protests

The history of environmental social movements took root in the 1950s after World War II when Taiwan's government, which was led by the Kuomintang 國民黨 (KMT) pursued rapid industrialization and economic growth (Ho, 2010; Hsiao, 1999). Through the 1950s, a number of new industries developed, including fisheries within the agricultural industry. The KMT's political popularity was challenged, however, in their ignorance towards social and environmental concerns raised by the public (Ho, 2010). Taiwan's rapid urbanization left many industries without proper policies, regulations, and safety protocol (Ho, 2010). Protests started to surface in the 1970s with the "Pollution Protests" being one of the first movements to gain a widespread following. Come election time in 1980s, the KMT were replaced by the Democratic Progressive Party 民主進步黨 (DPP). The DPP, a more left-wing party, were sympathetic to and in support of the social and environmental movements and gained popularity by pressuring the KMT to respond to public requests for greater environmental policies, regulations, and safety protocols (Hsiao, 1999; Ho, 2010; Tong 2005).

The responsiveness of the DPP stimulated further public protests, especially on the topic of environmental degradation. Additionally, the DPP's removal of martial law in 1987 reinstated free speech, resulting in the number of protests and active NGOs increasing in the following years (Ho, 2010; Hsiao, 1999). The sheer number of laws passed in the late 70s to early 2000s, including monumental developments such as the Environmental Protection Act [1979], Environmental Impact Assessment Act [1994], and the Environmental Basic Protection Law [2002], demonstrated the rapidly changing attitudes and priorities towards environmental care by both civil society and government (Hsiao, 1999). Strong social movements rejecting the development of nuclear power led to a referendum on the fourth nuclear power plant in 1995, and notably in the case of plastics, the growing concern surrounding plastic pollution prompted rigorous efforts to ban certain plastic items and to integrate proper plastic recycling into everyday life (Hsiao, 1999; Walther et al., 2021). The upsurge in policies, regulations, and recycling programs surrounding plastic came into effect in the early 2000s, reflecting the changing values and concerns surrounding plastics at this time (Walther et al., 2021).

Protests within the fishing industry also gained traction during this time. During the rapid industrialization and economic growth period of the 1950s, Taiwan used loans from the Taiwanese government, the United States, the World Bank, and the Asian Development Bank to expand coastal water fishing to distant water fishing, making remarkable progress in fishery development within a short time period of 15 years (Huang & Chuang, 2010). However, like other industries at the time, by the 1970s and 80s the lack of regulations and the pace of development and economic growth resulted in declining fish stocks. In alignment with the growth of environmental protection in the 1980s and 90s, the 1990s show the earliest enforcement of regulations on catch sizes, vessels, and gear to combat the declining fish stocks. For example, standards and regulations on fishing vessels were established in 1991, and driftnet fisheries were banned in 1992 (Huang & Chuang, 2010). However, it wasn't until recently that priorities in fishery management expanded from strictly maintaining sustainable fish stocks to focusing on overall marine health, conservation, and protection.

2.2.2. The Influence of Civil Society

This shift in focus in fishery management from maintaining fish stocks to overall marine conservation and protection can be traced back to the growing concerns voiced by NGOs, scuba divers, and other members of civil society. The media, who has historically played an instrumental role in mobilizing individuals and groups within civil society, has begun drawing attention to marine debris and plastic waste issues, as can be seen by the increasing number of news articles focusing on Taiwan's plastic filled coastlines (Sui, 2021). In response to this, activities such as beach clean ups have grown in interest, with NGOs, like ReThink Taiwan and Greenpeace, as well as corporate social responsibility branches of businesses organizing beach clean-up activities and publicly reporting their volumes of collected marine debris. The scuba diving community has also been vocal in their concerns over marine health, citing the first-hand impacts they see underwater from marine debris, and in particular, ALDFG.

To date, the Taiwanese government has been responsive to the call for greater levels of marine protection. Gear marking, a tactic emphasized by the United Nations Food and Agriculture Organization (UNFAO) as one of the most effective and cheapest methods to reduce ALDFG, was implemented in 2020. The "Plan for the Marking of Fishing Gillnets" had a soft start in January 2021, with enforcement of fines up to

NT\$150,000 (US \$3000) for those caught fishing without marked gear in June 2021 (Tseng & Kao, 2022). In addition to this, two municipalities with larger fishing ports, Keelung and Penghu, have created a subsidy program for fishermen to change from vessels that use gillnets, a problematic gear type that is banned in many countries, to nets that do not snag as easily on rocks and corals. This program has been successful, with the number of boats using gillnets in Keelung dropping in approximately a year from 131 to 22, with only 10 in active use (Sui, 2021). A new trial buy-back program is also currently underway, with the aim to create a widespread gear retrieval system that not only prevents the creation of ALDFG, but also works to clean up the ALDFG caught as bycatch by fishermen.

Additionally, new policies have also been implemented to govern the overall maintenance of marine health. While the Salute to the Seas policy, implemented in 2020, governs the maintenance of above water marine conditions (eg. Beaches and coastlines), the Open Policy for the Ocean policy, which was also implemented in 2020, governs the maintenance of underwater marine conditions. Additionally, the latter policy was implemented by the Ocean Conservation Administration (OCA), a new government body established in 2018 focused solely on marine conservation and protection. These policies, as well as the creation of the OCA, will be further elaborated on in Chapter 4. Finally, in recent years, some small-scale circular economy pathways have also successfully been implemented for specific fishing gear types. In Chiayi County, the local government has successfully implemented a recycling initiative for oyster ropes. After retrieval and payment to fishermen of 15NT (\$0.49 USD) per kilogram, the local government has partnered with Formosa Chemicals and Fiber Corporation to process these oyster ropes back raw pellets for subsequent use in threads and fabrics for clothing and other textile products (Formosa News, 2023; Kuo, 2018).

This history and progress so far demonstrates the unique position civil society plays in lobbying for and expediting environmental policy change in Taiwan. Government responsiveness to civil society's growing concern and advocacy for greater marine protection and action on marine debris and ALDFG follows a similar trajectory of past social movements. This suggests that while Taiwan may be in the early stages of developing new policies and regulations to aid marine protection and conservation, it's likely bottom-up advocacy will help to drive more resources and political will towards the successful development of a circular economy for marine debris.

2.3. Global Directives for Marine Debris and Circular Economy Development

2.3.1. International Initiatives

The development of a circular economy for marine debris in Taiwan emerged within the context of an international push to raise marine protection standards globally, while still balancing environmental and economic sustainability. International attempts at creating global marine protection and conservation standards have historically failed due to the differing social, environmental, and economic priorities between countries, and regional or country specific initiatives have generally been ad-hoc. Amongst various published guidelines focused more broadly on marine litter as a whole, the United Nations Environment Programme (UNEP) and UNFAO published the Guidelines on Abandoned, Lost, or Otherwise Discarded Fishing Gear, which discusses causes, prevention, mitigation, and clean-up methods to address fishing gear waste (Macfadyen et al., 2009; UNEP, 2009). Large NGOs with considerable expertise in ocean plastic related issues, such as the Global Ghost Gear Initiative, Greenpeace, and the Ellen MacArthur Foundation, have also identified ALDFG as one of the biggest threats to marine health and have since published guiding documents and other resources to help countries manage marine debris issues as it relates to ALDFG (Drinkwin, 2017; Greenpeace Germany, 2019; Greenpeace, 2019; Ellen MacArthur Foundation, 2020). However, despite these efforts, some common limitations exists across countries in protecting and conserving marine environments and developing circular economies for marine debris. This section explores how marine debris has historically been addressed on an international scale, elaborates on how other countries and regions have attempted to combat marine debris and ALDFG, and expands on limitations currently being experienced globally.

Internationally, similar to the timeline surrounding marine conservation and protection discussions, interest in circular economies began in the 1950s and only explicitly became part of policy papers in the 1990s (Winans et al., 2017; Chen, 2015). Multiple international, transnational, and regional agreements have been made since, with the focus and aim of each evolving over the years in attempts to secure higher levels of protection for the sea, and cooperation and coordination between states. The

first United Nations Conference on the Law of the Sea was held in Geneva in 1958. Attended by 86 states, this conference considered all the “technical, economic, and political” aspects of the sea (Treves, 2008). While conservation itself was not the overarching aim of the convention, it did produce environmental measures as a step within, for example, fisheries and resource management. This was later replaced in 1994 with the United Nations Convention on the Law of the Sea (UNCLOS) (Chen, 2015). UNCLOS uniquely includes dedicated articles for marine conservation and preservation. Although it lacks explicit mention of “marine litter”, these articles put limitations and penalties on the “dumping” of waste at sea, providing a backbone for the governing of marine waste as a whole (Chen, 2015; United Nations Convention on the Law of the Sea, 1994).

The number of instrumental international agreements have continued to grow or undergo modifications within the last decade. Annex V of The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) from the International Maritime Organization, came into effect in 2013 after revisions in 2011. This convention directly addresses marine pollution from ships, banning the discharge of garbage at sea and outlining the areas of where the bans are in effect (Chen, 2015; MARPOL, 1978). Additionally, the London Protocol, which governs dumping at sea also underwent modifications in 2006 (International Maritime Organization, 2019). The United Nations High Seas Treaty, which has been in negotiations for over a decade, is the most recent attempt at securing higher levels of international protection and conservation for the sea. On March 3, 2023, states reached an agreement on legally binding measures to protect 30% of the world’s oceans by 2030 (Stallard, 2023). While the official Treaty has yet to be published, member states at the United Nations Environment Assembly in 2022 agreed that an end to plastic pollution by 2024 should be included as a primary aim (Sea Circular, 2023). Presently, the Treaty still requires ratification in each participating country, and while the text still contains flaws and limitations, as pointed out by Greenpeace (Greenpeace International, 2023), it is still the most comprehensive and ambitious Treaty agreed on and signed onto by countries since UNCLOS in 1982 (Stallard, 2023). At present, the text is still undergoing technical edits and translations (United Nations Press, 2023).

These treaties and agreements demonstrate the shifting values and priorities surrounding ocean conservation and marine debris. While this focus is not directly

related to circular economy development for marine debris, it does demonstrate the international efforts to curb marine pollution and the identification of plastics as a significant threat to marine health. Additionally, these longstanding historical efforts are often referenced in discussions when developing circular economy systems for marine debris to justify and advocate for the long overdue aggressive actions needed against marine debris, particularly for the case of plastics.

2.3.2. National and Regional Initiatives

Several countries in addition to Taiwan have also begun to address marine debris, and in particular ALDFG, nationally by adopting suggestions from the UNFAO. For example, gear marking policies are in place in countries such as Canada, the United Kingdom, and Australia (MacFadyen et al., 2009), and onshore collection programs for old and/or retrieved gear, or similar fishing-for-litter schemes, are in effect in countries such as Greece, the Netherlands, the UK, Greenland, Ireland, Norway, and Scotland (Macfadyen et al., 2009; Charter, 2017; Deshpande et al., 2020). Korea's "National Integrated Management Strategy for Marine Litter" takes measures to prevent, mitigate, and clean-up marine debris with initiatives such as buy-back programs, underwater and shoreline clean-up operations, and recycling or disposal pathways for used or collected materials. So far, these efforts have become a commonly cited case study to demonstrate the opportunities and limitations with different marine debris prevention and mitigation schemes (Macfadyen et al., 2009; Chen, 2015; Hong et al., 2018). Additionally, the European Union, which has the world's highest recycling rate, has made the most significant progress in not only addressing marine debris, but in developing a full circular economy system, particularly for ALDFG. ALDFG was officially included in the European Union's circular economy by 2050 plans in 2018 (European Union, 2018; European Union, 2020 May). Since then, new measures to facilitate ALDFG through recovery and reuse have come into effect. This includes for example, removing fees and other financial barriers to fishermen to encourage recycling, implementing changes in port reception facilities to enable easier collection and recycling of ALDFG, subsidizing businesses who source sustainable materials, and implementing Extended Producer Responsibility (EPR) schemes for fishing gear (to be fully implemented in 2024) to hold producers responsible for the entire lifecycle of their products (European Union, 2018; European Union, 2020; European Union, 2020 May). Further, in 2020, the European Commission released a report analyzing ALDFG's

potential for circularity to guide research and development funding and policy modifications (European Union, 2020).

While Korea and the European Union have taken the most coordinated approaches to circular economy development for marine debris and ALDFG, limitations still exist. Further, many countries remain lacking wider plans for circularity and implement policies on an ad-hoc basis. For example, in some cases like in United Kingdom, gear marking is enforced for a narrower focus, such as for “reduc[ing] navigational risk of static gear to vessel operators” (Macfadyen et al., 2009). Further, in the case of Greece, fishing-for-litter is only voluntary, limiting the effectiveness of addressing marine debris issues at the source (Macfadyen et al., 2009). Korea’s approach, while noted by scholars generally as a successful case study, has still been criticized for their limited efforts in creating behavioural change in fishermen through education on marine debris issues (Wyles et al, 2019). Scholars have voiced concerns over leaving monetary compensation as the sole motivation to act on marine debris issues, as it jeopardizes the stability of the program if funding for compensation declines (Cho, 2009; Morishige, 2010; Jang et al., 2014).

2.3.3. Common Limitations Globally

While the local contexts of countries and regions play a role in how marine debris issues are addressed, there are some common limitations countries face in the literature. These limitations can be broken down into two categories: 1) technical and economic barriers and 2) governance and institutional barriers.

First, technical and economic barriers generally refer to difficulties in acquiring equipment and technology to retrieve, sort, clean, and recycle marine debris and ALDFG at a marketable scale. Once ALDFG has been retrieved, it must be sorted by material type and cleaned of any contaminants (eg. Salt water, barnacles, algae, and etc.) to avoid lowering the quality of reprocessed materials (Juan et al., 2021 & Weißbach et al., 2022). These are the most laborious steps within a circular economy system and are often completed manually. Further, once retrieval, sorting, and cleaning is completed, complications often occur in the process of recycling of marine debris and ALDFG. Nylon is the most valuable plastic making up fishing nets, lines, and other gear types due to its durability and strength (Juan et al., 2021; Weißbach et al., 2022; Ospar Commission,

2020). While some types of fishing gear are made completely of nylon (eg. Nets), it is not uncommon for fishing gear to be made up of a mixture of materials to optimize qualities such as durability and strength. Come end of life, these materials must be chemically separated from one another for proper recycling. Additionally, salt water, abrasive underwater environments, and sun exposure can also degrade plastics over time, limiting recycling prospects. Technologically speaking, although studies have shown that effective technologies and systems exist, the coordination and implementation of these technologies remain the biggest barrier to progress (Ospar Commission, 2020). Chemical recycling methods, which are more efficient and scalable in processing ALDFG, have been preferred in recent years. However, due to the cost of this relatively new technology, most recycling companies only have capacity to recycle ALDFG using more costly and inefficient physical methods (Ospar Commission, 2020). Victor Martinez, a materials scientist currently working on creating resin for 3D printing with ALDFG using physical methods, described his frustrations with clogged machines, detailing how “cut up fishing nets are small, lightweight, and pointy.” According to Martinez, static electricity makes these pieces stick to walls and other hard-to-reach places of machinery, resulting in many maintenance halts during production and overall limiting production capacity (V. Martinez, personal communication, December 10, 2021). While better machines and technologies exist, Martinez cited cost and the coordination of deploying these technologies as the most significant barriers to setting up these technologies at marketable scales (V. Martinez, personal communication, December 10, 2021).

Second, governance and institutional barriers are usually concerned with the complications in creating systems that encourage stakeholders such as fishermen, recycling companies, and businesses to participate circular economy development for marine debris. Many countries domestically lack the social, economic, or political mechanisms that facilitate the movement of ALDFG and other marine debris materials through a circular economy system. Policies, regulations, and other initiatives that would facilitate movement include, for example, providing government subsidies for public educational initiatives on marine debris, providing funding for recycling technology research and development, creating penalty and reward schemes to incentivize recycling, subsidizing the use of recycled materials for businesses, and installing EPR schemes to hold producers accountable for end-of-life costs and management (Ospar

Commission, 2020; European Union, 2020). Most recently, Environmental Social Governance (ESG) policies, which would require companies to have measurable data as proof of their eco initiatives, have gained interest internationally (McGarry et al., 2022). As it relates to ALDFG, ESG policies could, for example, apply lower import or export fees for products made with recycled materials. However, ESG concepts are still relatively new, and many countries are still working on integrating these concepts into government policies.

Finally, on an international scale, although the new United Nations High Seas Treaty agreed on this year has been monumental in scope, its effectiveness and enforceability in practice is still unknown. Historically, enforcement of agreements and Treaties have been limited. As it relates to ALDFG, there is considerable tension surrounding drift waste, where marine debris from one country drifts into the borders of another country for management and end-of-life solutions, and IUU fishing. Seeing as the origin of drift waste and the culprits of IUU fishing is often unknown, penalties outlined within international Treaties and agreements have overall done little to effectively address these issues.

Chapter 3. Research Design and Methods

Initially, this study aimed to interview fishermen, government workers, NGOs, and academics in order to explore the drivers and barriers in reducing ALDFG from entering the ocean in Taiwan. However, it became clear on arrival after an interview with a government official, that due to policy and regulation development in Taiwan during the pandemic, it would be more valuable to instead adopt a “follow the plastic” approach and explore the effectiveness of the initiatives they had implemented instead. Using the pathway of retrieval, sorting, cleaning, recycling, and reuse described by a government official, this study mapped out the route ALDFG would ideally take in a circular economy and interviewed relevant stakeholders within each step of this circular economy route.

Originally, this field work was scheduled to take place in the summer of 2020. However, due to COVID-19 border restrictions, field work for this study was postponed and took place instead between October 13 and December 20, 2022. The timeline for this fieldwork, while initially proposed to take place over three to four months, was limited to ten weeks due to time constraints. In general, time in Taiwan was split between Keelung, the location of one of Taiwan’s largest fishing ports, and Taipei, where many NGOs and government offices are headquartered.

In total, 13 semi-structured interviews were conducted with academics, government officials, NGOs, dive shops, media, and recycling companies active in the ocean conservation community. Apart from two interviews held remotely in the earlier months of the COVID-19 pandemic, all interviews took place in Taiwan. Further, as data collection drew to a close, two follow-up interviews were conducted with academics and government officials. Each interview was 45 to 60 minutes long.

Additionally, in order to learn of the on-the-ground cultures attitudes and priorities within civil society on marine debris issues, a concerted effort was made to attend NGO and community organized beach clean-ups, dive clean-ups, and other educational events. Unfortunately, an uncharacteristically late typhoon season in October and November of 2022 resulted in the cancellation of almost all outdoor clean-ups and events. Locals noted that typhoon season had become increasingly variable in recent years, with 2021 having missed it entirely. However, in total, attendance was made to five events and exhibitions. Two of the events were public fairs showcasing ocean

conservation lectures amongst booths run by NGOs working on ocean related issues and businesses working on creating products with recycled ocean plastics. One day was spent with an academic visiting fishing ports in Keelung to learn about port reception facilities and to see sorting and cleaning stations. A visit to Keelung's new Ocean Museum Exhibition, which focuses on ocean conservation, protection, and research, was also made on this day. Finally, invitations were received to attend two private events. The first event was a day-long meeting hosted by the Environmental Protection Administration (EPA), where representatives from each city and/or county receive directions from the EPA on sustainability goals and priorities for the coming year. The second event was a half day-long visit to Taiwan's Meteorological Bureau, in which I attended alongside a class of master's students completing an Environment/Business degree. Informal conversations with civil society employees and NGOs from these events and exhibitions are present in this study.

As the year drew to a close, time for interview participants became limited. While many individuals expressed interest in participating in an interview, some participants were only able to provide information via email correspondence. Some data collected from email correspondence is also present in this study.

3.1. Interview Development

Semi-structured interviews were chosen as the best method of data collection for their ability to allow for open ended questions and responses. Interview participants were encouraged to bring up anything they felt was of relevance at any point in the interview, and as the research progressed, interview questions changed slightly to gain deeper insight into commonly voiced concerns being raised by interview participants.

Overall, interview questions covered four main topics: awareness around ALDFG, opinions on current and prospective policies and regulations regarding ALDFG, perceived barriers to further progress in policies and regulations, and perceived opportunities and barriers in directing ALDFG into a circular economy.

Awareness of ALDFG aimed to understand at what point ALDFG became a concern for that individual, as well as how and why it became a concern. This section

also worked to gauge the individual's level of awareness on marine debris issues, as well as learn how ALDFG ranks in priority amongst other daily and/or moral concerns.

Opinions on current and prospective policies and regulations regarding ALDFG worked to learn how effective and exhaustive government mandated policies and regulations seemed to the participant. This section also asked about perceived relationships between different stakeholders (eg. Government, NGOs, fishermen).

Perceived barriers to further progress in policies and regulations questions worked to identify who or what the participant felt was the biggest barrier to progress. Participants were encouraged to both elaborate on and think beyond stakeholders and consider potential obstacles, such as data collection, funding, institutional organization, and etc.

Finally, perceived opportunities and barriers in directing ALDFG into a circular economy aimed to understand how well interview participants understood the circular economy supply chain for marine debris and ALDFG. Participants were asked to describe their understanding of how marine debris moved through a circular economy and were asked to describe who they thought was responsible for each step of the system. Additionally, this section aimed to gauge market readiness for ALDFG in a circular economy.

3.2. Sampling Methodology

Recruitment initially began through a combination of personal contacts and cold emailing/calling. After initial contact was made, snowball sampling was then used to expand this study's reach within Taiwan's ocean conservation network. All interview participants received a summary of this research project and a consent form via email or LINE, a commonly used phone messaging application in Taiwan. Informed consent to participate was granted by all participants and all interviews were audio recorded. This research was conducted in English and/or Mandarin depending on the participant's preference. For interviews completely in Mandarin, a translator was present to prevent any communication errors.

Whilst the initial intention was to continue interviews until no new responses from interview participants were recorded for each stage in the circular economy system (in

which this study would have reached saturation), COVID-19 border restrictions limited the available time in Taiwan to conduct interviews. While this study was unable to reach saturation, it did attempt to interview at least one stakeholder along each stage of the circular economy system in place. Most notably, although this study was able to interview government workers, academics, dive community members, and NGOs that work closely with fishermen, fishermen themselves could not be interviewed within the allotted timeframe. Although this study can extrapolate the perspective of fishermen through the attitudes and values described by government workers, academics, dive community members, and NGOs, it is important to note that the perspectives and positionality of these individuals may result in a divergence between how fishermen are perceived to feel versus how they actually feel. This means that while fishermen perspectives can be inferred, they cannot be taken as fact.

All interview participants will remain anonymous for the purpose of this study; however, a break-down is provided below with the general characteristics of those interviewed. Within this break-down, each interview participant has been assigned a number (eg. Interview Participant 1). These numbers will be used to refer to participants throughout this thesis. A number and a description has also been provided for the events and exhibitions attended, as well as for data collected via email correspondence and informal conversations. These numbers will also be used to refer to these experiences throughout the thesis.

Table 1. List of interview participants, events, informal conversations, and emails

Assigned Number	General Characteristics
Interview Participant 1	Materials Scientist, Academic
Interview Participant 2	Reporter
Interview Participant 3	Academic and Government Official at the Ocean Conservation Administration
Interview Participant 4	Academic, NGO, Consultant

Interview Participant 5	Academic and Government Official at the Environmental Protection Administration
Interview Participant 6	NGO
Interview Participant 7	Academic, Researcher
Interview Participant 8	Diver
Interview Participant 9	Government Worker at the Fisheries Agency
Interview Participant 10	Recycling Company
Interview Participant 11	Government Worker at the Ocean Affairs Council
Interview Participant 12	Government Worker at the Ocean Affairs Council
Interview Participant 13	Government Worker at the Ocean Affairs Council
Event 1	A meeting where city or county representatives meet to get directions from the EPA on sustainability goals and priorities for the coming year.
Event 2	Port Visits in Keelung and Keelung Ocean Museum Exhibition
Event 3	Presentation at Taiwan's Meteorological Bureau
Event 4	Public Ocean Conservation Fair

Event 5	Public Environmental Protection Fair
Email Correspondence #1	Government Worker at the Ocean Affairs Council
Email Correspondence #2	Recycling Company
Email Correspondence #3	Recycling Company
Informal Conversation #1	Government Worker at the Environmental Protection Administration
Informal Conversation #2	Taiwanese Seafood Company Worker
Informal Conversation #3	Three general workers at Keelung's fishing port

Chapter 4. Stakeholder Mapping

A number of stakeholders are involved in the process in developing a circular economy for marine debris in Taiwan, and as mentioned before, Taiwan is unique in that government bodies are generally responsive to the lobbying efforts of NGOs, dive community members, and other members from civil society. Given that previous studies have shown that communication and coordinated action between different stakeholders in society is an asset that generally results in better long-term action on marine debris, the current status of communication and responsiveness between stakeholders in Taiwan is promising (Kandziora et al., 2019). This chapter outlines the participating parties in policy and regulation development and provides a brief description of other stakeholders involved in the circular economy system once implemented.

4.1. Government Bodies Responsible for Policy Making

Three main government bodies are responsible for developing marine related policies and regulations: the Fisheries Agency (FA), the Environmental Protection Administration (EPA), the Ocean Affairs Council (OAC) and its associated Ocean Conservation Administration (OCA). Each of these bodies, though aligned in their overarching aim to provide marine protection and conservation, have differing scopes and mandates, which differentiate them in their priorities.

First, the FA is the longest standing institution established specifically for the fishing industry. As an agency under the Council of Agriculture, which broadly works to promote all forms of agriculture in Taiwan, the FA's mandate is more specific and works to promote and regulate the fishing industry to ensure long-term economic growth. In terms of environmental sustainability, the FA focuses solely on prioritizing policies and regulations that protect marine environments as they relate to the maintenance of healthy fish stocks. This includes specifying, for example, total allowable catches, allowable fishing methods for certain species, and mandatory fisheries maintenance requirements. In order to implement their policies and regulations at each fishing port in Taiwan, the FA works alongside local city governments, providing funding for the implementation of policies and regulations. Additionally, given that ports in each city or county differ slightly in their catch (eg. Cities in Southern Taiwan heavily rely

economically on oyster production, while other fishing ports which catch a greater number of fish species have a more diversified income), the FA also works alongside local city governments to develop city or country specific plans to ensure the implementation of policies and regulations are relevant and sustainable.

Unlike the FA, the EPA is a government body whose mandate is much broader in scope and works to regulate and manage any environmental issues that relate to clean air, water, and energy. In addressing water-related issues, following the publication of the National Ocean Policy White Paper in 2020 by Executive Yuan, Taiwan's highest level of government, the EPA became responsible in leading a four-year ocean cleaning project where they would be held responsible in ensuring all central and local government sectors create measurable strategies to track their ocean cleaning initiatives (Ocean Affairs Council, 2020a). In addressing this request, the EPA has since created a new policy called *Salute to the Seas*. This policy was implemented in 2020, and in addition to promoting ocean research and education, dedicates the EPA to coordinating the cleaning and maintenance of "every inch of shoreline" in Taiwan with local city governments and other agencies (Executive Yuan, 2022).

Finally, given the abundance of marine resources in Taiwan, the OAC was founded in 2018 to focus solely on ocean affairs and policies that contribute to marine development for marine related business in Taiwan (Ocean Affairs Council, 2020b). Unlike the FA, this scope is not limited to fishing related business and can include other business ventures related to, for example, tourism. Under the OAC is the OCA, a branch which solely focuses on developing "solutions" to balance the protection and conservation of oceans with development for business purposes. The National Ocean Policy White Paper also prompted significant policy development by the OCA, who has since developed the *Open Policy for the Ocean*. A government official described how while this policy is similar to the EPA's *Salute to the Seas* policy, it differs in that rather than focusing on shorelines and beaches, the *Open Policy for the Ocean* focuses exclusively on cleaning and maintaining underwater habitats (Interview Participant 3). A government official explained that:

The EPA is responsible for above the water, the OCA is responsible for below the water. (Interview Participant 3)

In considering marine health and business development, the OCA has since pursued a circular economy for marine debris as a possible economic and environmentally sustainable solution. To begin developing their circular economy system, the OCA initiated a four-year long trial ALDFG buy-back program in efforts to begin establishing a circular economy pathway for ALDFG and other marine debris (this will be further explained in Chapter 5). Additionally, other initiatives by the OCA that fall under this policy include, for example, funding for community or business led marine conservation projects. A dive community member described how they had a friend successfully obtain funding from the OCA to pursue an ocean clean-up project, saying that:

The OCA is funding a wide variety of projects to help find new solutions to ocean waste. They are open-minded. All you need to do is apply. (Interview Participant 6)

4.2. The Role of NGOs, Academics, and the Diving Community in Policy Making

To include NGOs, academics, dive community members, and other relevant stakeholders in society in policy making for marine debris and circular economy development, the EPA and OCA have begun to co-chair quarterly general meetings to openly discuss marine-related issues. Through these meetings, dialogue concerning current and future policies and regulations between various stakeholders and government officials is moderated, encouraged, and exchanged. While these quarterly meetings are invite-only, it was confirmed by government workers, NGOs, and academics that obtaining an invitation is not difficult, as the purpose of this meeting is to facilitate conversations between stakeholders (Interview Participant 3; Interview Participant 6; Interview Participant 7).

It is easy to get involved. I can easily refer my friends working at NGOs to come as long as they are working on ocean-related issues. (Interview Participant 6)

A dive community member also confirmed the inclusiveness of these meetings, saying that:

Yes, I've attended them before. They are working hard to coordinate all 300+ dive clubs at these meetings. (Interview Participant 8)

According to a government official from the OCA, these meetings have grown considerably since they began (Interview Participant 3). An NGO who attends these meetings also confirmed that they have seen more and more NGOs attending as word has spread about these meetings (Interview Participant 6).

Outside of these meetings, government officials also often work with academics in developing policies and regulations. One academic mentioned how their colleagues who are well-known in ocean-related research are often contacted by government officials to help provide scientific backgrounds to policy or regulation developments (Interview Participant 7). Government workers overall agreed that academics are needed in policy and regulation development to ensure there is strong scientific reasoning in decision-making (Interview Participant 3; Interview Participant 9; Interview Participant 11, Interview Participant 12; Interview Participant 13). However, one individual from the diving community, though in agreement that policies and regulations need scientific backing, expressed concerns that since many academics rely on government funding for their research, the government may unfairly influence the outcome of research findings to push for certain sustainability narratives (Interview Participant 8). For example, Interview Participant 8 described how previously a public vote to keep an abandoned power plant dormant was overturned by the government.

If the government wants to do something, they'll recruit the people they want to recruit who will support their ultimate plans. Any public consultation and hearings are for show because at this point, any opinions against the idea will only have results if it fits in good timing with elections. (Interview Participant 8)

However, despite these concerns, Interview Participant 8 was somewhat optimistic for ocean-related issues, describing how since the OCA is relatively new, they have been very receptive to ideas and suggestions. In addition to working with researchers and academics, Interview Participant 8 also cited previous successes the diving community has had in pushing for policies that deploy more eco-friendly nets in high-traffic fishing ports. Government officials and the media have both referred to the diving community as "stewards of underwater habitats" and in general, take their concerns on marine health seriously (Interview Participant 2; Interview Participant 3).

4.3. The Role of Fishermen in Policy Making

A significant stakeholder missing from the general meetings mentioned above are fishermen. However, government officials explained that they are omitted from these meetings because they have other methods of voicing concerns to government bodies. Since the population of fishermen is quite large and concerns voiced by fishermen are often specific to their fishing ports or personal situations, concerns from fishermen are instead directed to their local Fisherman's Association, which are subsequently channeled to the FA (Interview Participant 3; Interview Participant 9). The Fishermen's Association, though funded and governed under the Council of Agriculture like the FA, works to safeguard the rights and interest of fishermen and improve fishermen livelihoods (Council of Agriculture, 2021). Each Fishermen's Association is made up of elected directors and supervisors, and in total, 1 central Fishermen's Association and 39 district Fishermen's Associations currently exist. An academic who has worked closely with fishermen in the past confirmed that fishermen do often voice their concerns through their district's Fishermen's Association and overall, find that the responsiveness of government bodies through these methods are sufficient (Interview Participant 7). This academic also noted that fishermen are usually open to working with researchers as needed, as it is understood that participation in research may help translate to better policies and regulations in the future (Interview Participant 7). However, the limited timeframe of this study resulted in the inability to confirm these sentiments with the fishermen themselves.

4.4. Educating Stakeholders and Civil Society

In addition to policy making, there was a strong consensus from government officials, academics, and NGOs that public education on marine debris is necessary for long-term sustainability outcomes because it encourages behavioural changes in society. One NGO mentioned how the number of marine conservation-oriented NGOs has blossomed in recent years, with many focusing on educating certain demographics within society (Interview Participant 6). For example, some NGOs focus specifically on educating primary school students, while others focus on educating businesses. At the two public environmental protection fairs attended, the majority of booths were hosted by NGOs working on marine debris education initiatives (Event 4; Event 5). Both of these

events also had free seminars on marine debris, which attracted anywhere from 15-30 listeners at a time (Event 4; Event 5). However, in general, the reporters, academics, and dive community members interviewed said that while the general public is interested in marine debris issues, there is limited action unless the issues being discussed directly impact their daily convenience or lives financially (Interview Participant 2; Interview Participant 6; Interview Participant 7). For example, a dive community member and a reporter both mentioned that the likelihood for Taiwanese citizens to purchase more eco-friendly products is somewhat low (eg. Items made from recycled ocean plastics). The dive community member said:

It is not like North America here. Everything in Taiwan is cheap, so if the price increases, people will not be willing to buy it. (Interview Participant 6)

The reporter, who has investigated the recycling habits of consumers, plastic waste, and marine debris said many plastic policies have been undermined by locals and businesses over convenience.

People just don't really care unless it impacts their daily life. When they banned plastic shopping bags, bakeries didn't give their customers a paper bag for their buns. Instead, they just wrapped each bun individually in plastic, which means the policy was pointless. Maybe more education and awareness will help, but convenience is still more important for the average person. (Interview Participant 2)

However, overall, there was a consensus that interest in ocean sustainability is growing, especially with the media currently putting a heavy focus on marine debris issues.

Additionally, the government has made significant efforts to educate fishermen on marine debris issues to help them understand sustainability from an environmental, rather than purely economic perspective. While previous studies have shown that fishermen tend to have a positive attitude towards marine sustainability (Chen, 2010), a recent study on the perspectives of fishermen found that while ample educational events and seminars exist for fishermen, attendance remains relatively low (Yang, 2023). Interviews with government officials and academics both confirmed the low attendance rate, but explained that while attendance of fishermen is low, the attendance of fishermen's wives are very high (Interview Participant 3; Interview Participant 7). The government worker explained that:

Fishermen must take on the role of the provider, so instead their wives attend, and the fishermen learn at home after a day's work over the dinner table. (Interview Participant 3)

An academic who has worked with fishermen also said that:

Usually their wives attend and then teach them at home. The wives tend to be more interested in the sustainability events and attend more often than the fishermen. They are also just more likely to listen to their wives than government workers. (Interview Participant 7)

During a port visit, an educational event for marine debris was occurring in one of the Fishermen's Association buildings. A number of fishermen's wives were in attendance and the room had more of a community event feel than a formal sustainability lecture.

The academic further explained that:

The education events aren't just lectures. There's lots of activities too, so I think the wives also like to go to socialize. (Interview Participant 7)

Overall, those who have worked with fishermen agreed that following the implementation of these educational initiatives, the general awareness and understanding of marine debris issues has risen in recent years (Interview Participant 3; Interview Participant 7).

4.5. Market Linkages: Recycling Companies and Businesses

Finally, within a circular economy, recycling companies and businesses interested in using recycled raw materials are key stakeholders in closing the loop. The handbook on marine debris published by the OCA includes a pre-identified list of recycling companies actively accepting marine debris and ALDFG (Ocean Conservation Administration, 2021). Once recycled, businesses interested in using recycled materials may directly contact recycling companies to purchase their reprocessed raw materials. The opportunities and limitations of recycling companies and businesses will be further elaborated on in Chapter 5.

Chapter 5. Following the Plastic

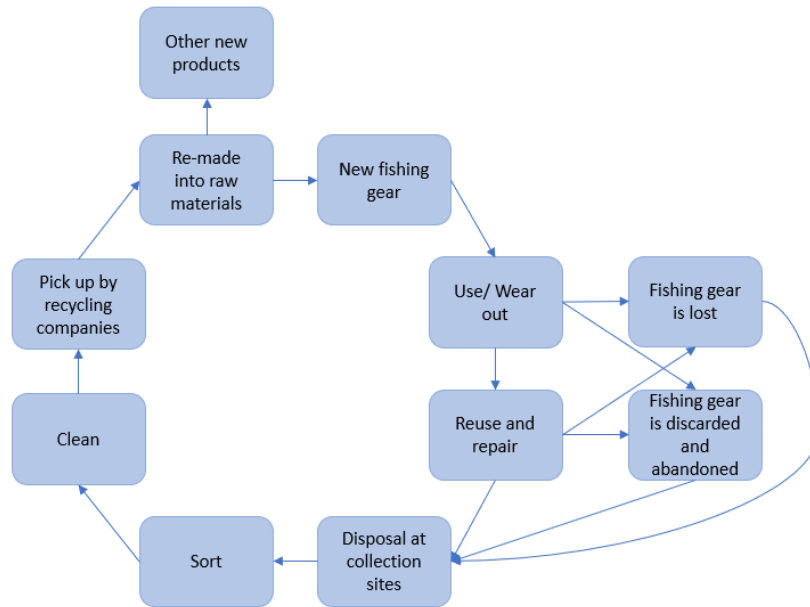


Figure 1. How ALDFG would ideally move through a current circular economy system in Taiwan.

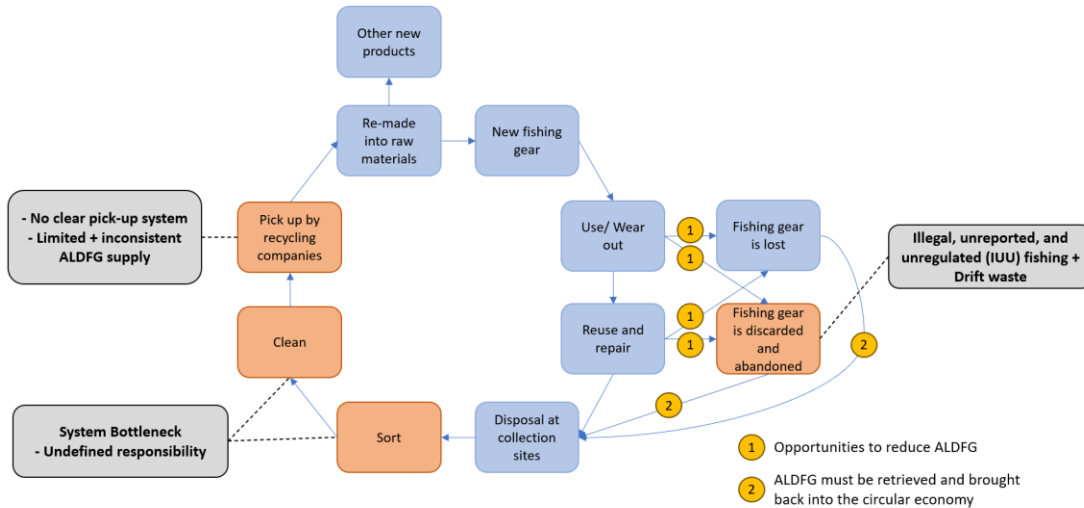


Figure 2. How ALDFG currently moves through the circular economy system in Taiwan.

This chapter aims to “follow the plastic” from its initial purchase and use, through to its reuse in new products as a raw material. Relevant stakeholders, as well as opportunities and barriers will be elaborated on for each stage in the circular economy system. Throughout this section, reference will be made to Figure 1 and Figure 2 above to show discrepancies between an ideal circular economy system and the current status of circular economy development in Taiwan. Additionally, while a variety of different fishing gear types can make up ALDFG (eg. Oyster floats are made of Styrofoam), there has been significant interest from government officials, academics, and recycling companies in focusing on ALDFG made up of nylon due to its high recycling potential and value. This interest in nylon has resulted in a keen interest in developing circular economy pathways particularly for fishing nets, and when interviewing stakeholders, fishing nets were generally the gear type of primary concern. While this research primarily follows the pathway of fishing nets in a circular economy system, other gear types will be discussed as they become relevant. Overall, the circular economy system has been broken down into four sections. First, I will elaborate on where gear is purchased and how it is subsequently retired and/or lost, becoming ALDFG. Next, I will elaborate on the various prevention and mitigation initiatives in place to reduce ALDFG production from its source. The third section will expand on how ALDFG is retrieved, sorted, cleaned, and recycled. Finally, the last section will expand on the opportunities and challenges that currently exist for the reuse of recycled raw materials into new products.

5.1. Purchasing, Use, Retirement, and/or Loss

The trail of plastic begins in mainland China, where almost all fishing nets used by Taiwanese fishermen are produced and imported from. While other fishing net manufactures exist, the manufacturing capacity of China outweighs that of Taiwan and other countries, making gear purchasing from mainland China cost-efficient for fishermen who are wholly responsible for sourcing their own gear (Interview Participant 3; Interview Participant 9). A government worker at the FA said:

Fishermen have to buy all the gear they use themselves. Right now, they buy all their gear from mainland China because it's cheap. (Interview Participant 9)

Currently, no guidelines or regulations on the wholesale import of gear or gear purchasing for fishermen or local suppliers exist to sway purchasing considerations away from pure cost-efficiency (Interview Participant 9).

Once bought and in use, fishing nets are used by fishermen until natural wear and tear renders them unusable or until the gear is lost or otherwise discarded. Fishing nets in Taiwan reach their end-of-life for many of the same reasons as described in Chapter 2. For example, gear conflict, or exposure to the sun, wind, currents, or ocean salinity can degrade gear over time until they must be retired. For gear that has reached its end-of-life, there was a strong consensus amongst both the government workers and academics interviewed that fishermen would not intentionally dispose of their gear at sea, and would instead, bring the gear ashore to properly dispose of or recycle (Interview Participant 3; Interview Participant 7; Interview Participant 9). However, while disposal and recycling stations are available in Taiwan, government workers described how these facilities vary between cities and may or may not be located in-port (Interview Participant 9). Additionally, academics and government workers acknowledged that the proper recycling of gear charges fishermen a small fee, which disincentives them to use these facilities, especially if these facilities are not conveniently located in-port (Interview Participant 7; Interview Participant 9). Although this could potentially be a reason for illegal disposal of used gear into the ocean, both government workers and academics were confident that most Taiwanese fishermen were responsible in bringing used gear ashore, and that gear left at sea from Taiwanese fishermen is mostly accidental loss (Interview Participant 3; Interview Participant 7; Interview Participant 9). A recent study done on fishermen perspectives on ALDFG supports these sentiments and found that poor weather was the most commonly reported reason for lost gear, being mentioned in 69% of gear loss instances (Yang, 2023). While the accidental loss of gear is not punishable, failure to report lost gear to the FA is. Unfortunately, according to a government worker from the FA, the ratio of lost to retrieved gear has been identified as a data gap, and at present, little data on material flow volumes exist (Interview Participant 9). Currently, the most reliable data that is being collected by the FA is the identification of hot spots where gear is often lost due to gear conflict. Local city governments are currently being asked by the FA to record the location of where fishermen report lost gear to help identify and prioritize the highest at-risk locations. This

data, however, is still being collected and few solutions have been implemented so far (Interview Participant 9).

However, gear that is intentionally disposed of at sea remains the first instance in where the current circular economy system in Taiwan strays from the ideal, as displayed in Figure 1 and 2. For gear that is intentionally illegally disposed of at sea, government workers and academics pointed to IUU fishing as the culprit, specifying that the majority of IUU fishing and illegal dumping is not done by Taiwanese fishermen, but by foreign fishermen. To combat IUU fishers and illegal dumping, the FA has installed a policy called the National Plan of Action to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated Fishing (Fisheries Agency, 2020). Though not a member of the United Nations, this action plan was voluntarily developed in accordance with the UNFAO's International Plan of Action to Prevent Illegal, Unreported, and Unregulated (Tai et al., 2020; FAO, 2001), and outlines plans to monitor and control waters within Taiwan's border. However, enforcement of this national plan relies on the accurate monitoring and reporting of sea activities. Although the Coast Guard, local fishermen, and other citizens may report illegal sea activities, there is limited data on how effective enforcement has been so far. A government worker at the FA said that:

We have a policy to prevent illegal fishing, but it is only a deterrent. If illegal fishers and illegal dumping is not caught, we cannot enforce the policy's consequences. (Interview Participant 9)

5.2. Prevention and Mitigation Efforts

Several methods have been developed and implemented by the Taiwanese government in an attempt to reduce the production of ALDFG from accidental loss and IUU fishing at its source. Seven prevention and mitigation measures discussed by interview participants will be detailed in this chapter, along with the opportunities and barriers to their successful implementation. First, the four major initiatives put in place by the FA will be discussed. These initiatives include gear substitution, gillnet license reductions, the creation of marine protected areas (MPAs), and the new gear marking policy. The OCA's new gear buy-back program currently on trial, which is directly aimed at marine circular economy development, will follow. Finally, hotspot targeting and gear manufacturing regulations will be discussed. These final two initiatives are currently undergoing consideration.

5.2.1. Gear Substitution (pull and line, longline, and biodegradable gear)

Gillnets are one of the most common types of fishing nets used by fishermen and are designed to trap fish by their gills on an attempted escape. Gillnets are a significant contributor to ghost fishing in Taiwan and have been known to cause general damage to marine ecosystems. Further, if caught in the propellers or rudders of boats, gillnets may compromise the safety of fishermen (Tseng & Kao, 2022). As the first of the FA's four major policies, the FA has begun encouraging gillnet fishermen to transfer their licenses and substitute their use of gillnets with pull and line or longline fishing gear. A government worker from the FA explained that:

Fishermen can choose a license for what kind of fishing they want to do, and currently fishing licenses are transferrable. Right now, the FA is trying to ban fishing nets, so we are reducing the number of licenses [for gillnets] available. If you do not have a license, you cannot buy a boat that uses gillnets. (Interview Participant 9)

Of all policies and regulations implemented to address ALDFG and environmental damage, the government worker noted that this policy has been the most successful at preventing and reducing environmental damage (Interview Participant 9). When asked if fishermen pushed back on this policy, the government worker said that so far, there has been "no significant pushback" to this policy (Interview Participant 9). An academic suggested this is likely because a fishermen's overall catch remains roughly the same, given the amount of bycatch the use of nets produces (Interview Participant 7).

Additionally, while the substitution to pull and line or longline fishing has been successful, biodegradable fishing gear has been proven to be a more effective substitution. The development of biodegradable gear has been in the works for some time, and according to academics and government workers, the government has funded Taiwanese ocean institutions to progress its development (Interview Participant 7; Interview Participant 9). However, the main barrier to using biodegradable gear is fishermen buy-in. Although the gear is designed to only biodegrade under specific environmental conditions, the vast majority of fishermen feel the risk of losing some or your entire catch due to faulty biodegradable gear is too high (Interview Participant 7; Interview Participant 9). Although rigorous testing has proven the risk of use to be low and comparable to the non-biodegradable fishing gear currently in use, fishermen's

perception of biodegradable gear remains low. The most recent study on fishermen perspectives on ALDFG found similar sentiments, noting that currently there are no biodegradable materials that fishermen have approved of (Yang, 2023). Though ready to be deployed, currently the use of biodegradable gear remains almost entirely in labs and in testing stages due to limited fishermen buy-in.

5.2.2. Gillnet License Reduction

The FA's second major policy works to reduce the overall volume of fishing nets being used by reducing the number of licenses for boats that use gillnets. As mentioned previously, currently fishing licenses are transferrable, allowing fishermen to decide the fishing method they'd like to use (gillnets, longline, etc.). However, a government worker explained that as the FA is currently banning the continued and expanded use of gillnets, over the last few years, the number of licenses has dropped significantly (Interview Participant 9). Fishermen overall, however, have been minimally impacted by these new regulations since the reduction of licenses has fallen in step with the natural retirement rate of fishermen (Interview Participant 7; Interview Participant 9). An academic said that:

Since a lot of the fishermen who use gillnets are starting to retire anyways, they don't really mind these new regulations. (Interview Participant 7)

As the current fishermen population is generally over the age of 45 (Liao et al., 2019), according to an academic, the retirement rate of fishermen has consistently been greater than the rate of uptake by younger generations (Interview Participant 7). Younger generations, including the children and grandchildren of current fishermen, tend to have achieved a higher level of education and tend to opt for less manual career paths (Interview Participant 7).

There's some younger fishermen, but most young people are not working as fishermen right now. (Interview Participant 7)

For those younger fishermen who are joining the fishing industry, government workers have so far reported limited pushback (Interview Participant 9).

5.2.3. Marine Protected Areas

The creation of MPAs is the third of the FA's four major policies to protect and preserve marine environments. MPAs are set by the FA, often in collaboration with academics, and enforced by local city governments (Chung & Jao, 2022). Ranging in size from a few hundred meters to a few kilometers long, the number of MPAs have expanded from the first MPA in 1982 to 47 as of 2023 (Interview Participant 7; Ocean Conservation Administration, 2023). Overall, the size of MPAs are dependent on a variety of factors, including fishery size, tourism opportunities, and overall traffic (Interview Participant 7; Chung & Jao, 2022).

A recent study on MPAs found that academics are generally strong advocates for increasing the number of MPAs in Taiwan, as well as governing them with stricter regulations (Chung & Jao, 2022). The academics interviewed agreed with this, saying that from an ecological standpoint, MPAs will have the best impacts on long-term marine health (Interview Participant 4; Interview Participant 9). However, although MPAs are the most effective form of marine protection, they also face the most pushback from fishermen and other stakeholders from civil society. An academic who has worked with fishermen and a government worker at the FA described how they have heard from fishermen that the creation of MPAs would reduce the number of open fisheries, limiting fishing opportunities and consequently negatively impact their overall catch (Interview Participant 7; Interview Participant 9).

A dive community member whose business relies on tourism also said that MPAs may also limit tourism and business opportunities (Interview Participant 8). In particular, dive shops feel that MPAs unfairly impact their ability to sell diving or snorkeling packages, especially since the diving community is generally most protective of marine environments (Interview Participant 8). Although diving and snorkeling is not completely banned in many MPAs, most MPAs have daily quota limits, which can be as low as 20 divers a day. It was noted by a dive community member that overall, the specified quotas feel arbitrary and lack good scientific reasoning for enforcement (Interview Participant 8). This dive community member also mentioned how small and/or family-run businesses who run restaurants or other businesses in previously tourist dense seaside areas have also faced some negative consequences due to the reduced foot traffic (Interview Participant 8). He further elaborated on this issue, describing how little

government support has been provided for these small businesses to replace the lost income from tourism. However, Interview Participant 8 also admitted that these impacts have likely been exasperated by border restrictions due to the COVID-19 pandemic, and that some of these small businesses have or have started second businesses to make up for the lost income.

5.2.4. Gear Marking

As mentioned earlier, the FA's fourth major policy, gear marking, was introduced into nation-wide legislation in 2020 as recommended by the UNFAO as one of the most effective and cheapest methods to reduce ALDFG. This policy, which requires fishermen to attach identifying tags to all gear in use, had a soft start in January 2021 and was fully implemented with the inclusion of fines up to NT\$150,000 (US \$3000) for removing or fishing without tags in June 2021. Although a reporter said that there were concerns amidst the initial implementation that fishermen would simply remove their tags once on open water (Interview Participant 2), a government worker from the FA has confirmed that to date, no one has been fined for non-compliance (Interview Participant 9). Further, no interviewees voiced concerns that fishermen were not following the rules, again emphasizing that Taiwanese fishermen tend to follow government rules when there are consequences for non-compliance outlined (Interview Participant 3; Interview Participant 7; Interview Participant 9).

According to a government worker at the FA, since implementation of the gear marking policy, the only concern voiced by fishermen has been the fear of possible consequences for those who have difficulty tagging their gear due to illegible handwriting or illiteracy (Interview Participant 9). With majority of the fishermen population over the age of 45 and having completed at best, only up to senior high school, this was recorded as a concern across all fishing ports in Taiwan (Liao et al., 2019). To address this, the FA has provided fishermen who are unable to clearly write with printed tags. Since the provision of printed tags, according to a government worker at the FA, no further complaints regarding this issue have been noted (Interview Participant 9). It was also noted by another government official that while some fishermen initially opposed this policy, since its implementation, the number of those opposing the policy have consistently declined (Interview Participant 3) This finding has been consistent so far with the observations of other government workers and academics (Interview Participant

9; Yang, 2023). The findings of a recent study on fishermen perspectives reinforced this observation, describing how although in some cases fishermen need to be reminded of the gear marking policy, overall, fishermen have stayed compliant. Additionally, this policy has not affected the income of fishermen, which was a commonly cited concern during initial implementation stages. The relaxation of this concern has overall incentivized fishermen participation, promoting the long-term success of this policy (Interview Participant 3; Participant 9; Yang, 2023).

While cheap and effective, one major drawback of this policy is its tendency to target those fishermen who are already responsible and compliant to fishing rules, regulations, and policies (Interview Participant 3; Interview Participant 9). A government worker mentioned how those who usually discard their gear into the water have little incentive to stop if not caught. It was mentioned for example, that this policy has had no impact on reports related to foreign IUU fishers even though it is suspected a significant proportion of ALDFG is due to their illegal dumping of used gear (Interview Participant 9). Additionally, this policy has had no impact on ALDFG that floats in from nearby countries. An academic who works with fishermen and takes part in many beach clean-up activities for their research said that a large proportion of ALDFG floats over from nearby countries such as mainland China (Interview Participant 7).

You can see on some of the floats and tags that the gear is from mainland China. (Interview Participant 7)

said Interview Participant 7, pointing out etchings on specific float markers in a pile of disposed gear. A government worker from the FA expanded on this, saying that:

Kinmen is only a 30-minute boat ride away from mainland China, so with the currents, lots of gear floats in from places like Hong Kong and China. (Interview Participant 9)

Overall, it was also mentioned that so far, this policy has had no significant outcomes within the Taiwanese fishermen population. According to a government worker at the FA:

Since fishing nets are the property of fishermen, there is a general feeling of personal responsibility towards this gear. This disincentivizes illegal dumping into the ocean (Interview Participant 9)

This sentiment was also noted in a study on fishermen perspectives done by Yang (2023), supporting the notion that fishermen are generally responsible and abide by government rules.

5.2.5. Gear Buy-back

The OCA's gear buy-back program is Taiwan's most ambitious marine debris clean-up initiative to date and is currently on trial run in 12 city and county governments (Interview Participant 12). As described by three government workers at the OCA, this program focuses on not only removing ALDFG from the ocean, but also on finding and facilitating the development of market incentives to create circular economy systems for marine debris (Interview Participant 11; Interview Participant 12; Interview Participant 13). The details, as well as opportunities and limitations of this program will be further expanded on in sections 5.2-5.4, but broadly, this program compensates fishermen using a point system for the return of their used gear and other marine debris to in-port collection points. The garbage is weighed once back in-port, and once the appropriate number of points have been allocated, these points may be traded-in at their local Fishermen's Association for daily necessities, like tissue paper and garbage bags (Interview Participant 3; Interview Participant 11; Interview Participant 12; Interview Participant 13). A government official at the OCA said that the plan is to first retrieve used gear, then sort and clean the gear before selling the used gear to recycling companies for regranulation into raw materials (Interview Participant 3). A visual representation of this can be seen in Figures 1 and 2. This trial run began in 2020 and is scheduled to run until the end of 2023. If the middle to long-term plan submitted to Executive Yuan by the OCA is approved, this program will officially be implemented permanently in 2024 (depending on available funding). Those interviewed at the OCA expressed confidence that the success of the project has thus far been realized, and that the program will be renewed with adequate funding in time for a prompt 2024 start date (Interview Participant 3; Interview Participant 11; Interview Participant 12; Interview Participant 13).

5.2.6. Hotspot Targeting

Hotspot targeting refers to the identification of geographical locations where gear is often lost. While hotspots may occur for a variety of reasons, gear conflict has been

identified as the most common reason for gear loss in Taiwan, with a recent study reporting that 57% of lost gear is due to gear conflict (Yang, 2023). Gear conflict refers to gear that is lost when multiple kinds of gear interfere with one another when concurrently in use in the same area. For example, gillnets can become caught on crab cages or become tangled in fishing lines. When gear is lost, fishermen must include the location they lost their gear in their gear loss report to the FA. Based on the location and variety of gear being lost, the FA has begun to identify multiple hotspot locations where gear conflict is the most likely reason for loss. Currently, the FA has requested local city governments to collect both gear loss and gear retrieval location data and report this data to the FA to begin compiling a list of hotspot locations (Interview Participant 9). Once hotspots have been identified, a government worker from the FA said that the FA will work with local city governments to create solutions that best suit each hotspot location (Interview Participant 9). A possible solution, for example, would be to create fishing zones, where buoys or flags would mark the allowable areas for the use of different gear types. However, government workers at both the FA and OCA mentioned methods like zoning, while shown from past use to be effective, is difficult to deploy and maintain because fishermen are not always able to clearly discern hard boundaries between buoys and flags (Interview Participant 3; Interview Participant 9). According to a government worker at the FA, to date, while fishermen have been notified of gear conflict issues and have been made aware of hotspot locations, it is unclear at what point zoning or other mitigation methods will be officially deployed (Interview Participant 9).

5.2.7. Regulation of gear manufacturing with manufacturers

Finally, since all fishing nets bought and used in Taiwan are imported from manufacturers in mainland China, cooperation with these manufacturers appears to be an effective source-control method to regulate the quality and types of imported gear. No relationship currently exists between Taiwanese governing bodies and mainland Chinese manufacturers, however a government worker at the FA mentioned that this method of regulation has been discussed before and has been considered as a viable option for the long-term future (Interview Participant 9). However, the development of an agreement would take significant negotiating and it is unknown at this time if imposing higher standards for manufacturers would impact the profit margins of fishermen, as it is expected that regulation standards would increase the price of gear. A recent study on

fishermen perspectives has echoed this concern, noting that higher prices for fishing gear would disadvantage fishermen who prioritize cost and durability as their main purchasing considerations (Yang, 2023). While a viable option, the FA was firm in that this option is far from developed and is not considered to be a pursuable option in the near future.

It would take a long time to negotiate this. It is something for the long-term future. Probably at least 10 years from now. (Interview Participant 9)

5.3. Retrieval and Holding of ALDFG

In the event the prevention and mitigation measures fail and used gear becomes abandoned, lost, or discarded at sea, retrieval of this ALDFG is then the next priority for a circular economy system. Government workers at the OCA said that while in some cases fishermen or clean-up crews specifically go out to sea to retrieve used gear, a large proportion of ALDFG is actually caught by fishermen as bycatch during their daily fishing activities (Interview Participant 3; Interview Participant 11; Interview Participant 12; Interview Participant 13). In either case, ALDFG must then be brought back to in-port facilities to await the next steps of sorting, cleaning, and recycling (see Figures 1 and 2). While previously it was common practice for fishermen to throw ALDFG bycatch back into the sea to save boat space for their catches, as mentioned in 5.2, the educational initiatives coupled with the gear buy-back trial program has been instrumental in incentivizing bringing ALDFG ashore and moving it through the first step of a circular economy system.

Once ashore, fishermen may weigh and drop off their retrieved ALDFG at collection points in each port (see example photos of retrieved ALDFG piles in photos A, B, and C below in Chapter 5.4). These points are designated by the FA and maintained and run by the OCA (Interview Participant 9). The weight of retrieved ALDFG is then converted into a point rewards system, which can be redeemed by fishermen at their local Fisherman's Association for daily necessities like tissue paper and garbage bags. Funding for these daily necessities is provided to the Fisherman's Association from the OCA (Interview Participant 9). Although government workers at the OCA did not have clear data on how many fishermen have redeemed points so far and how many points it takes to be redeemed for each daily necessity item, the return scheme in general abides by the redemption rate of 15NT (\$0.49 USD) for every kilogram of waste brought back

(Interview Participant 11). Government workers from the OCA shared that data from local governments covering the period of April to November 2022 showed successful metrics, with 139 tonnes of old fishing gear having been brought back for recycling (Interview Participant 11; Interview Participant 12; Interview Participant 13). More recent data was unavailable as it is still being collected and processed. While so far, government workers at the OCA are happy with the results of the program, a study was recently published analyzing material flows for commercial fishing gear in Taiwan. This study found that there is 4,575 tonnes of fishing gear in Taiwan at a time annually as “stock”, and of this 4,575 tonnes of fishing gear, 27% is being used, 23% is in fishing ports, and 50% enters the ocean (Su et al., 2023). These findings suggest that while the gear buy-back program has had a strong start, there is still room for more aggressive clean-up measures in Taiwan.

So far, fishermen have been extremely receptive to this program, and it was noted by a government official at the OCA that the majority of fishermen have opted-in to the program (Interview Participant 3). Both government workers and academics cited the free in-port collection points as a primary incentive for participation by fishermen, since other recycling collection points require fishermen to pay a small fee (Interview Participant 3; Interview Participant 7; Interview Participant 9; Interview Participant 11; Interview Participant 12; Interview Participant 13). Government officials have also found that the point system has been well received, saying that:

The main concern of fishermen is providing for their families, so being able to redeem points for daily necessities helps them in this aspect. (Interview Participant 3)

Although motivation to participate is partly for sustainability concerns, it was mentioned by multiple interviewees from both government and academia that this is a secondary concern to traditional familial roles. As mentioned before, since fishermen take on the role of providing for the family, it is actually the fishermen’s wives who advocate most strongly for participation for sustainability reasons (Interview Participant 3; Interview Participant 7).

While effective in removing and keeping used fishing gear out of the ocean, a limitation of the current system in place is its inability to discern how much of the garbage left at collection points is ALDFG retrieved from the ocean versus from dumping

and/or other sources (Interview Participant 11; Interview Participant 12; Interview Participant 13). This data limitation may skew government records when estimating and completing material flow analyses. Since recycling fishing nets and other gear cost fishermen a small fee at normal recycling drop-off points, government workers and academics mentioned that they suspect most retired fishing gear, whether ALDFG or not, and other kinds of garbage would likely be discarded at these free in-port collection points (Interview Participant 7; Interview Participant 11; Interview Participant 12; Interview Participant 13). However, as dumping still increases the overall recycling rate of used gear, it was not seen as a negative drawback by government workers. Instead, to incentivize and reduce barriers to recycling for fishermen, discarding any kind of fishing gear as well as other garbage at the designated collection points is allowable under this new program (Interview Participant 11; Interview Participant 12; Interview Participant 13). Further, government workers also noted that it is beneficial to capture retired fishing gear that has not yet been degraded by ocean water and other environmental conditions at ports for two reasons; First, this poses as a preventative measure to discourage the creation of ALDFG, and second, since ALDFG that has been heavily degraded by environmental conditions is often rendered unrecyclable and is sent to landfill or incinerated, collecting “fresher” gear also has higher financial feasibility for recycling, and in turn promotes and progress the development of a circular economy for marine debris (Interview Participant 7; Interview Participant 9). Overall, while this data gap has been noted, it has not been a priority or concern of the OCA so far.

5.4. Sorting, Cleaning, and Recycling

Once retrieved, ALDFG must then be sorted and cleaned before it can be sent or picked up for recycling. However, sorting and cleaning have so far been the phases where the flow of materials begins to stagnant through the circular economy system, as noted in the red squares of Figure 2. While at this point, a significant amount of ALDFG, other retired fishing gear, as well as garbage has been collecting at designated in-port points, according to an academic and some general workers at fishing ports, these piles sit in ports for anywhere from weeks to months waiting for sorting crews to separate out materials that are recyclable or for disposal (Interview Participant 7; Informal Conversation #3). Currently, the sorting and cleaning of materials is costly and does not fall under the responsibility of any one stakeholder in particular. A government worker

from the FA also said that this responsibility is that of the OCA (Interview Participant 9). NGOs who were interviewed said, though they were not 100% sure, they believed the sorting and cleaning was the responsibility of the OCA and alluded to some OCA run cleaning crews (Interview Participant 6). Government workers from the OCA however, said that while they are in charge of organizing and coordinating sorting and cleaning, they do not have cleaning crews at the moment and generally said that sorting and cleaning is sometimes done by fishermen, though it is not their responsibility. They further described how the lack of foreign workers due to COVID-19 has limited their ability to create these designated sorting and cleaning crews, as usually foreign workers tend to fill many of these labour-intensive jobs in Taiwan, and mentioned how NGOs are often there to help with the sorting and cleaning to fill this gap (Interview Participant 3). Academics and NGOs elaborated on how NGOs are currently voluntarily filling this gap (Interview Participant 6; Interview Participant 7). According to an academic who has participated in these NGO led sorting parties, every two to four months, volunteers and fishermen will be hosted by one or more NGOs to sort through these piles of waste (Interview Participant 7). However, while these sorting parties are helpful, they do not happen frequently enough to completely manage the amount of waste building up in ports (Interview Participant 7). In general, government workers, NGOs, and academics all agreed that sorting should not fall under the sole responsibility of fishermen (Interview Participant 7; Interview Participant 8; Interview Participant 9). An NGO said:

Fishermen are already tired after a day's work. They don't have the time or energy to sort through all this garbage. The government should be in charge of this, not them. (Interview Participant 6)

This was echoed by an academic, who said that:

Once fishermen come back they're really tired so it would be unfair to expect them to sort out what they bring back too. (Interview Participant 7)

In general, sorting is a two-step process, where waste is sorted from a "catch-all" pile (Figure 3), and then subsequently sorted out by fishing gear type and material. According to an academic who often works with fishermen, since fishermen are often tired from being at sea, at the end of the day the "catch-all" pile often contains not only trash, but also items like bins and buckets that need to be put back away in their proper place (Interview Participant 7). Once the fishing gear is sorted out of the "catch-all" pile, the secondary pile (Figure 4), which is fishing gear specific and may contain a mixture of

items including but not limited to nets, lines, buoys, tags, ropes, and Styrofoam, must then be sorted out into their respective categories (Interview Participant 7). An academic estimated that the fishing gear captured in Figure 4, though collected in a few weeks, would likely take at least one to two months to sort, depending on how large and how often sorting and cleaning events take place (Interview Participant 7).



Figure 3. Broad view of both the "catch-all" holding area and ALDFG pile.



Figure 4. Closer view of the "catch-all" pile.



Figure 5. Close up of the ALDFG pile.

While sorting is the first significant barrier in the system, cleaning also poses as a significant barrier as it too, is not only costly, but time and labour intensive. To prevent compromising the integrity and quality of recycled fishing gear, salt from sea water and other impurities, such as barnacles or algae, must be cleaned off prior to processing. Additionally, any ALDFG that has degraded over time to a point where recycling is not financially feasible must be removed and disposed of, with the most common method of disposal being incineration.

The cleaning stage was where most NGOs and other stakeholders were not only unsure of the process, but also unsure of who the relevant stakeholders involved were. While some NGOs assumed that the recycling companies were responsible for cleaning the gear (Interview Participant 6), academics and reporters noted that based on prior knowledge, usually items going for recycling must be sorted and cleaned before being picked up or sent off (Interview Participant 2; Interview Participant 7). Those interviewed from government bodies mostly agreed that the organization and coordination of

cleaning is the responsibility of the OCA, however the OCA acknowledged in interviews that this is a step of the cycle that has not been entirely decided across all municipalities and is dependent on the decisions of local city governments and recycling companies (Interview Participant 3; Interview Participant 9). When recycling companies were asked of their processes and expectations regarding the cleanliness of gear on pick-up, a number of recycling companies mentioned that they prefer for the gear to be cleaned before being picked-up, as the cleaning of gear would increase the overall cost of their recycled raw materials and impact their profits (Interview Participant 10; Email Correspondence #2, Email Correspondence #3). Notably, of the 13 recycling companies featured in the OCA's handbook (Ocean Conservation Administration, 2021) on ALDFG, only four continue to recycle fishing gear. When these recycling companies were contacted by phone, many simply said that recycling ALDFG at the moment was "too complicated" but did not comment further. Of those willing to comment on their company's decision to halt the recycling operations of ALDFG, most cited technical complications and lack of guidance regarding policies and regulations as reason for refocusing their recycling efforts away from ALDFG and onto other retrieved marine debris materials (Email Correspondence 2; Email Correspondence 3). The most commonly recycled marine debris were plastic bottles and jugs. Although plastic bottles and jugs share many of the same characteristics as fishing gear, such as high material value and consistency, recycling rates and interest from recycling companies remained higher than that of fishing gear because of the greater potential for profits, seeing as plastic bottles and jugs are a more widely accepted material and are in higher demand by businesses (Email Correspondence 2; Email Correspondence 3).

One recycling company who still recycles ALDFG agreed to an interview (Interview Participant 10). This recycling company confirmed that there is a lack of government guidance on recycling ALDFG, and that financially, no subsidies or other economic incentives exist for recycling companies to pursue ALDFG recycling. Further, this recycling company worker identified three major barriers recycling companies generally face in recycling ALDFG. First, due to financial constraints, recycling companies do not have the capacity to sort and clean gear. Second, there often is not a steady supply of sorted and cleaned ALDFG to recycle, significantly reducing the profitability of recycling ALDFG, and finally, those recycling companies who recycle using physical methods rather than chemical methods are at a disadvantage, as

chemical recycling is a more feasible recycling method for the materials making up ALDFG.

The recycling companies who are most successful at recycling fishing gear are those that use chemical methods, but not all recycling companies have switched over to chemical recycling. (Interview Participant 10)

When asked how their recycling company, who uses physical methods, has stayed economically afloat, they said that:

Physical methods are still possible, but this is when the steady supply of fishing gear becomes an issue. Right now, for fishing gear waste in Taiwan, we have a third party that we buy fishing gear from who sorts and cleans the gear. Other than that, we import fishing gear ready to be recycled from places like Korea. (Interview Participant 10)

Further investigation of these third parties was not possible during the allotted time in Taiwan, however, the recycling company worker interviewed said that these third parties are usually for-profit NGOs who work directly with fishermen, but generally they are not common. The import of gear from countries like Korea was also consistent with the solutions for steady supply described by an academic (Interview Participant 7), however the process Korea has to collect, sort, and clean gear at rates where export is profitable was generally unknown by NGOs, academics, and recycling companies interviewed.

5.5. Reuse in New Products

Finally, once recycling companies process recycled fishing gear and the gear is re-granulated into plastic pellets, recycling companies may then sell this raw material to manufacturers and businesses for use in new products. Pathways into new products vary significantly at this point, as different end products require different manufacturing steps (eg. The production of resin for 3D printing is vastly different from textile production). However, according to a recycling company worker, manufacturers and businesses looking to purchase recycled raw materials must purchase materials directly from recycling companies (Interview Participant 10). So far, it was noted by academics and reporters that the fashion and textile industry seem to be the largest consumers of recycled ALDFG plastics (Interview Participant 1; Interview Participant 2). Although those interviewed were unsure of why exactly this seemed to be the case, the general hypothesis was that the fashion and textile industry is simply one of the largest industries

world-wide, and that those working within this industry tend to serve customers who care more for ocean conservation and sustainability issues (Interview Participant 1; Interview Participant 2).

Overall, the growth in companies using recycled ALDFG in Taiwan is consistent with an upward trend in numbers being seen globally (Charter et al., 2018). The number of both small and large businesses adopting the use of recycled ocean plastics into the products have been warmly received by citizens in Taiwan, as can be seen by the increasing number of booths at sustainability events selling their products and educating the public on the rationale behind their material choice (Event 4, Event 5).

However, it is important to note that globally, there is limited regulation on the marketing of products with recycled materials. Companies “greenwashing” their products by for example, over-reporting the amount of recycled content in their products without third party verification or publishing lofty sustainability goals without transparent plans or deadlines has instilled varying levels of mistrust within consumers. The consequences of lax marketing regulations are currently being experienced in Taiwan. A common concern voiced by academics, NGOs, and those from civil society relates to the limited transparency behind a “sustainable” product’s production. While the number of businesses selling products with recycled material has increased, many refrain from disclosing the exact percentage of recycled materials within their products. At a public sustainability event, an environmental consultant who has previously worked both in academia and the NGO sphere shared their displeasure at the publication of an investigative article revealing that a keyboard being promoted by the government and marketed as made from “100% ocean plastics” actually contained less than 1% of recycled ocean plastic material (Interview Participant 4). Conveniently, this keyboard was being sold at a booth at the public sustainability event this interview took place at. This consultant described how when they asked the booth workers about the actual ocean plastic content in their keyboard, the booth attendants refrained from answering (Interview Participant 4).

I’m not sure if they were told not to tell the public this information or if they themselves don’t actually know as well. Even those government workers selling other recycled products promoted by the government won’t say. (Interview Participant 4)

When asked about ways to overcome transparency issues, the consultant said:

It's really up to the business, there isn't anything forcing them to disclose anything in Taiwan, but this is a problem globally. Maybe the ESG or EPR policies will help, but no one really knows yet. (Interview Participant 4)

A government official also mentioned that eventually the ESG policies and principals currently in development will encourage companies with higher import and export fees to take on greater lifecycle responsibility for their products. ESG policies were generally perceived as a good idea by interviewees both from NGO, government, and civil society spheres, and knowledge around ESG concepts appeared relatively high in those interviewed. It has been noted in media articles that Taiwan is also leading many of the ESG developments globally (Bloomberg, 2018). However, ESG initiatives are still relatively high-level and full implementation of ESG policies to address products specially made from marine debris, while feasible and possible to implement, are also still in development (Interview Participant 3).

Finally, to close the loop for marine debris and ALDFG, businesses must not only use recycled materials, but also have their end-of-life products recycled into raw materials and re-used again. In Taiwan, once the use of these new products reaches the end of its life, EPR schemes come into play. While Taiwan first established EPR schemes in 1988 under the Waste Disposal Act, current EPR initiatives and subsidies are largely focused on land-based sources of plastics, metals, and glass from containers and e-waste (EPA, 2012). While various academics mentioned EPR schemes should be expanded to cover ALDFG and other marine debris wastes, it is unclear how this would feasibly be implemented as end-products with recycled marine debris content in them may be covered under EPR schemes. Overall however, this has yet to be fully developed and installed into legislation (Interview Participant 4; Interview Participant 7).

Chapter 6. Discussion/Conclusion

Overall, within a short time period, Taiwan has laid a strong foundation in both preventing and mitigating ALDFG and in establishing a circular economy. This study has shown that the case of Taiwan confirms the literature in that challenges in coordinating and implementing circular economies pose a larger threat to success than technological innovation. Additionally, Taiwan also adds to the literature in that government responsiveness to lobbying from civil society and an investment in education is beneficial in establishing behavioral change in society and in creating momentum in circular economy development.

However, while the trajectory of Taiwan is promising, like many other countries, a variety of barriers prevent them from fully closing the circular economy loop. While on an international level, limitations in global standards, regulations, and policies regarding for example, marine conservation of international waters, IUU fishing, and drift waste, show stagnating progress and create challenges in closing the “stream” of ALDFG in the ocean, the biggest barriers Taiwan currently faces in implementing a circular economy is on a domestic level. In reference to Figure 2, the sorting and cleaning stages are the “bottlenecks” in Taiwan’s circular economy system. However, while on the surface, this bottleneck is described by interviewees to be due to the lack of designated responsibility over sorting and cleaning, the underlying cause of this bottleneck is mainly tied to weak market incentives and linkages.

Currently, while government, NGO, and civil society interviewees have noted the challenges and lack of action in sorting and cleaning, the lack of monetary incentives and market pressure limits the progress in addressing this issue. If adequate market linkages and monetary incentives were to exist, businesses would play a larger role in influencing the rate of circular economy development. Specifically, their demand for recycled raw materials would incentivize recycling companies to increase their demand for clean, sorted fishing gear, and subsequently apply pressure on either the government to designate and allocate funding towards sorting and cleaning crews or apply pressure on other third parties to deploy other strategies to expedite the sorting and cleaning phase to loosen the current bottleneck. However, due to the marketing and regulation loopholes for businesses in regard to “greenwashing”, the limited motivation to source

recycled materials has resulted in little market pressure so far, and has overall created little incentive for businesses and recycling companies to invest in their roles within a circular economy. In this context, even with proper government designated roles at the sorting and cleaning phases, the bottleneck would continue to persist as there would still be no guarantee ALDFG would continue to move through the circular economy system at the recycling stage. While some market-based solutions to incentivize businesses and close the circular economy loop were mentioned by interviewees, such as the implementation ESG and EPR policies, progress for these developments are still in the works, and currently the effectiveness of these policies and schemes are unknown for the case of ALDFG in Taiwan.

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Appendix A.

Interview Questions

Section 1 - Awareness of ALDFG

1.1 How concerned are you about ALDFG waste in the ocean?

Probing questions:

- When did ALDFG first become an issue for you? How did you learn about ALDFG?
- Is addressing ALDFG a priority? What made it become a priority?
- Why do you think this has become a priority recently for the government?
- Do you think other groups like fishermen or the public are more or less aware of ALDFG? How are they becoming aware? Do you sense their concern for action?

1.2 What is the most concerning consequence of ALDFG?

Probing questions:

- Are other groups like fishermen/NGOs/government/civil society or the public aware of this impact?

1.3 Are there any awareness initiatives coming out from you/your organization?

Probing questions:

- Has it been received well by others?
- What has been the most successful in raising awareness?
- What kind of responses have you received?

Section 2: Opinions on current and prospective policies and regulations

2.1 How do you feel about the current policies and regulations in place?

Probing questions:

- Are they addressing your concerns regarding ALDFG?
- Do you feel the government is putting in sufficient effort to address ALDFG?
- How do you think they are received by fishermen/public/media? Do you notice a lot of pushback? Why?
- What are your thoughts on the new gear marking policy? Do you think it will be successful?

2.2 How do you feel about the way policies and regulations are developed?

Probing questions:

- Do you think enough input and feedback is incorporated by the public?
- How would you voice your opinion to the government if you had something to say?
- Do you think the way policies and regulations are developed needs improvement? What kind of improvements?
- Was it a smooth transition to work with the government and other NGOs?

2.3 What kinds of policies or regulations would you like to see in the future?

Probing questions:

- Do you think there are any policies or regulations that are more likely to be implemented than others? Why?
- Have you heard about the boat subsidies in Keelung and Penghu that replace gillnets with better nets? Do you think this or something similar would work in other cities?
- I've heard about buy-back programs for Styrofoam buoys in Taiwan. Do you think something like this would work well for ALDFG?

Section 3: Perceived barriers to further progress in policies and regulations

3.1 What do you think are the biggest barriers to implementing more policies and regulations?

Probing questions:

- How big of a role does the media play? NGOs? The public? Funding? Politics? Data collection? Government bureaucracy?
- Are there any groups or initiatives that are helping progress the most? What about hindering?
- Where do you suspect is the most pushback?

Section 4: Perceived barriers in directing ALDFG into a circular economy

4.1 From your understanding, how does ALDFG move through a circular economy?

Probing questions:

- Who do you think or feel should be responsible for this step in the circular economy?

4.2 Do you think people in Taiwan are willing to purchase products with recycled materials?

Probing questions:

- What might encourage/discourage purchasing products with recycled materials?
- Have you noticed an interest in products with recycled materials by your friends/family/government/businesses?