Tackling plastic pollution in New Zealand's fin fishing industry

Case study: Moana NZ

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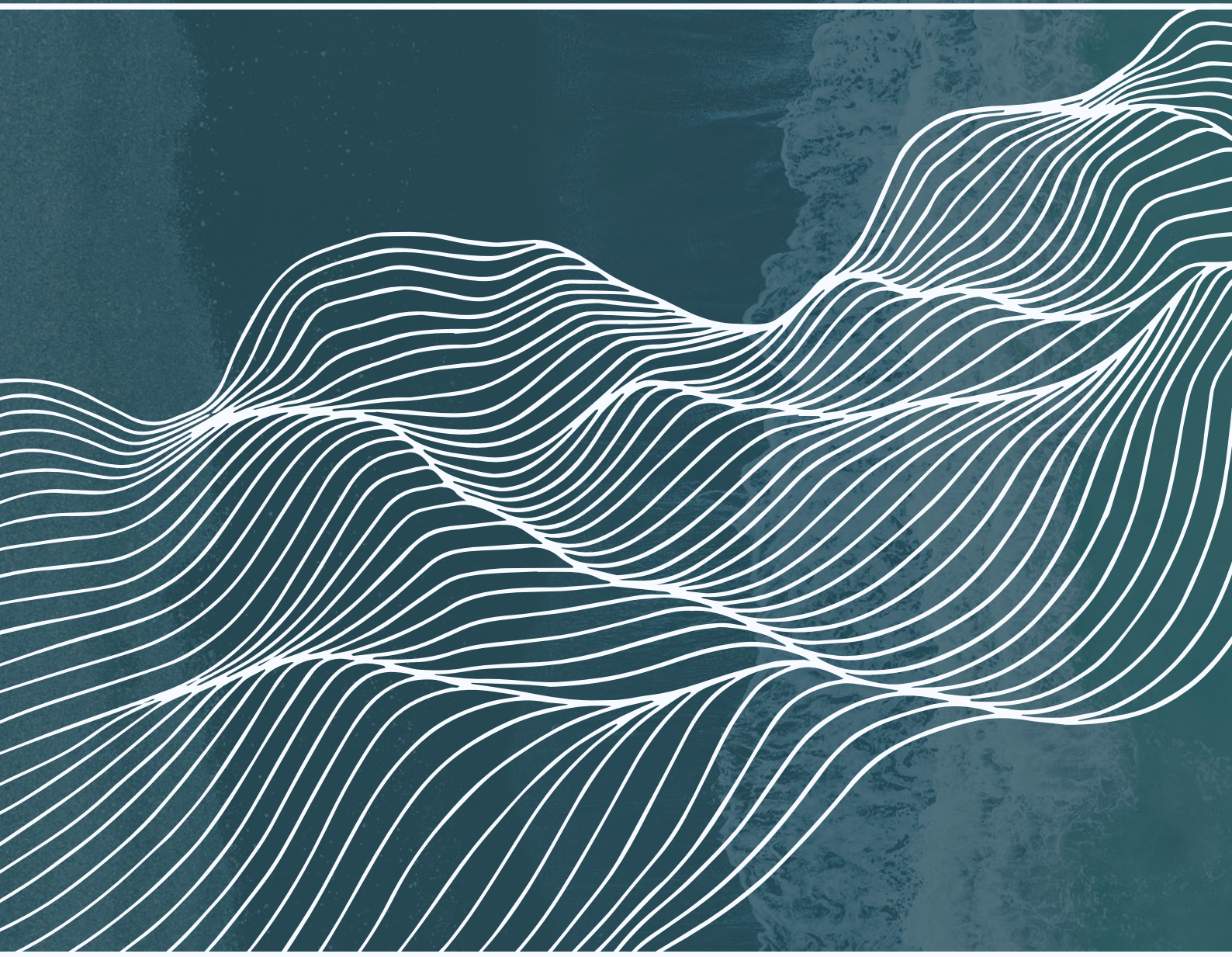

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Contents

5

6

7

8

Contents

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Abbreviations

ALDFG – Abandoned, Lost and Discarded Fishing Gear

CRS – Container Return Scheme

EDCs – Endocrine Disrupting Chemicals

EEZ – Exclusive Economic Zone

EPR – Extended Producer Responsibility

EPS – Expanded Polystyrene

FAD – Fish Aggregation Device

FAO – Food and Agriculture Organisation

FARNET – European Fisheries Area Network

FFL – Fishing for Litter

IMO – International Maritime Organisation

ISSF – International Sustainable Seafood Foundation

MARPOL – 1973 Annex V of the International Convention for the prevention of pollution from ships

MPP – Marine Plastic Pollution

NIAS – Non-Intentionally Added Substances

NOAA – National Ocean and Atmospheric Administration

PACPOL – Pacific Ocean Pollution Prevention Programme

PHAs – Polyhydroxyalkonoates

PLA – Polylactic Acid

POPs – Persistent Organic Polluants

PRF – Port Reception Facilities

PS – Polystyrene

PVCs – Polyvinyl Chloride

SDWG – Scheme Design Working Group

SPREP – Secretariat of the Pacific Regional Environment Programme

SPRFMO – South Pacific Fisheries Management Organisation

SUP – Single Use Plastic

UN – United Nations

UNEP – United Nations Environment Programme

WCPFC – Western Central Pacific Fisheries Commission

List of Figures

1. Executive Summary

Tackling plastic pollution in New Zealand's fin fish industry.

This study aims to seek ways to prevent marine plastic pollution leakage in New Zealand's commercial fin fishing industry supply chains. Drawing on a case study approach, this research investigates how sea and land-based plastic material flows are perceived by those working for commercial fishing company Moana NZ. It considers current global, regional and national policies, as well as current initiatives that seek to minimise marine plastic pollution and considers the potential for their implementation in this context. This study also acknowledges the significant role that industry can play in implementing best practice guided by the top of the zero waste hierarchy.

Background

Marine plastic pollution (MPP) is internationally recognised as evidence of a global plastic pollution crisis. The world's oceans have become the ultimate sink for increasing volumes of plastic production. Millions of tonnes of mismanaged plastics enter the ocean annually. MPP threatens the health of marine ecosystems, carrying an economic burden to the industries that rely on oceans, such as fishing and tourism, exacerbating climate change impacts, and threatening coastal communities directly reliant on marine life for their own survival. Commercial fishers are contributing significantly to global MPP as a result of abandoned, lost or discarded fishing gear (ALDFG). The land-based elements of commercial fishing involve the processing, packaging and distribution of fresh seafood (all of which involve the use of plastics) and these can lead to the leakage of plastics into the environment, including marine environments. This report responds directly to Section 4 of the NZ Prime Minister's Chief Science Advisor's report *Rethinking Plastics* (2019), 'Create and Enable Consistency in Design, Use and Disposal' (p. 15) which proposes active dialogue with fisheries and other sectors toward opportunity identification and target setting for plastic pollution reduction.

Methods

This qualitative study examines the attitudes and perspectives of people working in Moana NZ's fin fish supply chain. Moana NZ is the largest Māori owned seafood company and the only business owned by all iwi (Māori tribes) in Aotearoa, New Zealand. The research methods involved semi-structured interviews with contract fishers and other staff members, as well as an online survey and observations of fin fish operations. The aim was to determine participants' understanding of the issue, potential solutions, and perceived barriers to change. All interviews were transcribed, and the data was coded and analysed using NVivo© Qualitative Analysis software. The dominant ideas and concerns expressed by participants in the interviews were then considered in relation to the broader context of the MPP and the commercial fishing industry as well as potential solutions offered in the literature and publicly available agreements, strategies, plans and reports.

Findings

This report finds that plastics are used extensively throughout the fin fish supply chain (land and sea-based operations). Poly bins (expanded polystyrene bins) were noted as the key material of concern. Cost was noted as one of the biggest barriers to significantly reducing the use of plastics – as this will inevitably require operational change in fish processing and distribution. Amongst participants, there was a general willingness to improve the use of plastics to ensure the long-term sustainability of the marine environment and the fishing industry.

The policies and plans of the New Zealand Government, and the ongoing work of regional and international bodies signal systemic changes in the use, production and disposals of plastics including commercial supply chains. Companies such as Moana NZ would be advised to pre-empt these changes in order to ensure they meet their legal obligations to forecasted multi-scale plastic pollution regulations.

Recommendations

Based on the findings, the following mechanisms for reducing plastic use and leakage throughout the fin fish operations of Moana NZ are proposed:

Table 1 **Mechanisms to Reduce Plastic Usage Throughout the Fin Fish Supply Chain (Moana New Zealand)**

Action	Strategy	Actor/s
Rethink	Rethink global distribution system - scope for circularity and container return scheme (poly bin)	**Industry/Management**
	Collaborate with other members of the industry for the procurement of wool cool as a poly bin alternative - economies of scale	**Industry/Management**
	Consider the ways that Extended Producer Responsibility would work within this supply chain	**Management**
Redesign	Continue development of kelp poly bin prototype	**Management**
	Redesign plastic packaging to ensure it is fully recyclable in onshore recycling facilities (or that it is compostable)	
	Work towards finding a redesigned fishing net that uses an alternative to plastic	**Management/Fishers**
	Conduct research about viable plastic alternatives to fishing gear such as ropes	**Fishers/Management**
Reduce	Set specific plastic reduction targets throughout entire operations	**Management**
	Evaluate current procurement practices and switch to suppliers with better management or to products containing more less virgin plastic	**Management**
	Prohibit the purchase of non-recyclable or SUP products from producers (i.e plastic wrapped bait)	**Management**
	Phase out single use and hard to recycle plastics throughout all operations	**Management**
	Implement a reduction in ice and bait bags and food packaging on fishing vessels	**Fishers/ Management**
Reuse	Ensure fishing gear is re-used and repaired as much as possible	
Recycle	Ensure all plastic used in packaging and processing is recyclable in domestic recycling facilities	**Management**
	Provide adequate information and education about recycling to all staff	**Management**
	Support initiatives to recycle products such as gum boots (which can be made into the mats on childrens play equipment)	**Management**
	Collaborate with local companies who are using recycled fishing nets or collected MPP to produce certain products	**Management**
	Ensure mandatory recycling of fishing gear such as nets	**Management**
	Collaborate with Terra Cycle to establish methods to reduce plastic waste in factory	**Management**
Recover	Ensure lost fishing gear is reported and retrieved where possible	**Fishers**
	Ensure mandatory reporting of lost gear	**Management**
	Develop gear audit system of plastics on and off vessel	**Management**
	Incentivise the collection of MPP of fishers while at sea	**Management**
	Organise community beach cleans in areas of high fishing activity	**Management**
	Continue developing collaborative project with ghost diving NZ	**Management**
	Ensure mandatory marking of fishing gear	**Management**

Conclusion

An examination of relevant policies, plans, strategies, and initiatives (national, regional, and global) illustrates that the tide is turning in relation to the production and consumption of plastics. The New Zealand Government aims to make 'best practice standard practice' when it comes to the production, consumption, and disposal of plastics. However, 'best practice' for the full commercial fishing supply chain has not yet been established. The co-development of plastic pollution best practice by industry, independent researchers, communities, iwi, and policymakers will significantly enhance the international reputation of Aotearoa's fin fishing industry as leaders of plastic pollution prevention while also reducing plastic pollution in the marine environment.

2. Background

This study comes at a time when the global plastics crisis discourse is prevalent in the media, and in the public consciousness, with policymakers, and across multiple scales of governance. The New Zealand public no longer sees the crisis as something that is the responsibility of other nations but one of a collective global responsibility. The Prime Minister's Chief Science Advisor's *Rethinking Plastics Report* (2019) states:

> Aotearoa New Zealand is at a pivotal point where we must rethink our relationship with plastics. Increasing public concern over the harmful effects of plastic pollution on our environment and health, and a growing appreciation of what we can learn from te ao Māori values such as kaitiakitanga, make it an opportune time to initiate changes to mitigate the negative impacts of plastics while retaining its many benefits. We are in a unique position where we can weave our understanding of science, society, and economics with mātauranga Māori to establish new practices that make a difference by reducing plastic pollution. Acting now is critical to preserve our natural environment for generations to come.

The prevalence of the plastics crisis is reflected in global and local policy frameworks, initiatives, community groups and consumer choices. There has been a growing recognition that the status quo when it comes to plastics is not sustainable and large-scale change is required throughout sections of society in order to overcome our systemic plastic crisis.

The ubiquitous and deep time implications of plastics are expressed by Villarrubia-Gomez, Cornell and Fabres (2018). They argue that plastic pollution has become so pervasive that it is now a threat to the planetary boundaries (the safe operating space for the existence of human societies within the Earth's system) (Steffen et al. 2015), infiltrating our natural systems in an irreversible way. This synthetic material is so widespread throughout the environment that it is considered a geological marker of the Anthropocene: the emerging epoch in which human activities now have a decisive influence on the state, dynamics, and future of the Earth's system.

Plastic is now pervasive in terrestrial, marine, and freshwater environments globally (Xanthos & Walker 2017). Two articles published in Science in September 2020 concur that drastic measures will need to be taken to begin to offset the amount of plastics produced annually and the growing volumes entering the world's oceans (Lau et al. 2020; Borrelle et al. 2020). The study conducted by Borrelle and colleagues (2020) indicates that, even with ambitious and coordinated international commitments, annual global emissions could reach 53 million metric tonnes per year by 2030.

The properties that make plastic so appealing: its durability, lightweight, strength and low cost, make plastics the most highly demanded consumer material in the world (Hopewell et al. 2009). Modern society has experienced an exponential growth in the use of plastics. In the 1950s, world plastic production was approximately 2 million metric tonnes (Dauvergne, 2018). In 2018, global plastic production was estimated 359 million tonnes (Plastics Europe 2019). There are estimates that this figure may double within the next 20 years (Lebreton & Andrady 2019) and some estimates suggest that plastic consumption may quadruple by 2050 if we maintain the status quo (World Economic Forum 2016). It is estimated that 99% of plastics are fossil-fuel based. Of this, 38% are used in the packaging industry (Rabnawaz et al. 2017). Plastic packaging is one of the most prevalent forms of plastic pollution that is found: accounting for 13.3% of the litter found in the 2017/18 National Litter Survey (Rethinking Plastics in Aotearoa New Zealand 2019).

The contamination of land, sea, and air with microplastics (size of 1–5000 μm) and nano plastics (size < 0.1 μm) carries ecological implications. Microplastics can either be primary (i.e. intentionally produced) or secondary (i.e. when plastic fragments into micro sized pieces). All plastics in the marine environment will eventually degrade into micro and nano sized particles (Rochman et al. 2019). When plastics degrade, their associated chemicals (including solvents, non-intentionally added substances (NIAS), oligomers, monomers, intermediates, surfactants, plasticizers, stabilizers, biocides, flame retardants, colourants, accelerators) can leach out. When they degrade, plastic particles also become small enough to be ingested by birds, fish, molluscs and other marine species, when they are mistaken for food. This exposes humans to toxicants when seafood is consumed.

The possible effect of microplastics on human health through the consumption of seafood is an emerging line of enquiry (Waring et al. 2018). However, early studies of micro and nano-sized plastic particles show that they disrupt the reproductive and central nervous systems of aquatic and non-aquatic animals (Waring et al. 2018), and people (Sarasamma et al. 2020). Their small size allows them to pass through the blood brain barrier (Mattsson et al. 2017). When organisms ingest micro and nano plastics, they can be transferred between trophic levels in the food web (Bergmann et al. 2015). At the time of writing this report, a study was published showing the first evidence of microplastics in a human placenta (Ragusa et al 2020). The toxicological implications for human health is also a growing concern (Seltenrich 2015; Barboza et al. 2018). Barboza et al. (2018) call for close monitoring and preferably a strict regulatory framework to ensure food safety and protect people from the consumption of plastic particles and associated chemicals including phthalates, antimony, styrene monomer, bisphenols and a range of persistent organic pollutants (POPs.).

3. Introduction

This study examines the use of plastics in the fishing industry with the broad aim of minimising MPP. A research case study of a fishing company in Aotearoa (Moana NZ) was undertaken to identify the key challenges and barriers faced by Moana NZ in preventing plastic pollution in their land and sea-based operations.

This report outlines a small-scale qualitative research project conducted at the beginning of 2020. The study focused on the perspectives of those working as contract fishers and other Moana NZ staff members. The study sought to answer the following research questions:

- Where and how plastics are used throughout the fin fish supply chain?
- What are the potential areas for reduction or improvement in the use of plastics?
- What are the attitudes and perceptions of staff and contract fishers to MPP?
- What are staff and contract fishers' perceptions of the challenges and solutions to preventing MPP?

The attitudes and perceptions of Moana NZ management and contract fishers and the recommendations summarised in this report may contribute to the development of measurable, time-sensitive and ambitious plastic pollution elimination targets for Aotearoa's fin fishing industry.

3.1 Marine Plastic Pollution

The world's oceans have become a major sink for a significant proportion of plastic debris (Pabortsava & Lampitt 2020). Pathways for plastics to the ocean from land-based sources include river, stormwater and sewerage systems, wind, rain, failed landfills, and storm surges (Reisser et al. 2013). It is estimated that 19-23 million metric tonnes entered the world's marine ecosystems in 2016. This constituted 11% of the plastic produced globally in that year (Borrelle et al. 2020). Statistics such as this have led to the declaration by the United Nations Environment Program (UNEP) that plastic pollution is 'one of the biggest threats to the world's oceans' (UNEP 2020). Estimates suggest that there is at least 79 thousand tonnes of plastic floating in the Great Pacific Garbage Patch (an area of ocean that is 1.6 million square km in size that occurs in the sub-tropical waters between California and Hawaii) (Lebreton et al. 2018). Of these, 1.8 trillion pieces were microplastics and of the larger debris 46% comprised of fishing nets (Lebreton et al. 2018). Another commonly observed microplastic is expanded polystyrene (EPS) (Eriksen et al. 2014). Polystyrene fish bins ('poly bins') are made of EPS and are highlighted as a material of primary concern in this study.

MPP has many negative environmental, social, and economic impacts (Xanthos & Walker 2017). Environmentally, MPP can lead to the entanglement of animals (Stelfox et al. 2016). It can also impact marine animals through ingestion, strangulation, blocked intestinal tracts, and the spread of pathogens and invasive species (Avery-Gomm et al. 2018). Economically, MPP has aesthetic impacts on coastlines which can lead to a decrease in tourism (Jang et al. 2014). MPP also poses a threat to the commercial fishing industry due to damage and loss to vessels and gear. It is estimated that the economic impact of MPP on marine environments is approximately $13 billion (US) annually (Xanthos & Walker 2017). A polluted ocean poses a particular threat to the cultural identity, health, and wellbeing of Pasifika peoples. The ocean is core to the cultural identity of the Indigenous peoples of Oceania and coastal communities are directly reliant on a healthy marine environment for their livelihoods, wellbeing, and sustenance.

3.2 Plastic pollution and the fishing industry

Many items commonly used in commercial fishing contain plastics. These include nylon lines, ropes, nets, traps, pots, and artificial drifting fish aggregating devices, light sticks, floats, poly bins, fish tubs, safety and wet weather gear and packing bands, and the plastic packaging used for food and beverages taken on board by fishers while at sea. Polypropylene, polyethylene and nylon are the polymers most used in the fishing industry (Deshpande et al. 2020). Some degrade or fragment at a faster rate than others in the marine environment depending on their application (Deshpande et al. 2020). For example, nylon long lines are among the most likely fishing gear to be lost on deployment, whereas purse seines are rarely lost. The use of nylon lines (for commercial long lining) can cause entanglement for marine animals and ecosystems. These can be particularly damaging for fragile ecosystems such as coral reefs and other benthic communities (GGGI 2017). Some particularly durable fishing gear may be repaired or reused several times before replacement is necessary (Deshpande 2020). Gillnets and traps/pots are the two types of fishing gear that carry the highest risk of becoming ghost gear (fishing gear that has been abandoned, lost or discarded and continues to fish through entanglement and entrapment). However, mid-water trawls and purse seines need to also be considered when discussing ghost gear (GGGI 2017).

Other areas of concern are microplastics associated with the paint used on ships and fishing vessels. Lacerda et al. (2019) found fragments of paint particles (of which the polymer composition was polyurethane) in varying degrees of degradation at all their sampling sites in the Southern Ocean. Thirty times more paint fragments were present in the samples than other plastics. An additional area of concern is that of biofouling. This typically occurs when micro or macro-organisms increase the material density of plastics in the marine environment causing them to lose positive buoyancy and sink (Fazey and Ryan 2016). When vessels and gear are submerged, biological communities, and organisms, such as barnacles, can grow on them. When they are cleaned off fishing gear or vessel hulls, or they fall off, they can take fragments of plastic with them contributing to MPP. MPP has also been found to increase risks associated with the rafting of invasive species and pathogens (Rech et al. 2018).

Commercial fishers contribute significantly to global MPP. ALDFG accounts for approximately 10% of all MPP (Macfayden et al. 2009). However, it is likely that this is a conservative estimate as Lebreton (Lebreton et al. 2020) found that 46% of macro plastic debris in the Great Pacific Garbage patch is ALDFG. According to the Food and Agriculture Organisation (FAO) (2016), every year at least 640,000 tons of ALDFG finds its way into the sea. For the purpose of this study, fishing gear is defined as:

> any physical device or part thereof or combination of items that may be placed on or in the water or on the seabed with the intended purpose of capturing or controlling for subsequent capture or harvesting, marine or freshwater organisms whether or not it is used in association with a vessel (FAO 2016, p. 2-3).

ALDFG includes monofilament lines and nylon netting which do not degrade over time but float at varying depths in the ocean trapping fish and other aquatic organisms in a process known as 'ghost fishing' (Matsuoka, Nakashima & Nagasawa 2005). In Europe, it is estimated that 80-85% of marine debris on beaches is plastic and of this, 27% is fishing-related (EU Directive 2019b). Aotearoa's commercial fishers are contributing to this problem. For example, of the 24 fish bins found washed up on Rapa Nui in 2016/17, 18 were identified as belonging to NZ and Australian fishing companies (Rethinking Plastics in Aotearoa New Zealand 2019).

Identifying the causes of ALDFG is an important step in attempting to overcome the issue. MacFayden, Huntington and Cappell (2009) demonstrate that as fishing gear can either be 'abandoned', 'lost' or 'discarded', its entry into marine environments is either intentional or non-intentional. Causes for ALDFG include factors such as bad weather, other fishing activities, other marine activities such as merchant shipping, operational errors, and theft (MacFayden, Huntington and Cappell 2009). However, the Global Ghost Gear Initiative Ghost (GGGI) reminds us that fishers do not wish to lose expensive gear 'but sea conditions, equipment failure, the actions of others and safety considerations can lead to loss or abandonment of gear' (GGGI 2017, pp. 19). Furthermore, it should be noted that there is a greater economic incentive to abandon low-value gear, especially in medium to large scale fisheries, as a result of the difference in the cost of replacement (MacFayden, Huntington and Cappell 2009). The availability of adequate waste disposal facilities is another factor that can cause ALDFG. After a limited life span, the majority of fishing gear has to be discarded. This can either be done in a designated disposal facility at port (which may carry a cost), or if the cost is too great or in the absence of adequate facilities, it may be irresponsibly disposed of at sea, leading to ALDFG (MacFayden and Huntington 2009). A study by Richardson et al. (2018) shows that the ghost nets causing issues on Australia's Northern coastlines mostly originate from Southeast Asian fishing vessels operating outside of Australia's Exclusive Economic Zone (EEZ). Using a fault tree analysis, Richardson et al. (2018) found that the reasons for this ALDFG was largely due to overcrowding (of vessels) and illegal, unreported and unregulated fishing activity. Issues such as overcrowding on vessels are likely to be more prevalent in regions where there is larger degree of unregulated or illegal fishing practices.

A full life cycle approach to plastic fishing gear includes the responsible management of ALDFG retrieved from the marine environment. Plastics can be brought back on vessels and then offloaded into waste reception facilities at ports if they are available. However, this does not necessarily mean they are then responsibly managed at land-based facilities. ALDFG are often contaminated with rotting biomass and are difficult to clean, reuse, or recycle. It is important to note here that the most significant aspect in relation to the best practice management of ALDFG is through prevention rather than just mitigation (i.e. recovery). At the end-of-life phase of plastic fishing gear, this includes the provision of adequate disposal facilities that work to encourage the responsible behaviour of fishers and subsequent responsible disposal. The provision of adequate disposal facilities ensures that barriers to the responsible disposal of end-of-life fishing gear are eliminated (GGGI 2017).

Commercial Fishers' roles as the problem and a potential part of the solution makes them ideally positioned to contribute to MPP prevention strategies. Fishers sustained presence in relatively isolated marine environments means they have the potential to support MPP monitoring (including self-monitoring). While studies in MPP and the fishing industry often focus on the retrieval of existing MPP (Wyles et al. 2019, Ronchi et al. 2019), this study explores mechanisms to prevent MPP entering the ocean. It is known that MPP emissions from fishing vessels are globally significant, however the perceptions of staff in

commercial fisheries and seafood businesses to the flows of plastics across the full supply chain (including land-based operations) will contribute to effective plastic pollution prevention strategies. Fleming et al. (2014, p. 40) put forward a case for investigating the supply chain as a whole, stating that 'a holistic perspective allows examination of barriers and opportunities that would not be apparent from a focus on a single element, such as the wild fish capture stage. This study, therefore, explores the leakage of plastics to the environment throughout the entire supply chain. The aim of this study shares similarities with that of Deshpande et al. (2020), who use a material flow analysis to quantify the plastic waste generated throughout the supply chain of commercial fisheries in Norway. However, this study takes a qualitative approach to inform an understanding of the ways in which plastics move through one commercial fishing company. This includes the plastics used in processing and distribution and fishing gear used on vessels.

3.3 Global context - Policies and Initiatives for potential solution

As the urgency of the plastic waste crisis intensifies, solutions at local, national, and international levels have been offered to attempt to mitigate and prevent MPP across the full life cycle of plastics. MPP is a truly global environmental challenge. Over 50% of the world's oceans are situated outside national jurisdiction (Borrelle et al. 2017) making the development of policy frameworks even more challenging (Vince and Hardesty 2017).Avery-Gomm et al. (2019, p. 217) argue that MPP is a 'clear example of the tragedy of the commons, difficult to manage and govern globally'. Attempts to respond to the plastics crisis at multiple scales of governance have been unsuccessful. Current national, regional and global policy relevant to plastic pollution has been described as ad hoc, and lacking in the following areas: attention to the full life cycle of plastics; a focus on prevention at the top of the waste hierarchy; transboundary flows of plastics outside of formal trade arrangements and monitoring, coordination, and regulation (e.g. see Dauverge 2018, p.22). There are increasing calls for a multi-governance structure and a legally binding global treaty dedicated to global plastic pollution (Borrelle et al. 2017, Farrelly & Green 2020 , Tessnow-von Wysocki and Le Billon 2019,Vince & Hardesty 2017).

Despite the lack of a dedicated plastic treaty, extensive efforts have been made globally to address MPP. Many of these efforts include measures for the commercial fishing industry. These have included various policies from international bodies such as the United Nations (UN) and the International Maritime Organization (IMO). The 1973 Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL) bans the dumping of pollution by ships and has been instrumental in setting regulations to prevent ALDFG. However, MARPOL focuses on MPP and fails to address the 80% of plastics that enter the ocean from land-based sources (Borrelle et al. 2017). The 'London Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter 1972' and its subsequent 'London Protocol 1996' seek to minimise harm inflicted on the marine environment as a result of human activities by controlling the sources of marine pollution (IMO 2019).The FAO have developed guidelines for the marking of fishing gear, which seeks to implement a comprehensive gear marking scheme. The schemes includes identification of illegal, unreported, and unregulated fishing activities and provides traceability for commercial fishing gear. The marking of fishing gear can also help to identify sources of ALDFG. While these are voluntary and, therefore, are not legally binding, they have been adopted by FAO members (FAO 2019).

Global efforts, such as the United Nations Environment Programme Clean Seas Initiative (2017), the Global Ghost Gear Initiative (GGGI) and the IMO GloLitter Partnerships project seek to minimise the plastics entering the ocean from ships and vessels and to retrieve MPP already in the ocean.The GGGI targets fishing gear already in the ocean through a cross sector partnership of fishing industry representatives, stakeholders, NGOs, governments and academics (GGGI 2017). They also emphasise working with fishing communities to establish best practice mechanisms for industry to stop plastic gear from entering the ocean. The IMO GloLitter Partnerships Programme works with the FAO to prevent MPP from fisheries and shipping. Their mechanisms for prevention include addressing the adequacy and availability of port reception facilities, the marking of fishing gear, and enhanced awareness and education about the issues surrounding MPP (IMO 2020). The IMO have also adopted an Action Plan to address marine plastic litter from ships, which looks at ways to enhance existing measures and establish new mechanisms to prevent plastic litter from ships.This includes measures such as reviewing the provision of training for fishers, enhancing public awareness, strengthening international networks and cooperation (such as the UNEP and FAO) and the mandatory marking of fishing gear (as per the guidelines by the FAO) (IMO 2018).

In 2011, UNEP, alongside the National Oceanic and Atmospheric Administration (NOAA), launched the Honolulu Strategy, a global framework for the prevention and management of marine debris. The strategy presents a range of recommendations and best practices for the land and sea-based operations of the commercial fishing industry to minimise plastic leakage into the marine environment. Specific examples include 'the use of fishing gear modifications or alternative technology', 'incentives to take waste back to port', 'approaches for end of life materials management for packaging materials', and 'voluntary extended producer responsibility' (UNEP 2011a). However, these rely on voluntary action and without a legally binding international treaty, these actions cannot be enforced.

At the regional level, there have been some significant initiatives and policies to mitigate and prevent MPP. Notably, the NOAA Marine Debris Program to retrieve existing MPP and prevent future MPP (NOAA 2020). In addition, in the European regions the *European Commission's Single Use Plastic (SUP) Directive* is a legally binding framework that outlines the ways in which the EU can transition towards a circular economy by rethinking the design, production, consumption, and disposal of plastics (European Commission 2020b). A circular economy approach involves designing pollution out of economies while keeping materials in use within the system for as long as possible. The *EU Plastics Directive* is a unique regional effort to reduce plastic pollution because the agreements under the directive are transposed into the legislation of member states and are, therefore, enforceable. The European Commission has also produced a set of guidance standards for the circular design of fishing gear, in which they establish the importance of relying on recycled/reused plastics and phasing out virgin plastics in the manufacturing of new fishing gear (European Commission 2020b).

A major component of the Directive is Extended Producer Responsibility (EPR), some of which relates directly to the fishing industry under Article 4:

This Directive recognises that plastic fishing gear has a high recycling potential. Producers are responsible for financing the environmentally sound waste management of the plastic components of fishing gear. The Directive also applies the 'polluter pays' principle to ensure producers are responsible for the collection of ALDFG.

> Member States [of the EU] shall ensure that extended producer responsibility schemes are established for fishing gear containing plastic placed on the market of the Member State, in accordance with Articles 8 and 8a of Directive 2008/98/EC … Marking requirements are already required for fishing gear pursuant to Regulation (EC) No 1224/2sm9 … In the framework of an extended producer responsibility for fishing gear containing plastic, Member States should monitor and assess, in line with the reporting obligations laid down in this Directive, fishing gear containing plastic.

3.4 Regional Context

The Pacific Islands rely heavily on fishing and tourism for their gross domestic product (GDP), and MPP has significant impacts on these. Seafood is the main source of protein for most Pacific Island peoples (Charlton et al. 2016). Therefore, in addition to the significant risks MPP presents to the economies, cultural identities, and wellbeing of Pacific nations, MPP is also a food security issue. Programmes such as the Cleaner Pacific and the Pacific Ocean Pollution Prevention Programme (PACPOL) that works with the IMO and the Secretariat of the Pacific Regional Environment Programme (SPREP) are significant initiatives in attempting to mitigate this issue in the Pacific. The Pacific Regional Action Plan for Marine Litter has been developed by SPREP to illustrate the policy context and the main actions for minimising MPP in this region. The commercial fishing industry in NZ impacts Small Island Developing States in the Pacific. As a metropolitan member of SPREP, Aotearoa has obligations to act in the best interest of Pacific Island Countries and Territories (PICTs) in relation to marine pollution.

3.5 New Zealand Context

Aotearoa is an island nation with strong cultural ties to the ocean. Despite its relatively small size, it has the fourth largest EEZ in the world. Its seafood sector contributed $1.8 billion of the export market in 2017 (Rethinking Plastics 2019). The Rethinking Plastics Report (2019, p. 52) states:

> Our wellbeing is connected to the wellbeing of the oceans. Māori have a deep connection to the sea (Tangaroa) and this is shared by most other New Zealanders. In addition to the commercial fishing industry, our community depends on a healthy marine environment for recreational fishing. There is both an expectation and a shared responsibility to keep it free from plastic pollution.

It is particularly pertinent that the necessary steps be taken to ensure the wellbeing of Aotearoa's unique marine ecosystems. In addition, the Government has emphasised that the industry must exercise best practice and strong leadership to retain its excellent reputation (Rethinking Plastics Report 2019).

Solutions at a local or national level have been the primary form of mitigation of marine plastic pollution (Borrelle et al. 2017). While any long term, global, and significant impacts can only be achieved by a coordinated and regulated global effort, local initiatives can result in some tangible outcomes (Vince and Hardesty 2017). A commitment to mitigating this problem can be seen on a domestic scale in NZ. Organisations such as the Aotearoa Plastic Pollution Alliance (APPA) are seeking to prevent plastic pollution both in New Zealand and Oceania more broadly. APPA (2020) is a collaboration of researchers, industry and conservationists, who wish to engage policy makers and the public in order to develop tools to mitigate plastic pollution.

Aotearoa has implemented legislation to ban the illegal dumping of waste from ships (including commercial fishing vessels) in accordance with international and regional conventions and initiatives, including MARPOL, the Western and Central Pacific Fisheries Commission (WCPFC) and the South Pacific Regional Fisheries Management Organisation (SPRFMO) – via Conservation and Management Measures (CMMS; CMM 2017-04 and CMM 17-2019).

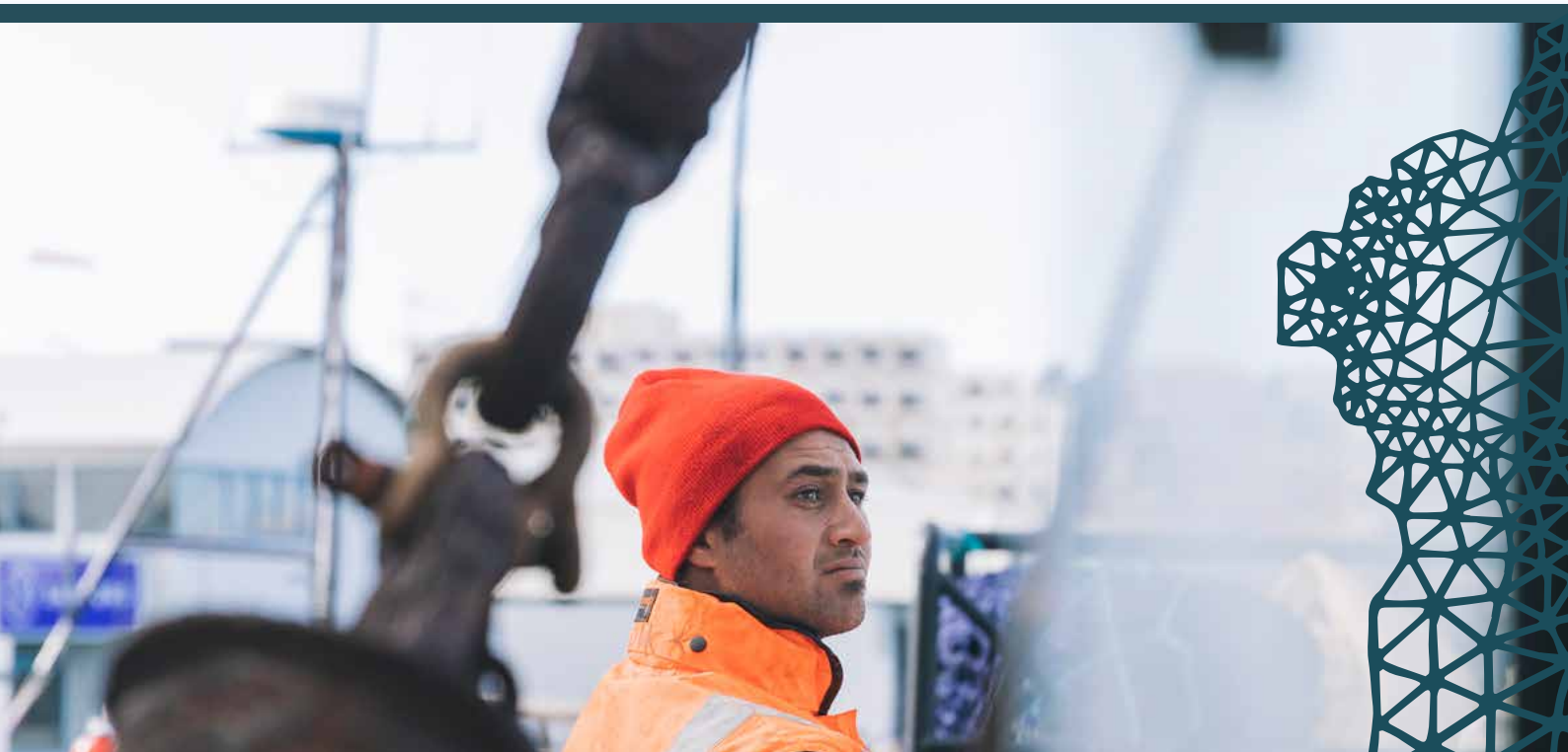
The Prime Minister's Chief Science Advisor's Office released *Rethinking Plastics* in 2019. The report details certain strategies to help NZ move away from its dependence on plastics. Partly in response to the release of the report, in August 2020, the Government released a proposal to phase out a range of single-use items and hard-to-recycle plastics including Polystyrene (PS), expanded Polystyrene (EPS) and Polyvinyl chloride (PVC). If accepted by Cabinet, the proposed phase out is highly likely to impact the supply chains of commercial fisheries (this is discussed in more detail later in the report). Of particular interest to this study is the proposed phase out of EPS bins (poly bins). The

Government proposes cardboard with wool insulation as the alternative currently available on the market (MfE, 2020, p. 41). Furthermore, a national container return scheme (CRS) has also been designed by a national multi-stakeholder scheme design working group (SDWG) in Aotearoa. The scheme will initially capture beverage containers but the CRS managing agency will be tasked with expanding the scheme to capture a broader range of containers which will likely significantly impact on the fishing industry.

The *Rethinking Plastics* report (2019) encourages local councils to support the imposition of targeted restrictions or levies on undesirable and problematic materials. The report offers the example of fishing centres as sites where these problematic plastic materials can be concentrated (p. 46). The report identifies fisheries as one of the sectors most in need of plastics reduction strategies. This report responds directly to section 4 in *Rethinking Plastics*, 'Create and Enable Consistency in Design, Use and Disposal' (p.15) which proposes active dialogue with fisheries and other sectors toward opportunity identification and target setting. It is clear from the *Rethinking Plastics* report that current plastics use in the fishing industry is set to change. The *Rethinking Plastics* report (2019, p.52) emphasises the value of the seafood sector to the NZ economy. The impacts of plastic pollution on the industry will be hard felt throughout NZ if significant changes are not made now in plastics use and leakage from the industry's operations. *Rethinking Plastics* (2019, p. 52) acknowledges that a lack of industry response to plastic pollution will also damage NZ's reputation as 'leaders on ocean issues':

> **With fisheries plastic gaining increasing international attention, poor practice by Aotearoa New Zealand may pose a reputational risk but best practice may present an opportunity to show international leadership on the issue'.**

New Zealand seafood is recognised internationally as a high-quality product (Ministry of Business Innovation and Employment 2017). Consumers want to buy products from trusted and sustainable sources. A recent industry-led survey found that close to 70% of consumers were willing to pay more for a product that came from a company committed to making a positive environmental and social impacts (Nielsen 2015).



3.6 The role of industry

While there is currently an unprecedented volume of policy development in the plastic pollution and waste management space in NZ, national, regional and particularly global policy frameworks are relatively slow to establish and enact.

Vince and Stoett (2018) argue that industry should be playing an important role in transitioning away from a linear single use economy and toward a circular economy. In the absence of any national mandatory producer responsibility schemes, there are pockets of industry that are voluntarily working towards mitigating the plastic pollution crisis by investing in circular economy approaches. Those companies are generally strong advocates for mandatory product stewardship, which, if regulated nationally, would even the playing field and eliminate opportunities for 'free riding.'

There are some global and regional initiatives that are incentivising industry advances in the sustainable use of plastics. Many of these involve the fishing industry either directly or indirectly. Among these are prototypes for green chemistry products (such as MarinaTex – the plastic film made from fish scales) and circular economy models within the industrial sector (such as Fishing Filaments (UK) which uses old fishing nets and recycles them to make 3D printed filament and plastic granules). Industry is also working towards finding suitable alternatives to plastic products and integrating these into existing industrial structures, such as cotton-based mussel ropes that are currently being used in aquaculture in NZ and Ireland. Seafood Business for Ocean Stewardship (SeaBOS) connects key actors in the fishing industry to science and research with the aim of improving sustainability within the industry throughout a range of issues, including plastic pollution. SeaBOS (2020) is a member of the GGGI and they work towards tackling ALDFG in marine environments. The European Fisheries Area Network (FARNET), based on recommendations from the *EU Strategy for Plastics in the Circular Economy* (EC 2020a), argue that fisheries should consider all stages of the supply chain when examining what scope they may have to move towards more circular and sustainable industrial systems. Therefore, they suggest that fisheries:

> … ask themselves where there is scope for re-thinking the design of production systems and products (eco-design); what to do with waste and by products from fisheries/aquaculture production; how equipment and products are used and maintained and what happens with the materials from these products when they come to the end of their life (recycling) (FARNET 2019, p. 5).

3.7 Zero Waste Hierarchy

The Zero Waste Hierarchy is a tool that has been developed to provide guidance in waste and resource management and to assist in the transition from a linear to a circular economy (Zero Waste Europe 2019). The Hierarchy prioritises the rethinking and redesigning of the way that we produce and consume goods towards zero waste economies. The second-tier priorities are aimed at reducing the quantity of plastics we use and minimising our ecological footprint by reusing and repurposing products.

Lower on the hierarchy is recycling, where plastics are collected from waste streams and are turned into high quality secondary raw materials/products. Materials recovery aims to keep materials and resources within the plastics economy loop. For the purposes of this study, the retrieval of MPP from the ocean is considered materials 'recovery'. Drawing on the waste hierarchy, policy makers, industry, and other stakeholders should prioritise actions which focus at the top end of the hierarchy, with the primary aim of phasing out problematic plastics (Vince and Stoett 2018).

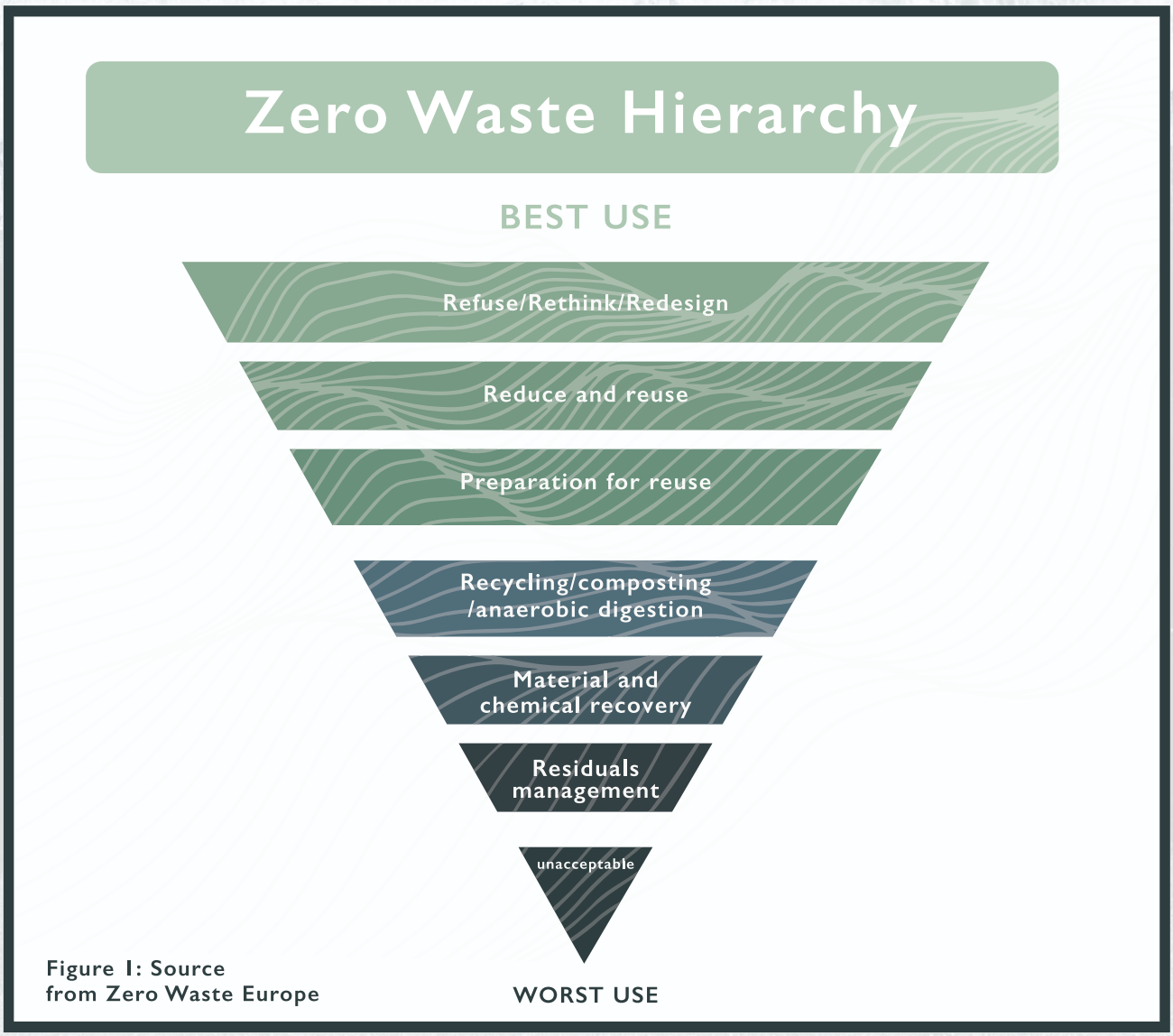


Figure 1: Source from Zero Waste Europe

3.7.1 Refuse, Rethink, and Redesign

Solutions to minimise plastic pollution from the land-based element of commercial fisheries should look at ways to refuse plastics, but where this is not possible, it should look at ways to minimise the use of plastics, rethink the current industrial system and redesign the flows of plastics to start transitioning towards a circular economy (Ruiz-Salmon et al 2020). Product stewardship ensures all parties involved in the life cycle of a product accept responsibility for the externalised environmental impacts of the products. Extended producer responsibility (EPR) incentivises producers to design safe, reusable, regenerative, and recyclable products (Tibbetts 2015) and sustainable delivery systems and services.

Fishing gear is generally made from high quality plastics such as polyamides (nylon) (CONH) or polyethylene (PE), with the potential to be repaired, re-used and recycled (Rethink Plastics Alliance 2020). EPR of plastic fishing gear would incentivise diversion of old fishing gear from landfill, and littering/discarding. Successful EPR schemes for the seafood sector would be mandatory and would place a value on lost and discarded fishing gear and plastics discarded in land-based fin fishing industry operations. A successful EPR based on the zero waste hierarchy would prioritise the elimination any unnecessary, toxic plastics, non-durable plastics and incentivise reuse systems.

Eco-proofing the production systems of fisheries is seen as a mechanism to help the industry transition to a circular economy (FARNET 2019). The eco-design of products involves considering the full life cycle of a product, rather than just the traditional linear model of produce, consume, and dispose. This involves thinking about what the product is made of, how it is used, how many times it can be reused, if it can be replaced with a more sustainable, durable, or safe material, if delivery systems can be altered to reduce or eliminate plastics and their associated toxicants, and if it can be recycled or reused at end of useful life.

Packaging is identified as one of the main sources of plastic pollution in the seafood sector (Rethinking Plastics 2019). It, therefore, must be recognised that there are elements of the land based components of the supply chain that need to be addressed in order to minimise plastic waste in the fishing industry. One of these is a rethinking of the way in which fresh seafood is packaged and distributed. De la Caba et al. (2019) argue that food waste can close the loop when it comes to plastic packaging by producing bio films for the packaging and distribution of fresh produce. Janes and Dai (2012) investigate the use of edible films for use on meat, poultry, and seafood. They suggest that these films can include food additives such as antimicrobials which can reduce microbial growth on the surfaces of food products and can extend the shelf life of the product while also minimising packaging waste and preventing pollution (Janes and Dai 2012). Ruiz-Salmón et al. (2020) further argue that packaging is one element of the seafood supply chain that will need to be altered in order to move toward a circular economy, as it currently carries heavy environmental burdens. They argue that while recyclability is a desirable trait for packaging, challenges include the highly perishable nature of seafood and the need to prevent microbial infection.

Bioplastics (including edible films) are acknowledged for their potential in reducing plastic pollution in the processing and packaging stage of the fresh produce supply chain (Janes & Dai 2012). However, Cho (2011) highlights several problems associated with the bioplastics available on the market today and the waste infrastructure required to manage them at end of useful life. Bioplastics currently available degrade at a similar rate to fossil fuel-based plastics when released into the marine environment and thus pose the same hazards to marine fauna as traditional fossil fuel-based plastics. They release methane as they break down in anaerobic conditions (in landfills), which further increases green house gas emissions adding to the acceleration of anthropogenic climate change. Almost all bioplastics contain endocrine disrupting chemicals (EDCs) also known as 'hormone mimickers'. They release

methane as they break down in anaerobic conditions (in landfills), and most bioplastics can only be composted in a commercial facility, and cannot be recycled (see Rethinking Plastics in Aotearoa New Zealand 2019; Northcott & Pantos 2018). Solutions for mitigating the issues associated with the packaging and distribution of fresh seafood can therefore be seen to carry many complexities highlighting that there is no simple and singular solution.

The redesign of fishing gear to prevent snagging, dragging and other issues that lead to it being lost at sea, or making gear from alternative materials, are important considerations for commercial fishers in minimising their contributions to MPP (Eriksen et al 2020). Kim et al. (2016) found that biodegradable driftnets had a similar catch rate to conventional nylon nets for their focus species, yellow croaker. In their comparison of biodegradable and nylon gillnets, Grimaldo et al. (2019), found that the nylon nets had a far greater catch rate and were, therefore, more efficient. Their findings did show, however, that biodegradable alternatives do reduce the potential for ghost fishing. However, aside from any intrinsic motivation, it could be difficult to convince fishers to implement options that do not maximise their catch. Thomas and Sandhya (2019) found that when a biodegradable float line on trawl nets were used, the float line would degrade relatively quickly in sea water, and the net would sink to the bottom. While this is effective at reducing ghost fishing, it has the potential to cause damage to reefs and other benthic ecosystems. These designs may also reduce fishing capacity and disincentivise fishers.

Bioplastics are plastics that are made from plant rather than oil-based polymers, and while in theory they can have a shorter life span than synthetic polymers, this is dependent on many factors, including the physical and chemical conditions they encounter (Zhu & Wang 2020). The definition and responsible management of 'bio' plastics is complex and their 'greenwashing' is common. Due to a lack of rigid certification and standards in testing, care must be taken when assuming bioplastics are the 'greener' option as current testing does not involve toxicity tests (Zhu & Wang 2020) and the full ecological and biological impacts caused by bioplastics are still relatively uncertain (Narancic et al. 2018).

Napper and Thomson (2019) have shown that bioplastics (specifically biodegradable, oxo-biodegradable, compostable and high-density polyethylene commonly used in compostable bags) do not rapidly degrade in marine and other environments, rather they maintain their function for over three years. Furthermore, Dilkes-Hoffman et al. (2019) have shown that the degradation of polyhydroxyalkonoates (PHAs) (commonly regarded as a marine biodegradable plastic) is actually relatively slow in the marine environment, with a PHA water bottle taking between 1.5 and 3.5 years to completely degrade. When redesigning and rethinking new materials for fishing gear, the adverse effects of swapping to 'bio' plastics should also be considered.

Functionality and efficiency are important aspects in the design of fishing gear and cannot be compromised in the redesign of fishing gear. The redesigning of fishing gear within a circular economy model, must ultimately draw on a high percentage of recycled and reused materials (EC 2020b). When rethinking and redesigning current systems for fishing gear, it is likely that further research and innovation will be needed to design fishing gear that is more recyclable (and eliminating and reducing polymers in circulation) while maintaining core functionality and efficiency (EC 2020b). The European Commission (EC 2020b)

illustrates that collating information can be difficult as much of the work going on in this arena is happening privately through industry. Therefore, the widespread dissemination of current information relating to gear trials and development throughout industry and society more broadly should be encouraged, to bring about effective change (EC 2019b).

3.7.2 Reduce and Reuse

Polystyrene fish bins or 'poly bins' have been noted within this case study and the industry more broadly as a major plastic reduction challenge. Approximately 22 million poly bins are used each year in the UK alone to transport seafood from wild capture and aquaculture (Fidra 2020). Hansen et al. (2012) examine some of the challenges involved in the bulk packaging and transport of fresh seafood; they also explore potential alternative methods and future trends in this area. Since fresh seafood is highly perishable and susceptible to microbial contamination, careful consideration must be taken in the design of packaging materials and delivery systems, including transportation temperature, insulating qualities, and transportation period. Poly bins have been the dominant material for bulk distribution of seafood as they satisfy the requirements for the transport of fresh fish due to their water resistant qualities (making it is suitable for the transport of seafood packed on ice) and thermal insulation properties (Hansen et al. 2012). Poly bin alternatives currently on the market are predominantly made of cardboard.

3.7.3 Recycle

Waste management is the collection, transport, treatment and disposal of waste materials. The recycling of plastics as a waste management strategy sits below refuse, rethink, redesign, reduce, and reuse on the waste hierarchy (Figure 1). In the absence of preventative options, recycling is an important waste reduction strategy. If recycling is included within a well-designed nationally mandated EPR scheme, it can be utilised to reduce plastic pollution. These EPR schemes can also be applied to the plastics used in the processing and distribution elements of fisheries supply chains. The EU Directive aims to recycle 15% of fishing gear by 2025 (EC 2019b). As mentioned above, the recyclability of fishing gear can be complex and making gear more recyclable requires the use of a narrow range of polymers. Mechanisms for upcycling or repurposing plastics should also be considered an important mechanism within the zero waste hierarchy.

3.8 Recovery

While preventative mechanisms should be prioritised, recovery of ALDFG is still a highly important mitigation method to minimise the negative impacts of MPP on marine ecosystems. The International Sustainable Seafood Foundation (ISSF) (ISSF 2020) argue that when it comes to fish aggregation devices (FADs) (which are commonly used globally) it is essential that they be made from biodegradable materials rather than synthetic polymers so as to minimise their negative impacts on marine environments. They further argue that until this is successfully implemented the ISSF put forward alternative options to reduce the ecosystem impacts of FADS – one of the most significant being recovery. This example illustrates that while alternative materials and the redesign of plastic (along with other preventative methods) are critical, recovery of existing ALDFG is also highly important. However, it must be noted that biodegradable FADs should not be seen as the solution (as a result of the complexities relating to 'bio' plastics that we discussed). Therefore, the banning (refusal) of FADs should be prioritised over making them biodegradable. While efforts to recover and retrieve existing MPP and ALDFG should still be recognised

as important, it is critical that we address the source of MPP in order to prevent any future leakage of plastics. However, until this is successfully implemented, the ISSF put forward alternative options to reduce the ecosystem impacts of FADS – one of the most significant being recovery. This example illustrates that while alternative materials and the redesign of plastic (along with other preventative methods) are critical, recovery of existing ALDFG is also highly important.

3.8.1 Fishing gear marking

Gear marking has been identified as a potential solution to preventing ALDFG (He & Suuronen 2018). Gear marking can provide valuable information that can be used to modify gear and understand sources of ALDFG (Wilcox et al. 2015). The marking of fishing gear with the company name and vessel number can minimise the risk of fishers losing their gear upon deployment and can also assist authorities in collecting and managing the retrieval of gear (Deshpande 2020). Gear marking can also be used to help design gear modifications aimed at preventing future ALDFG (Wilcox et al. 2015). Gear marking and mandatory gear reporting are presented by the FAO and the GloLitter project as important tools in tackling plastic pollution from vessels. It must be acknowledged that gear marking as a method to mitigate ALDFG carries certain limitations, for example, gear that is lost in the high seas cannot be easily traced. He and Suuronen (2018) argue that gear marking technologies all carry certain advantages and disadvantages and that technological advances should result in sophisticated gear marking techniques. To this end, they call for a global standardised and systematic gear marking regime that can help to combat ALDFG while suppressing illegal and unregulated fishing (He and Suuronen 2018).

3.8.2 Fishing gear auditing

A further solution is that of a plastic gear audit, which notes the plastic taken onto fishing vessels and then checks that what went out was also returned to port (Rethinking Plastics in Aotearoa 2019). Strategies such as this could be likened to the Garbage Record Book as per Annex V of MARPOL, whereby fishing vessels over 400 gross tonnage are required to keep a record of the garbage they produce and are able to obtain receipts for this from Port Reception Facilities (PRFs) (IMO 2019).

3.8.2 Fishing for litter

Under the Fishing for Litter (FFL) scheme, fishers in the United Kingdom and Europe are provided with bags for ALDFG and other MPP brought up in hauls or recovered from the ocean. These are then brought back to port at no expense to the vessel. Fishing for Litter is run by KIMO: a network of local governments working together in the European region to clean their local seas. Fishing for Litter is a voluntary scheme and there is no financial reward for the fishers who participate. Cho (2011) argues that there is a risk that schemes that provide financial incentives for collecting litter may encourage fishers to litter. Therefore, rather than providing monetary compensation, the FFL scheme relies on intrinsic motivation to encourage the retrieval of MPP (Wyles et al. 2019). If plastics are brought up in the hauls of local fishers, it can be a disincentive to bring it back to port if they have to front the cost of its disposal. The FFL scheme allows fishers to bring retrieved waste back to port for proper disposal without any financial disincentive.

The collection of ALDFG and MPP is also a measure in the EU SUP Directive which

aims to achieve a minimum collection rate of fishing gear of 50% by 2025 (EC 2019a). Mechanisms such as waiving port fees or waste fees, incentivising bringing hauled up litter back to shore and implementing better collection and sorting facilities on vessels and at ports were all flagged as potential solutions to help achieve this target (EC 2019a).

3.8.3 Port Reception Facilities

Ensuring adequate port reception facilities (PRF) is another important component in the recovery of MPP and in preventing the dumping of MPP from vessels (Eriksen et al 2020, Gilman 2015). This can be recognised as a highly significant method for tackling MPP and preventing the dumping of unwanted fishing gear and other plastics from fishing vessels (Gilman 2015). The EU Port Reception Facilities directive (EC 2019c) is a good example of how this has been mandated throughout EU member states and has become a significant policy element in managing MPP. As part of the EU Port Reception Facilities directive, adequate port reception facilities involve the enforcement of waste reception and handling plans for each port. However, there is currently no binding global agreement or international legislation requiring the enforcement of port reception facilities for plastics and therefore compliance may be weak.

3.3.4 Location Reporting of ALDFG Recovery

Recent findings from the Nordic Council of Ministers (Langedal et al. 2020) show that there are some key areas that need improving when it comes to the management of ALDFG. For example, it found that there was a lack of reporting on the location of lost fishing gear. Reporting on where gear is lost, is important if there is to be any hope of gear recovery. Building a global data pool about ALFDFG, including the location and frequency of lost fishing gear, is an important step. It is hoped that through further investigation and analysis of data such as this, more effective solutions can be developed (Richardson et al. 2019). Mandatory reporting is, therefore, an important component in ALDFG recovery.

4. The Study

4.1 Methods

This case study of a New Zealand commercial fishing company (Moana NZ) was based on semi-structured interviews (face to face, Zoom and telephone), onsite observations, and ongoing consultation with company representatives. Two surveys were designed: one for contract fishers and one for other staff including factory personnel. These surveys included a similar yet separate set of short and long answer questions, designed to target the specific experiences of each set of participants.

4.2 Research Sites

Research was conducted at four sites in the North Island of NZ (Onehunga Wharf, Mt Wellington (Head Office), Auckland Wharf – Coronation Rd. and Wellington). All the sites (except for the interview site in Wellington) are part of the company's fin fish operation. The sites were then selected based on factors such as whether vessels regularly docked at the wharves and if multiple vessels worked out of one area. The wharf sites were also selected based on the timing of vessels at the wharf. It was important to coordinate the research with the time that the vessels were docked, as the nature of wild capture fisheries means that vessels can be at sea for days at a time. Additional site visits in other locations such as Mangonui and Whitianga had been planned but were not possible due to the COVID-19 pandemic.

4.3 Participants

The study participants were either working as skippers of contract fishing boats or were working in the Moana NZ management team. One participant was a representative from Ghost Diving NZ. Potential participants were informed about the project by Moana staff. If they agreed to be interviewed, they were asked for consent from Moana staff to give their contact details to the lead researcher to arrange an interview. They were then given a participant information sheet and asked to sign a consent form as per the requirements of the Massey University Human Ethics Committee approval process. Nine interviews with nine participants were undertaken in total. It was our intention to interview 12-15 participants. However, this could not be completed due to the outbreak of the COVID-19 pandemic which meant the lead researcher had to return to Australia from NZ a few days into the fieldwork period. However, the nine interviews, observational data, the relevant international literature, and ongoing correspondence with the company provided sufficient data to draw valuable insights into the use of plastics in the case study and to make recommendations to reduce plastics in the company's sea and land based operations.

4.4 Interviews

Semi-structured interviews provided the rich data required to determine the role of plastics in the Moana NZ's fin fish supply chain. As Dunn (2005, p. 80) suggests, the strengths of semi-structured interviews as a method lies in their ability to 'fill a gap in knowledge that other methods … are unable to bridge efficaciously.' The interviews were informally structured, and topics were explored as they arose. Participants were asked questions based on their a) understanding of the problem including its scope; b) recommendations; and c) evaluation of the effectiveness of potential solutions specific to the NZ context. These included questions about fishing gear alternatives, schemes such as the European Fishing for Litter (FFL) scheme, fishing gear marking, response options to transition into a circular economy, recyclability of products, and product redesign or innovation.

The interviews were audio recorded and transcribed (with the written consent of participants). The lengths of these interviews varied from 40 minutes to 63 minutes. Six interviews were conducted face-to-face. One interview was conducted via phone and two via Zoom.

Table 1
Interview Participants

Position	Location	Sex	Interview Type
Ghost Diving NZ Representative	Wellington	M	Face to Face
Contract Fisher (skipper)	Auckland - at wharf	M	Face to Face
Moana Management Team	Auckland - Head Office	M	Face to Face
Moana Management Team	Auckland - Head Office	M	Face to Face
Moana Management Team	Auckland	F	Face to Face
Contract Fisher (skipper)	Auckland - at wharf	M	Face to Face
Contract Fisher (skipper)	N/A	M	Phone
Moana Management Team	N/A	M	Zoom (Phone)
Moana Management Team	N/A	M	Zoom (Phone)

4.5 Survey

The online surveys were designed according to similar studies measuring environmental behaviour change (Ballantyne et al. 2007), sustainability in the workplace (Blok et al. 2015), and attitudes of fishers towards litter (Wyles et al. 2019). The two surveys were specifically designed to determine the attitudes of participants towards MPP and to also gauge perspectives on certain measures designed to mitigate the problem. Respondents were asked a combination of qualitative and quantitative questions. Pilot surveys were sent to people working in the industry and Moana NZ representatives for feedback. This feedback shaped the final design of the survey. A link was sent to potential participants via the Moana NZ Communications and Sustainability Manager. The response rate for the survey was very low, and therefore of no statistical significance. Responses to short answer questions were coded and thematically analysed.

Table 3
Survey Participants

Position	
Contract Fishers	3
Management/Factory	6
Sex	
Males	7
Females	2
Age	
25-34	2
35-44	1
45-54	4
55-65	2

4.6 Observations

The observational study component involved site visits to two wharves (and one fishing vessel at each of these wharves), the Moana NZ Head Office in Auckland, and a factory tour. Observations were important components of this project as they contextualized survey and interview data and gave insight into where and how plastic was being used. The observational data was recorded in photographs and notes.

4.7 Analysis

Interviews were transcribed and, along with qualitative survey data, were thematically coded. Initially, all data was coded at a basic descriptive level. This involved coding attitudes and perceptions expressed by participants in relation to the nature of the problem, the challenges faced, potential solutions, the scope of the problem, and environmental impacts. The codes were then iteratively clustered according to emergent themes. These were then coded within NVivo© Qualitative Analysis software. Illustrative quotes from participants were identified and included to show dominant attitudes towards themes. Key themes were examined in relation to the data from observational research including notes, photographs, and company representative consultations. The dominant ideas and concerns expressed by the participants in the interviews were then considered in relation to the broader national and international commercial fishing industry and MPP. This allowed us to see where and how this case study was situated within a broader context and illustrated how key themes intersected with current initiatives and mitigation strategies. This analytical approach draws on the work of Voyer et al. (2017) who used thematic analysis to unpack their interview data in their project examining the attitudes of coastal users (such as recreational fishers) to marine protected areas. It also follows the work of Wyles et al. (2019) who used thematic analysis to identify recurring and dominant themes in their qualitative study on the attitudes and behaviours of commercial fishers towards the FFL scheme in the United Kingdom.

5. Results

The data collected throughout the case study identified some dominant themes in terms of the attitudes of fishers and staff to MPP in the companies' sea and land-based operations, solutions offered, and perceived barriers to potential solutions.

5.1 Overall attitudes and perspectives of the participants

Amongst participants (particularly those in management) there was a consensus that plastics are a matter of common concern within the industry, and there is a general willingness to be part of the solution. Amongst fishers, there was a feeling that Moana NZ's sea-based operations did not contribute greatly to MPP. Furthermore, fishers did not consider sea-based MPP as significant an issue in NZ relative to other countries. While they all reported seeing plastic pollution at sea, some fishers stated that this was infrequently observed: "You might see the odd plastic bottle float past, but I can't remember the last time I saw something float past to be honest." However, this is incongruent with fishers' reports that they regularly collected MPP in their hauls (see Figure 3). A likely reason fishers observed little ALDFG could be due to the buoyancy of plastic items. As plastic degrades almost all of it will eventually become invisible from the surface (e.g. invisible to fishers from the decks of their fishing vessels).

Management and fishers expressed a willingness to try new things, to adapt to changes that might be implemented by the company, and a desire to do the right thing environmentally:

> I can always sleep at night knowing that I've done the best that I can do. That's all you can do really - sort of educate or talk to other fishers about what's happening and that spreads around. But it's definitely better than what it was in the old days with environmental waste and stuff like that (Contract Fisher for Moana NZ).

This came with an acknowledgement that the future of the seafood sector is dependent on long-term environmental sustainability:

> There's always going to be the older sort of set in their ways … But I would say the majority of skippers these days they understand that if we don't take action now then it's going to be too late (Ghost Fishing NZ).

Fishers reinforced this sentiment. One fisher remarked, "We are in it for the long haul because we have our kids coming through." Another stated; "I love the ocean and grew up on it – I don't want to wreck it." The fishers had all observed a change in environmental attitude throughout the fishing industry over time. Some attributed this to the prevalence of plastic pollution in the media.

The values of the company, including thinking sustainably about the future were discussed by management participants. This included an acknowledgment that the health of the marine environment and the future prosperity of the fishing industry are interdependent; the company's 'long term' planning; and kaitiakitanga (guardianship).

One manager stated that the company is open minded about making change, and that to move forward, the company needed to invest "resource[s] towards helping big initiatives happen in a big way." Another manager emphasised the potential value of this study acknowledging the company needed to accept there is a problem when it comes to plastic use and pollution:

> We need to put some gauge on it. Understand what sort of problem we are dealing with. I think we need to know what the issue is. And then we can make or formulate some plan to become more sustainable ... I think it's a project in itself. But it has to be done.

The fishers all spoke highly of the way in which Moana NZ seeks to improve their environmental footprint. However, as one manager implied, there was more that needed to be done: "Overall, I think we've made some changes in the past, but you know, you could always be evolving."

5.2 Potential Barriers to Change

Cost was generally recognised as one of the biggest barriers when considering the implementation of changes. One manager stated, "The issue of cost is the biggest thing with social responsibility – it is hard to know how far you go with it." While this manager could understand what might be needed to transition to a circular system, how to invest in this transition without compromising the financial sustainability of the company was presented as a challenge. However, other participants stated that even though cost could be a significant challenge, this is something they would be happy to accept to move forward:

> It's just the flexibility of changing and being able to change and maybe try something different at the cost of your own pocket. And sometimes it doesn't pay off but, in your mind, you do feel better for it and it will pay off in the end that you're doing the best you can with what you can do (Contract Fisher for Moana NZ).

Cost was a topic of significant concern in relation to finding poly bin alternatives. WoolCool™ was presented as an alternative. However, it costs twice as much as poly bins.

Observations revealed that another potential barrier to change is a lack of awareness of available alternatives. The science of plastics is a complex and rapidly evolving field. There are no clear industry guidelines on plastic reduction and there is a general lack of awareness especially in relation to recyclability and the greenwashing of 'bio' plastics.

5.3 Flows of plastic

The case study informed understandings of the ways plastics are used throughout Moana NZ's fin fish supply chain as seen in this flow chart (Figure 2). The flow chart illustrates the sea-based plastics (those that are carried on and used on fishing vessels, or those retrieved from the ocean and brought onto fishing vessels); and land-based plastics (those used in the factory/processing site of Moana NZ as well as the plastics used in distribution and sale). The sea-based plastics are represented in blue and the land based in green. The direction of the arrows demonstrates the direction of the flow of that particular plastic.

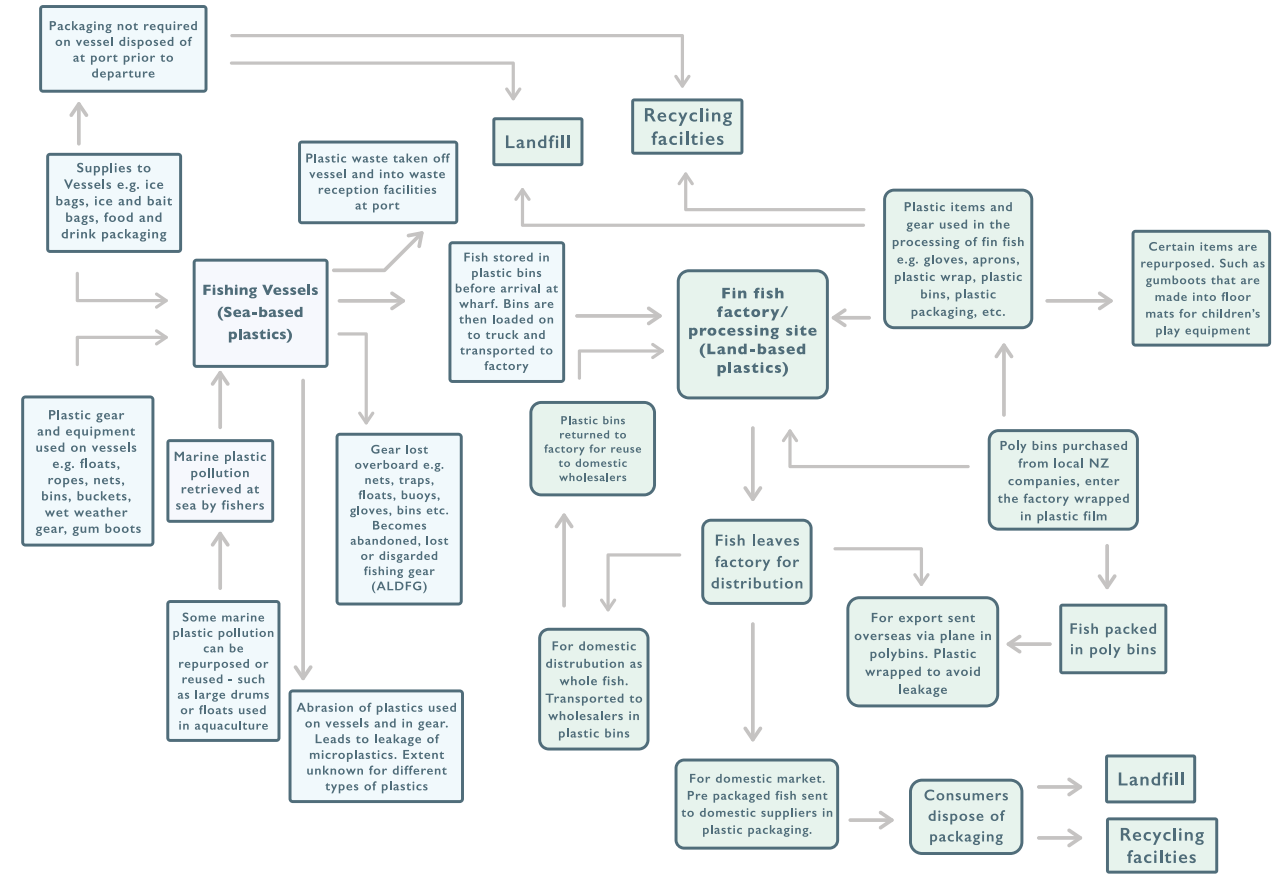


Figure 2: The flows of plastic in the fin fish supply chain (Moana NZ)

The following sections are divided into the company's sea-based and land-based operations to present participants' attitudes, perceptions, and recommendations for the elimination of plastic pollution across Moana NZ's fin fish supply chain.

5.4 Sea-based plastics

Sea-based plastics are defined here as the plastics brought onto the vessel, or used onboard. This may include fishing gear, bait boxes and other containers, wrapping, and food and beverage packaging. Plastics at this stage of the supply chain risk becoming MPP if not properly managed. There was consensus among participants that the sea-based component of the fin fish supply chain was a comparatively minimal contributor to MPP compared to the plastics used in land-based operations. One of the reasons fishers suggest they contribute little to MPP in sea-based operations is that fishing gear is expensive and that its loss at sea comes with substantial economic cost to fishers. As such, it is in their best interest to retain, reuse and repair it whenever possible. These Moana NZ fisher statements contradict growing international reports that ALDFG is a significant source of MPP globally (FAO 2019, EIA 2020).

5.4.1 Areas of Concern

5.4.1.1. Bait Bags

Bait bags were a plastic product of concern for those working on the long-line vessels. Some fishers found that these were difficult to keep on board because of their light weight and because they are used on deck rather than in the cabin. One fisher stated, "that would be the easiest thing to blow away – the plastic wrapping within bait boxes." One manager suggested that they could request that their external bait supplier sell bait in a cardboard box without a plastic bag.

5.4.1.2. Plastic Fishing Gear

Fishing gear such as nets are made of a polyblend polyethylene (PE). There was a consensus that fishing gear such as nets are used and repaired until they were no longer fit for use. Fishers were unsure of what happened to the nets at the end of their useful life, and there was significant discrepancy in statements regarding the longevity of nets. One fisher suggested that their nets can last about 10-15 years, while a manager stated that fishing nets last for one year on average before being sent to landfill.

Fishers said that they would be willing to use nets made of an alternative (potentially biodegradable) material if it was proven that these were fit for purpose:

> I would certainly look at it if I knew that kind of thing worked, then it would be good (Fisher).

> It is important to look for alternatives if it is better for the environment and the wellbeing of the product. We have to be aware of it and move forward with it and not just close our eyes to it and stick with the old. Because in the end if everyone had that mentality then it would fall to s**t pretty quick (Fisher).

5.4.2. Areas of Opportunity

5.4.2 1. Retrieving MPP

Fishers can be part of the solution by retrieving meso 5-25 mm and macro- (>25mm) MPP from the ocean. All respondents stated that they would always return plastics caught in their haul back to port: "We don't throw nothing back. I would hate to think how much stuff we have brought back." Figure 3 shows the MPP hauled onto the vessel during one fishing trip (over a two-three-day period) in the Hauraki Gulf.

Figure 3: MPP brought up in haul in Hauraki Gulf and brought back to wharf

5.4.2.2 Collaboration with Ghost Diving NZ and other initiatives

MPP retrieval is encouraged by Moana NZ management. The company has consulted with Ghost Diving NZ to establish a collaboration that would see skippers reporting ALDFG (either from their own vessel or that they had found) that they were unable to retrieve to Ghost Diving NZ. Ghost Diving NZ would then attempt to retrieve it. The representative at Ghost Diving NZ stated that it was rare for a commercial fishing company to voluntarily approach them. There is scope within this collaboration to extend company policy to include the mandatory reporting of lost gear and that of any other gear or significant MPP that the vessels were unable to retrieve for any reason.

Staff at Moana NZ referred to Aotearoa based company, Formway that manufactures chairs from discarded fishing nets and carpets. Establishing networks with local companies such as Formway to provide materials, either collected in ocean hauls, or from disused nets, could provide an opportunity for upcycling.

5.5 Land based plastics

The land-based elements of the fin fish supply chain are seldom discussed when it comes to commercial fishing and plastic pollution. However, plastics are used extensively throughout this part of the company's operations as can be seen in Figure 2. This involves the plastics used in processing the fish for distribution. It also includes the plastics necessary for the transportation of fish. Given that Moana NZ distribute their product to local and global markets, the plastics used in their land-based operations significantly contribute to their overall plastics use and disposal.

5.5.1 Areas of Concern

5.5.1.1 Poly bins

Poly bins were consistently recognised as a key challenge to preventing MPP in the company's operations. Poly bins are not used on boats, but they are used to support distribution throughout the supply chain including to supply the export market. These EPS boxes transport fish exported to international markets. In the Moana NZ's Bell Avenue Factory, 350 poly bins are used per day, 1750 per working week and 91,000 per year. These are staggering figures given that poly bins are designed and produced as single-use products; they are not reusable for the distribution of seafood, nor are they commonly recycled. In efforts to try and reduce their poly bin footprint, one of the Moana NZ factories in Palmerston North, compact the poly bins and send them to a company to be made into photo frames.

Some respondents acknowledged that they did not know what happened to the poly bins sent by their company at end of useful life once they had arrived at overseas markets. However, one manager stated, "When you go to fish markets around the world you see poly bins being blown around the fish market" illustrating that Moana NZ will need to consider their responsibility for the impacts of poly bins distributed domestically and also for the impacts they are likely to have on receiving countries. Most of Moana NZ's poly bins are sent to the Sydney Fish Market. The market has been trialling a poly bin management programme to reduce the 125,000 poly bins sent to landfill every year (Sydney Fish Market 2020). The poly bins are shredded, melted and shrunk into small compressed blocks, which are then resold and used to make hard plastics such as letterboxes (FRDC 2013). However, the programme does not have the capacity to receive all the poly bins at the Sydney Fish Market. Nor does

it have the capacity to influence nor offset the volume of poly bins Moana NZ annually distributes across Australia.

One seafood store in an outer suburb of Wollongong (New South Wales, Australia), approximately 80km from Sydney, sells Moana NZ seafood. Figure 4 shows the poly bins full of imported fish, ready to be unpacked and sold in Australia. The store owner said that after they unpack the seafood, the poly bins are sometimes given to customers, but that most of them end up going to landfill. Figure 5 shows how the fish is packed into poly bins. The plastic and tape around the outside (Figure 4) prevent leakage making the packaged fish suitable for air travel.

Figure 4: MPP brought up in haul in Hauraki Gulf and brought back to wharf

Figure 5: Moana NZ seafood for sale in Australia

5.5.1.2 Plastics used in processing

Participants indicated the plastics used in fish processing were materials of concern. Single-use plastic film, such as that wrapped around poly bins was noted as a particular material requiring improvement (see Figure 6). However, solutions would need to satisfy the requirements for the transportation of fresh seafood (as discussed by Hansen et al. 2012).

Figure 6: Poly bins wrapped in plastic film at the Moana New Zealand factory

Plastic aprons and gumboots are used every day by processing staff. The gumboots are made into mats for children's play equipment at end of useful life. Participants did not consider the potential repair of aprons and gumboots. However, managers reported attempts by the company to improve the recyclability of the plastics used to package the fish that were being sent to supermarkets and other commercial consumers. This has involved working on product design that meets the market requirements and that is more sustainable. In their design of plastic packaging they are making sure that "where possible we can and do use recycled materials". The company has just changed some of their plastic packaging to polylactic acid (PLA) which they claim is made from renewable resources (sourced from corn). However, PLA is not currently recyclable in Aotearoa (see bioplastics discussion 2.8.1). Nor should PLA be landfilled due to methane emitted in anaerobic conditions. In addition, NZ does not have the infrastructure necessary to compost PLA.

Fish bins are used to transport fish from the vessel to the factory for processing. The fish are also stored in these bins while the vessel is at sea. These fish bins are made of hard plastic. They differ from poly bins as they are not used as part of the global distribution of fish. They are reused and repaired until they are no longer suitable for the task. The manager in charge of ordering and supplying the bins believed each bin was in use for approximately four years. The bins are made from virgin plastic:

> We try not to use recycled plastic because it doesn't have the strength … Virgin plastic seems to hold better, and we are quite rough on our products, So it is important to use resilient material.

5.5.2 Areas of opportunity

5.5.2.1 Rimurapa poly bin alternative

A manager raised the potential for the development of a rimurapa (kelp)-based poly bin alternative. This protype is currently in development in New Zealand by Te Kete ō Tangaroa. The management felt this product showed promise as a sustainable material for packaging fresh seafood for distribution. One manager discussed the potential for Moana NZ to grow kelp as part of their aquaculture, to improve circularity within the supply chain. However, the prototype at this stage is inspired by rimurapa rather than being produced using this material. This means that the potential for the company to grow kelp may not be possible at this stage but could be a future opportunity. Another manager stated that this aligned with the company's values as rimurapa was used by Māori tūpuna (ancestors) for packaging food.

5.6 Results framed by the Zero Waste Hierarchy Framework

The zero waste hierarchy can be useful in framing the attitudes of respondents to strategies for plastic reduction at each stage of the hierarchy. The responses of some of the participants are discussed here along with research observations in relation to plastic minimisation guided by the zero waste hierarchy framework.

5.6.1 Rethink/Redesign

The management team at Moana NZ are looking for alternatives to poly bins, to minimise their plastic use, and ultimately to transition towards a circular economy. Respondents had trialled alternatives. One example is WoolCool™ bins which offer excellent insulating properties, was leak proof, and fulfilled the requirements for international freight. WoolCool™ products are also recyclable and compostable. However, the products are currently prohibitively expensive. One manager stated that to transition to WoolCool™ would double the company's packaging expenses.

There seems to be more scope for reuse and recycling when the fish are distributed domestically (wholesale and retail). One of Moana NZ's biggest domestic distribution networks, My Food Bag™ (an ingredient-based dinner delivery service) uses WoolCool™ as the packaging for their deliveries. One respondent stated that these boxes "can be reused if unpunctured and cleaned, but they don't have that collection and rotation system anywhere else in the world." There may be potential to address the prohibitively high cost of poly bin alternatives by developing a similar container return scheme, where the container is returned to the producer for reuse. Moana NZ is currently exploring options for this with their distribution to the Sydney Fish Market in Australia. WoolCool™ has a branch in Sydney, so there is potential for WoolCool™ to collect the containers post-distribution and for reuse and recycling. However, freight logistics (such as the cost of shipping back empty boxes) and food hygiene regulations (such as temperature control and industry standard sanitation) currently present challenges to reusable solutions. National mandatory 'take back' or container return schemes and reverse logistics/backhauling could be mechanisms to address some of the issues related to freight logistics.

5.6.2 Recycle

As noted, managers discussed efforts to improve the recyclability of plastics used to package products for national distribution. This involved working on product design that not only meets the market requirements but that is also more sustainable. One manager stated that in their redesign of plastic packaging they are making sure that "where possible we can and do use recycled materials." However, one manager detailed the complexities that can arise with coloured and multi-layered packaging:

> When we first started with oysters, … and even these used a … material that wasn't possible to recycle in NZ because of the colour. So we moved oysters to a fully clear PET [polyethylene terephthalate] and the fish is currently in a material from Australia called Plantic - and …. basically 80% is corn-starch. But they use a PLA [polylactide] layer to separate the corn starch from the product to stop it from dissolving - so it is recyclable but it is not biodegradable because of the layer - but the corn starch will break down - so it is reducing the amount of plastic we are using rather than getting rid of it. [it must be noted that the PLA layer is not currently recyclable in NZ.]

There is promise in innovative material design. However, as the quote above illustrates, these

can come with additional challenges. The same respondent stated that there was a desire for the packaging to carry the lowest possible ecological footprint. They were happy with the Plantic™ design as it made an 80% reduction to landfill and was more recyclable, but the PLA layer can only biodegrade in industrial composting conditions. Unless the packaging producer takes back packaging and end of useful life and can separate and responsibly manage each layer of the multi-layer packaging, this will most certainly go to landfill at end of useful life in NZ. However, what this does demonstrate is the willingness of managers to think carefully about the layers within their packaging choices and their environmental impacts. One manager emphasised the importance of sourcing suitable ecologically sustainable packaging that is also up to the task of hygienically housing a wet product:

> Once there is proof that a particular type of packaging works, the rest of the industry will follow suit … if it is tested and works, then it has a lot more traction - industry approval in other words.

5.6.3 Recovery

The representative from Ghost Diving New Zealand saw potential in a collaboration with Moana NZ. While the logistical details of how this collaboration would work between Ghost Diving NZ and Moana NZ skippers hasn't yet been finalised, it was suggested that skippers could GPS log the location of any ALDFG or hard to retrieve MPP that could then be collected at a later point by the Ghost Diving team.

Current global recovery schemes in operation such as the FFL scheme in Europe, were explained to participants who were unfamiliar with this scheme. They were then asked if FFL was something that they could see working in the NZ context. All participants were open to this idea, although the fishers did all say that they already bring any collected MPP back to port at the conclusion of a trip. While port collection fees can pose a barrier in some contexts, the fishers explained that they pay an annual port fee that is inclusive of all their waste disposal.

5. Discussion

The zero waste hierarchy provides an essential framework when considering plastic leakage in the company's fin fish supply chain. Specific examples of how the zero waste hierarchy could be integrated within the fin fish supply chain are summarised in Table 4 (This is not an exhaustive list; it is intended to indicate how specific elements may be integrated).

Society will need to rethink plastics. This will require a shift in our current industrial structures and cultural and economic systems (Tessnow von Wysocki & Le Billion 2019). Neither current international nor national policies effectively minimise plastic production and consumption. However, all indications suggest that industries will need to fully internalise their operating costs.

While the NZ Government's Waste Work Programme finalises its new single-use plastics legislation, industry should be setting their own voluntary plastic pollution elimination targets and implementing mechanisms to ensure these responses are regularly monitored and reported and that targets are met. This will simultaneously improve their reputation as a sustainable and ethical industry and increase international market share. Sanford™ has already made a strong start in this regard. They have set an ambitious plastics reduction target; proposed a shift from domestically un-recyclable and toxic polystyrene trays to insulated cardboard for shipping (Sanford 2018, p.70); removed single-use plastic sleeves from loading boxes (replacing these with a new cardboard packaging configuration); replaced single-use with reusable plastic chiller bags (p. 102); and included plant-based 'eco-ties' in their aquaculture operations (p. 73). The Sanford™ 2018 annual report also pledged that when they reopened their new Auckland Fish Market in late 2018, they would ensure that all packaging across their eateries would be 100% reusable, recyclable or compostable. Sanford teams are also regularly involved in beach clean-ups (Sanford 2018).

Zero Waste Hierarchy Framework Integrated Within Fin Fish Supply Chain

Activity	Actor	Area Impacted	Specific Example
Rethink/ Redesign	Management	Factory	Redesign plastic packaging to be fully recyclable in onshore recycling facilities
	Industry/Management	All	Design plastics out of the supply chain
	Industry	Fishers	Redesign nets using alternative materials or new technology that minimises loss
	Industry/Management	Factory	Redesign of poly bins to make them recyclable or reusable
	Govt.	All operations	Incentivise the transition a circular economy model within industry
	Management	All	Enhanced awareness and education for all staff/fishers
	Govt.	Management	Develop policies that support EPR and hold industry accountable for the end of life plastics
	Industry	Management	Ensure collaboration within seafood sector to ensure ideas and innovations are shared and spread
	Govt.	All	Expand container deposit scheme to include all plastics including poly bins and fishing gear
	Govt/Industry	All	Support research and innovation in redesigning plastic packaging using bioplastics
	Industry	All	Collaboration throughout industry in the procurement of sustainable products - economy of scale
Reduce	Management	Factory	Reduce SUP throughout processing
	Fishers	Fishing Vessels	Implement a reduction in ice and bait bags and food packaging on fishing vessels
	Management	All operations	Prohibit the purchase of non-recyclable or SUP products from producers (i.e plastic wrapped bait)
Reuse	Fishers	Fishing Vessels	Repair equipment like nets and fish bins until they are no longer usable
	Management	Factory	Reuse redesigned poly bins to enure transition to circular economy
Recycle	Management	Factory	Support initiatives to recycle products such as gumboots which can be made into photo frames
	Management	Fishing Vessels	Ensure mandatory recycling for end of life fishing nets
	Management	All staff	Provide adequate information about recycling
	Govt.	All	Increase capacity of plastics recycling and collection
	Govt.	All staff	Develop legislation and regulations to stop the production of hard to recycle plastics
Recover	Fishers	Fishing Vessels	Ensure lost fishing gear is reported and retrieved where possible
	Management	Fishing Vessels	Ensure mandatory marking of gear
	Govt.	Ports/Wharves	Ensure adequate port reception facilities at each port/wharf to deal with MPP from fishing vessels
	Management	Fishing Vessels	Initiate gear audit of plastic fishing gear on and off fishing vessels

Table 4: Integrated Zero Waste in the Commercial Fishing Industry

6.1 Prevention: Refuse, rethink, redesign, reduce, and reuse

A circular approach in the fishing industry would include a regulated EPR scheme for poly bins and other commonly-used plastics in the sector to incentivise plastics producers to design eco and bio benign, reusable or recyclable products, and to eliminate plastics from operations through alternative delivery systems wherever possible (Subramanian et al. 2009). Single-use plastics such as poly bins will have no place in a circular approach while products such as WoolCool™ may provide a viable alternative. Management showed that they were willing to undertake change, even if this came at a cost. However, as it currently stands, the replacement of poly bins for WoolCool™ could double packaging costs (a cost margin the company are currently unwilling to absorb). Industry-wide investment however, could overcome this challenge by increasing economies of scale. Furthermore, innovative product redesign and intra-industry collaboration could be another mechanism to minimise the high cost of current market products. The potential for collaboration within industry to produce their own wool cool like product (perhaps with a product such as recycled wool carpets, which have good insulation properties) could help to minimise the cost.

The NZ Government are proposing to phase out all hard-to-recycle plastics including Polyvinyl chloride (PVC) and Polystyrene (PS). Thus, it likely that Moana NZ will have to find an alternative to their poly bins. Testing viable alternatives to poly bins should therefore be a priority for Moana NZ.

Rimupara was also considered as an alternative poly bin material with the promise of offering a shift away from petrochemical based plastic products. Furthermore, if kelp growing and harvesting could be undertaken as part of Moana NZ's aquaculture enterprise, this would help close the loop for some of the plastic products used by Moana NZ. A kelp-based fish bin could be part of a CRS to ensure they were brought back for reuse or recycling. The potential for poly bins, fish bins, and poly bin alternatives to be incorporated into a CRS was considered by management. Fish bin and poly bin (or alternative) CRSs would require collaboration across stakeholders. Bio plastics initiatives such as MarinaTex is another potential opportunity. MarinaTex is an innovative plastic film produced using the scales of fish (Hughes 2020). If Moana NZ could use their own waste fish scales to produce the plastic film used in their fish packaging, this would be a noteworthy step toward a circular, zero waste fin fish supply chain.

From a sea-based perspective, Moana NZ's supply chain would benefit from the redesign of fishing nets. However, the literature suggests that there have been no significant achievements in bio-plastic based net alternatives (Grilmaldo et al. 2018). Fishers and managers were interested in trialling alternative materials, if evidence suggested their effectiveness in other contexts. The marking of fishing gear has been presented at international governance level as an effective sea-based mechanism for MPP prevention. Procurement practices that focus on robust plastic fishing gear made from recycled materials and with high recyclability qualities, would also support plastic pollution prevention in the industry.

Reuse and repair of plastic items used throughout the fin fish supply chain is economically viable and a mechanism to prevent MPP. Reuse keeps materials within a circular economy for as long as possible. As participants noted, fish bins are one plastic item in the case study that are reused as often as possible. While this is a positive, the fact that these are made from virgin plastics remain a concern. Perhaps looking for suppliers that make thicker fish bins out of recycled rather than virgin plastics, then this could effectively reduce the company's plastic production footprint. Thicker bins would have to be tried and tested in practice – but if they proved to be stronger than thinner bins made from virgin plastic then this could be an effective mechanism in reducing the company's footprint of plastic production.

The potential for poly bins, fish bins, and poly bin alternatives to be incorporated into a CRS was considered by management. Fish bin and poly bin (or alternative) CRSs would require collaboration across stakeholders. However, addressing this issue should be prioritised. This is because there is not end of life accountability for these products; they are not commonly recycled; they are designed as a single-use product; they pose significant threats to humans and ecosystems through leakage of toxics and fragmentation into micro plastics; and they are found in high volumes in MPP surveys.

Setting clear plastics reduction targets, as seen by the commitment made by Sanford™ throughout their operations, is essential for plastic reduction. Sanford™ has made a public commitment to reduce plastic waste by 70% by 2025 (Sanford 2018, p. 73). Furthermore, they have committed to reduce and recycle the plastics that they have identified as necessary throughout the company's operations.

Setting measurable plastic pollution elimination targets for SUPs and other problematic plastics can stimulate local economies. Plastics alternatives require innovative delivery and collection systems, materials and technologies offering new employment opportunities.

Reducing the use of plastics throughout all operations is one of Moana NZ's key motivations, which aligns with the broader objectives of the zero waste hierarchy. In a follow up conversation with one manager, they stated that Moana no longer purchases any plastic bag lined bait boxes.

From an industry-wide perspective there is a need for action on plastics throughout the whole fisheries supply chain. This could include the adoption of certification schemes that include considerations for plastics, and ALDFG prevention and recovery. Certification schemes have been shown to encourage best practice throughout industry including shareholders, consumers and other stakeholders (Vince & Hardesty 2017). Companies across the sector, could also join the GGGI and work towards incorporating the Best Practice Framework throughout their operations.

6.2 Recycling and Recovery

Moana NZ has shown initiative in this area by seeking collaboration with Ghost Diving NZ to further the work being done by fishers in helping to get ALDFG and other MPP out of marine environments. The material from the ALDFG collected by Ghost Diving NZ and/or by Moana NZ's fishers has the potential to be kept in the loop through cleaning, recycling and repurposing. Conversations with representatives at Moana NZ showed an interest in supplying companies with old fishing nets to make other products, such as office chairs or handbags. Ruiz-Salmon et al. (2020) argue that the implementation of the circular economy within the seafood sector creates value around the recycling of marine debris, which in turn creates opportunities for new businesses and can boost local economies. As discussed with Moana NZ management, the potential for innovative business collaborations in NZ exists.

Through the process of recovery of MPP, fishers observed positive trends in the reduction of plastic bags following NZ's national plastic bag ban which came into force in 2019. This shows that enforceable land-based plastics legislation contributes to the reduction of MPP. New Zealand's national container return scheme has come to the end of its design phase. It is expected that this will significantly reduce the volume of plastic beverage containers in the marine environment. Research from Australia and the United States shows that the implementation of a container deposit or return scheme can reduce containers found as debris in coastal areas by as much as 40% (Schuyler et al. 2018). Gear marking and mandatory reporting of gear was not a dominant theme nor flagged as a potential solution for the fishers. However, the representative of Ghost Diving NZ argued that gear marking is essential in increasing the retrieval rate of MPP. These solutions are not intended to 'name and shame' fisheries, but rather to identify the problem sources and make targeted prevention strategies. Langedal (et al. 2020) showed that there is a gap in the reception solutions for recovered or end of life fishing gear and insufficient recycling or reuse of fishing gear. Therefore, port reception facilities and initiatives aimed at recycling and reusing old fishing gear should be incorporated into national plastics policies.

6.3 Mechanisms to reduce plastic use throughout entire operations

The following table (Table 1) has been developed to illustrate the specific ways that Moana NZ could improve their management of plastics and minimise the use of plastics throughout their entire fin fish operation. This list has been developed under the zero waste hierarchy framework.

Table 1 **Mechanisms to Reduce Plastic Usage Throughout the Fin Fish Supply Chain (Moana New Zealand)**

Action	Strategy	Actor/s
Rethink	Rethink global distribution system - scope for circularity and container return scheme (poly bin)	**Industry/Management**
	Collaborate with other members of the industry for the procurement of wool cool as a poly bin alternative - economies of scale	**Industry/Management**
	Consider the ways that Extended Producer Responsibility would work within this supply chain	**Management**
Redesign	Continue development of kelp poly bin prototype	**Management**
	Redesign plastic packaging to ensure it is fully recyclable in onshore recycling facilities (or that it is compostable)	
	Work towards finding a redesigned fishing net that uses an alternative to plastic	**Management/Fishers**
	Conduct research about viable plastic alternatives to fishing gear such as ropes	**Fishers/Management**
Reduce	Set specific plastic reduction targets throughout entire operations	**Management**
	Evaluate current procurement practices and switch to suppliers with better management or to products containing more less virgin plastic	**Management**
	Prohibit the purchase of non-recyclable or SUP products from producers (i.e plastic wrapped bait)	**Management**
	Phase out single use and hard to recycle plastics throughout all operations	**Management**
	Implement a reduction in ice and bait bags and food packaging on fishing vessels	**Fishers/ Management**
Reuse	Ensure fishing gear is re-used and repaired as much as possible	
Recycle	Ensure all plastic used in packaging and processing is recyclable in domestic recycling facilities	**Management**
	Provide adequate information and education about recycling to all staff	**Management**
	Support initiatives to recycle products such as gum boots (which can be made into the mats on childrens play equipment)	**Management**
	Collaborate with local companies who are using recycled fishing nets or collected MPP to produce certain products	**Management**
	Ensure mandatory recycling of fishing gear such as nets	**Management**
	Collaborate with Terra Cycle to establish methods to reduce plastic waste in factory	**Management**
Recover	Ensure lost fishing gear is reported and retrieved where possible	**Fishers**
	Ensure mandatory reporting of lost gear	**Management**
	Develop gear audit system of plastics on and off vessel	**Management**
	Incentivise the collection of MPP of fishers while at sea	**Management**
	Organise community beach cleans in areas of high fishing activity	**Management**
	Continue developing collaborative project with ghost diving NZ	**Management**
	Ensure mandatory marking of fishing gear	**Management**

6.4 Future Research

Future research with a broader sample and participant base would offer a more comprehensive understanding of the attitudes and perceptions of fishers and staff in Aotearoa's fin fish industry. A greater awareness of the use of plastics throughout the industry would be useful to ascertain how industry can align with initiatives to phase out hard to recycle and single use plastics. Research on potential alternatives to plastics (particularly for fishing gear such as nets and ropes) is needed. Further research on the plastic-free distribution of seafood or toxic free reusable plastic alternatives would also be of use to Moana NZ, and to the domestic and global seafood sector more broadly. Further work, including a wider capture of fin fish companies in NZ compared to some comparable international companies, would highlight challenges and opportunities in reducing and preventing MPP in the fin fish industry internationally.

7. Conclusion

Within the commercial fin fish supply chain there is scope for the implementation of mechanisms that have the potential to significantly reduce the amount of plastics used in daily operations. This would subsequently reduce plastics that are leaked from the supply chain and infiltrate marine ecosystems. Safe reusable poly bins are a key component to this. Collaboration across the seafood sector would support the economies of scale necessary in significantly reducing plastic pollution in the industry. Furthermore, setting (and meeting) plastic pollution elimination targets and initiating EPR schemes for fishing gear and land-based plastics would reduce plastic leakage throughout the fin fish supply chain.

The tide is turning in relation to the production and consumption of plastics. Global, regional, and local policies and initiatives endeavour to reduce the widespread use of plastics and their subsequent leakage into the environment. To improve the procurement, use and management of plastics now, will benefit Moana NZ in the long term. The NZ Government aims to make 'best practice standard practice' when it comes to the production, consumption, and disposal of plastics. Putting mechanisms in place now to transition Moana's fin fish supply chain to achieve best practice as standard practice, will ensure that the company is equipped to implement and instigate change. It is clear that within the company there is a willingness to initiate positive changes when it comes to the management of plastics. The stage has been set globally for how the commercial fisheries sector enrols plastic in their operations. When thinking about the reputation of the brand and a desire to be seen to be leading the way in responsible business practices, it would be in the company's best interests to make significant changes sooner, rather than waiting for the Government to legislate such changes. This report has set out some recommendations for implementing change, and Moana NZ has indicated willingness to explore these options. In the year since this project began Moana NZ have made positive steps in relation to their management of plastics throughout daily operations. They have reported that in the company's latest sustainability strategy (which is in development) they are looking to set plastics reduction targets. They are conducting audits on the plastics being used throughout the company and are in the process of finalising their procurement policies. They have also suggested that they plan on committing to the 6rs of the zero waste hierarchy based on the recommendations made in this report.

The current use and management of plastics throughout industry and society more broadly are unacceptable. The earth's system is so heavily inundated with mismanaged plastic that it is now threatening the planetary boundaries (Villarrubia Gomez et al. 2018.). Commitments from state and industry for a significant systemic shift away from linear models of production, consumption, and disposal towards a circular economy in which resources are kept within the system is urgently needed. This report has illustrated that commercial fisheries have the scope to initiate significant changes throughout their supply chains to decrease the leakage of plastics. While many of these changes do carry an economic cost, the cost of inaction will ultimately be far greater to the seafood sector and consumers.

8. References

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