2020

Tackling plastic waste in New Zealand aquaculture

Sustainable Business Network | ADVISORY

Forewords

The Government's Aquaculture Strategy sets a vision that New Zealand is globally recognised as a world-leader in sustainable and innovative aquaculture management across the value chain. The Strategy includes an objective to partner with the aquaculture industry on a plan to reduce emissions and waste across all parts of their business.

I am pleased to be able to support the aquaculture industry in its work with the Sustainable Business Network to better understand its plastics use and the opportunities it has to minimise plastics waste in aquaculture. By tackling this challenge head-on, our aquaculture industry is clearly demonstrating its commitment to sustainability, innovation, and improved environmental performance.

Taking action on plastics is a challenge shared by all New Zealanders in the journey towards building a low waste and low emissions economy. The response to the impact of COVID-19 requires sectors to work together to drive our economic recovery in smarter and more sustainable ways, and I commend the aquaculture industry for taking this step in addressing plastics waste.

Hon Stuart Nash
Minister of Fisheries
Member of New Zealand Parliament

The New Zealand aquaculture industry is a band of 3,000 kiwis dedicated to sustainably producing the world's best seafood. Looking after our waterways is part of the job and we are always looking to improve our environmental performance.

Plastic waste has emerged as a global issue and we're keen to play our part and reduce plastic waste where possible.

This work was an essential first step in bringing industry together with experts in plastic manufacturing and recycling to identify areas we can improve by fine tune existing initiatives and implementing new programmes.

We see this as a part of our journey of continual improvement, one that will strengthen our green credentials and see the industry recognised globally for leading the way in reducing plastic waste across the production chain.

Gary Hooper
CEO
Aquaculture New Zealand

The Sustainable Business Network is committed to creating a more circular economy in New Zealand where resources are never abandoned to become waste and products are designed to be safe and easy to manage in cycles of production and reproduction.

It is fantastic, therefore, to use a circular economy lens to systematically address the challenges and embrace the opportunities associated with tackling plastic waste in aquaculture. Although the work represents an initial step as a sector, it is a crucial one to take to maintain the global leadership position in environmental best practice and reputation.

Plastic waste and pollution have become one of the key environmental challenges we face as a society. They represent the broader issues associated with our predominant take-make-waste linear economy. The sector is taking the challenge seriously and the Sustainable Business Network is very much looking forward to seeing the vision outlined via this work come to fruition.

James Griffin
General Manager, Projects and Advisory
Sustainable Business Network

Overview - a vital first step

Aquaculture New Zealand and the Ministry for Primary Industries (MPI) including Agriculture and Investment Services and Fisheries New Zealand have partnered with the Sustainable Business Network (SBN) to work together to minimise plastic waste in New Zealand aquaculture.

Released in 2019, the New Zealand Government's Aquaculture Strategy sets a vision for the New Zealand aquaculture industry to be globally recognised as a world leader in sustainable and innovative aquaculture management. Plastic waste and pollution has emerged as a key global environmental issue. Addressing this issue will be a significant part of achieving the strategic vision for the industry.

This report provides an initial snapshot of plastics use, challenges and recommended pathways forward. It is based on desktop research, a series of interviews and a workshop with SBN, industry participants and other experts. In total SBN interviewed 20 stakeholders from across the aquaculture industry and over 40 stakeholders attended a workshop. We asked them to identify where plastic was commonly used, any issues they identified with plastic use, initiatives they were taking or knew about to minimise plastic waste and how the industry might be able to make changes. During the workshop a broad vision for the industry was explored and the specific initiatives, priorities and next steps to achieve the vision identified.

Our focus is on three key products: King Salmon, Greenshell Mussels and Pacific Oysters.

The results provide a shared understanding of the issues, what success would look like and identification of the key opportunities for action.

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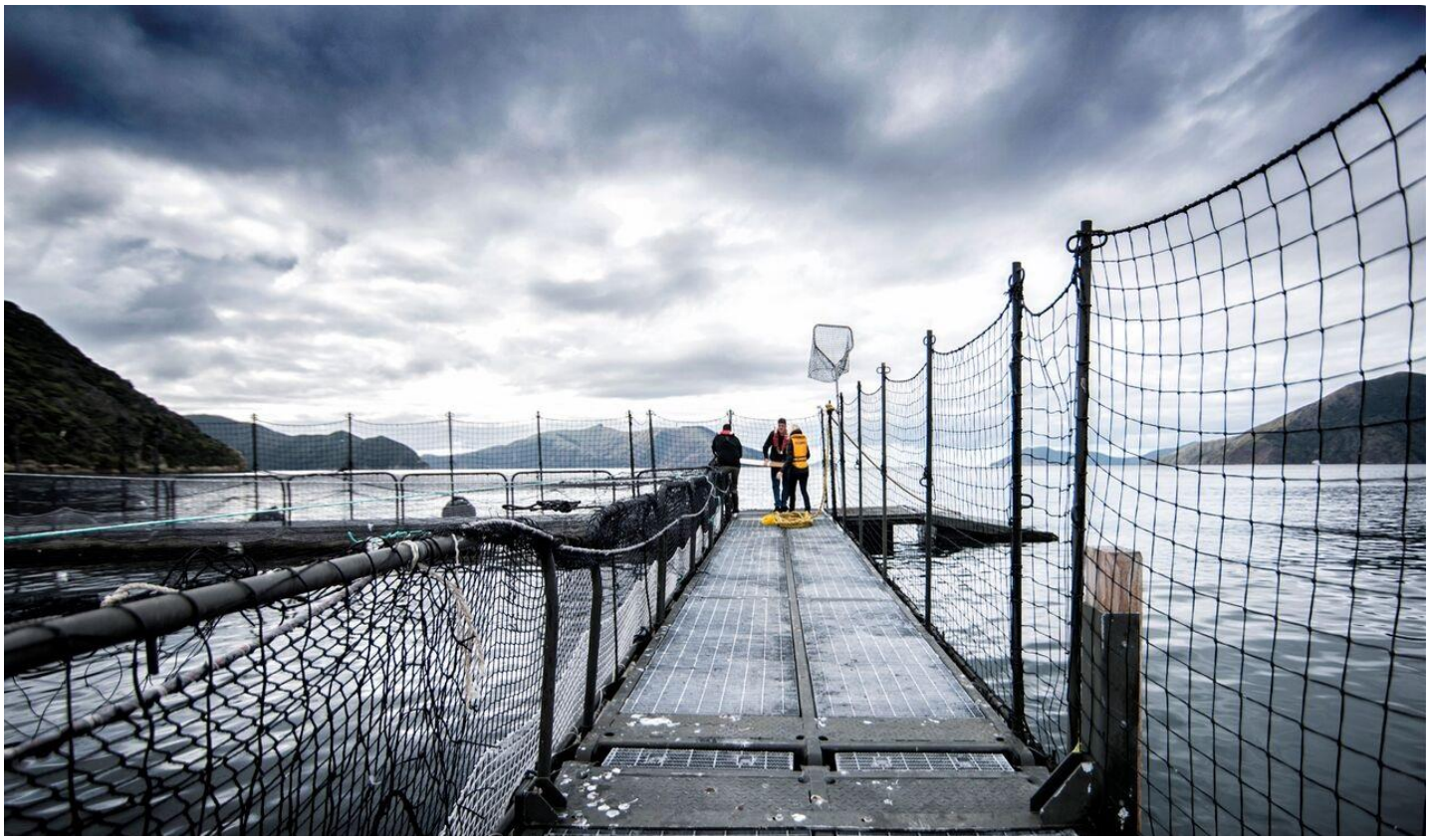


Background

Scale and sustainability in New Zealand aquaculture

Aquaculture is the world's fastest growing primary industry. Demand for aquaculture products is expected to strengthen significantly as the world's population grows and wild-catch levels remain relatively static. According to the Sustainable Fisheries project of the University of Washington a third of the world's fisheries are overfished, and 60% are fully fished.[1]

In 2018, world aquaculture production attained a record high of 114.5 million tonnes in live weight, with a total farmgate sale value of USD $263.6 billion. World aquaculture production of farmed aquatic animals has been dominated by Asia, with an 89% share in the last two decades or so. Among major producing countries, China, India, Indonesia, Viet Nam, Bangladesh, Egypt, Norway and Chile, have consolidated their share in regional or world production to varying degrees over the past two decades. In total for 2018, globally about 20.5 million people were employed in aquaculture.[2]

The New Zealand government has a vision for New Zealand Aquaculture to be globally recognised as a world leader in sustainable and innovative aquaculture management across the value chain, with a goal of $3 billion in annual sales by 2035.[3] In 2019, New Zealand's aquaculture sector generated more than $600 million in revenue and employed more than 3,000 people.[4] New Zealand's farmed seafood has been identified as a sustainable solution to feeding the world population by global conservation organisation, The Nature Conservancy.[5]

In 2019, the New Zealand Government released its Aquaculture Strategy. The strategy sets a vision for New Zealand aquaculture to be globally recognised as a world-leader in sustainable and innovative aquaculture management across the value chain, with a goal of $3 billion in annual sales by 2035.[6] Sustainability is at the heart of the strategy. The clear intention is that aquaculture should be a primary industry leading in environmentally sustainable practices across the value chain. This includes:

- encouraging practices that support environmental regeneration and improve the health of the aquatic environment
- the development of a transition plan with the industry to reduce waste and emissions across the value chain
- achieving net zero carbon emissions by 2050.[7]

Plastics - an overview

Plastic is material consisting of any of a wide range of synthetic or semisynthetic organic compounds that are malleable and can be moulded into solid objects.

Different plastics have different properties obtained by modifying the production process, for example by varying the temperature or pressure at which the plastic is processed or adjusting the types of monomers used. Manufacturers add chemical additives and adjust the molecular structure to obtain desired properties like hardness, malleability, or temperature tolerance. The impact of these additives on the ecosystem and human health are unknown.

Plastics can be categorised by whether they are thermoplastics or thermosetting polymers. Thermoplastics are the plastics that, when heated, do not undergo chemical change in their composition and so can be moulded

repeatedly. Examples include polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC). Thermosets, or thermosetting polymers, are irreversibly hardened by curing from a soft solid or viscous liquid prepolymer or resin and moulded into the final irreversible shape and are therefore often non-recyclable.

In 1988, a plastics resin coding system was introduced whereby plastics were coded 1-7. Now known as the ASTM International Resin Identification Code System (RIC), it was primarily developed to help differentiate between the different types of petroleum oil-derived plastic. The development of bioplastic has introduced further complexity to the identification of plastics. Some types of bioplastics (e.g. bio-HDPE) are chemically the same as petroleum-based types, whereas others, such as bio-based polylactic acid (PLA) are unique. Where codes are used, it does not necessarily mean that the plastic can be recycled in New Zealand or even offshore. (See Appendix 1 for more information on plastics and the properties associated with plastics of each resin code.)

Plastic production has increased exponentially since the early 1950s and plastic use is now ubiquitous across virtually every sector of our economy. It is expected that production of plastics will continue to increase in the foreseeable future and production levels are likely to double by 2025.[8] According to the Ellen MacArthur Foundation, if trends in oil consumption and plastic production continue as expected, the consumption of oil for plastic will account for 20% of the total consumption by 2050.[9] At that point there will also be more plastic by weight in our oceans than fish.[10]

In October 2018 the New Zealand Government became a signatory to the New Plastics Economy Global Commitment. This is an initiative led by the Ellen MacArthur Foundation and UN Environment Programme (UNEP) to address the root causes of plastic packaging waste and pollution. The Global Commitment brings together governments, businesses and NGOs around the world to commit to the adoption of a circular economy approach to plastic packaging, with key targets in place for 2025.

Marine plastics

Abandoned, lost or otherwise discarded fishing gears (ALDFG) are considered the main source of plastic waste coming from the fisheries and aquaculture sectors, but their relative contribution is not well known at regional and global levels.[11]

Aquaculture Stewardship Council, in their 2019 Marine Litter and Aquaculture gear report, investigated whether it was possible to estimate the contribution of aquaculture to the marine plastic stock. From their research it was evident that it is probably localised and relatively low compared to capture fisheries. However, with the likely continued growth of aquaculture, its contribution will increase unless more preventive measures are taken to reduce plastic use, reuse and recycle end of life plastic components and recover lost plastics and other aquaculture-derived debris wherever practical.

Plastics in aquaculture

Plastic meets a range of functional requirements for the aquaculture industry. Its strength alleviates the costs of breakage and various combinations of resin types provide the durability needed in very harsh marine and freshwater environments. For example, mussel ropes combine polyethylene for abrasion resistance with polypropylene for strength. However, when this quality is combined with improper waste management, this same durability can lead to long-term environmental contamination on land, in freshwater and in marine environments.

Plastic is used widely in aquaculture and in a diverse number of applications. It is used in filament form (in ropes and nets), as floatation for sea-pens, as structural or containment components (in sea-pen collars, buoys,

baskets, tanks, pipework, and mooring systems, pond liners, barrier membranes, and packaging).[12] (See page 6 for a sample of plastic uses in the industry).

This diverse range of materials used in these applications have different properties, which means they will behave differently when in the water. Some will abrade slowly (e.g. PE & PP ropes), leading to sinking microplastic formations. Some fragment (e.g. expanded polystyrene (EPS) floatation structures), also leading to floating microplastics, and others are stronger but will persist in the marine environment for generations. The causes of plastic loss from aquaculture are also varied.[13]

Low level 'leakage' can occur from intertidal and subtidal installations just through the working of components in what is a highly dynamic environment, leading to the abrasion of ropes, EPS floatation, and other structures. This can be exacerbated by poor material selection, under-specification, and a lack of maintenance. There is also a low level of plastic loss through poor waste management e.g. plastic feed bags and personal litter, which is itself a function of awareness and managerial capacity.

It is thought the main reason for marine litter from aquaculture is extreme weather and the catastrophic impact on facilities. In the case of inter or sub-tidal facilities this means entire components e.g. floats, sea-pens, nets and plastic containers being lost directly into the sea. Some major components are likely to be recovered through industry led beach clean-up efforts, whereas smaller items are likely to be permanently lost[14]. Problems caused by marine litter and aquaculture gear in the aquatic environment include ingestion by animals, entrapment and entanglement of animals and potential human exposure to microplastics. Freshwater aquatic environments are also receiving environments for aquaculture operations in NZ, e.g. from land-based hatcheries and salmon farms on hydro-canals, and therefore can be at risk of contamination with any associated plastic waste.

A UN Environment Programme report on addressing marine plastics stated losses due to extreme weather events are especially notable for aquaculture internationally. Monitoring data in some areas, such as that under the Oil Spill Prevention, Administration and Response (OSPAR) Convention for the Protection of the Marine Environment of the North-East Atlantic, shows fishing and aquaculture to be the most significant source of marine plastics. Plastic losses from fishing gear and aquaculture are especially concerning, due to the durability of the materials from which they are made and the potential for ecological effects.

The global issues of marine microplastics

There is a growing interest both locally and globally in the effects of microplastics on the marine environment and aquatic species. The impact of plastic pollution on human health is being examined but to date no immediate risk has been identified. In July 2019, Cawthron Institute released a report - A Review of Microplastics Risk – Implications for Environment Southland identifying that research on microplastics is a very new field and there is limited information about their risks, particularly in New Zealand.[15] There is also a large study underway led by The Institute of Environmental Science and Research (ESR) on the impacts of microplastics in New Zealand.[16] Furthermore, a study led by the Ministry for Primary Industries- New Zealand Food Safety, will analyse the dietary exposure of microplastics, absorption rates of plastics and potential contaminants through the human gut, and the impact of microplastics contamination on the primary industries. This scientific interest is also growing in the general public, who are increasingly questioning the misuse of plastic and potential for plastic pollution.

A summary of the current situation

The following information was collected through stakeholder interviews and some desktop research. The majority of stakeholders we spoke to were largely involved in operations and farm management rather than processing and distribution.

Where plastics are currently used in New Zealand aquaculture

Aquaculture makes extensive use of plastics in both the equipment and for packaging the various inputs. Plastics are an excellent material for use in a hostile marine environment, where resistance to abrasion, durability and non-corrosive properties improves the reliability and longevity of equipment, and its lightweight nature reduces handling and associated costs.

The ability to mould plastics into specific shapes means it is ubiquitous across farms, from high density polyethylene (HDPE) floats, baskets, polystyrene foam-filled sea pen collars to polymer-coated net pens to plastic harvest bins. The purpose of this section is, therefore, to attempt to classify the ways in which plastics are used by different forms of aquaculture.

Here are some of the key uses of plastic in the industry, based on our interviews and research.[17]

Product specific farm uses:

Salmon	**Mussels**	**Oysters**
	Floats	
Nets (7-8 years) (PE/Nylon)	Backbone ropes	Mesh bags
Predator nets	Backbones	Baskets
Ropes	Ropes – spat ropes, grow out	Trays
600L bins	ropes, surface line	Crates
Plastic containers	1 tonne processing bags	Rope
Electrical cable (coating)	Floats	Buoys
Feed bags (PP)	Mussock (cotton with PE blend)	Pegs
Tanks	Bulk bags	
	Strops	
	Buoys	
	Ties/Lashings (PP)	

General uses:

Long term single use	**Personal protective equipment (PPE)**	**Processing and distribution**
Barge refurbishments		Ice packs
Processing machinery (conveyors,	Gloves	Poly boxes
tubing, cables, etc)	Hard hats	Tape
Boats	Wet weather gear	Pallets
Dive gear	Aprons	Wrap
	Gumboots	Plastic box liners
	Hairnets	Bags

Primary Packaging

Huge variety in primary packaging types. Vary across product lines and markets

Current challenges

During key stakeholder interviews and the workshop, the following plastic challenges were expressed.

Industry wide plastics challenges

Global awareness and impact of microplastics in food

Our interviewees raised concerns about the effects microplastics may be having the health of our oceans and the potential and perceived effects on public health. There was concern that public awareness of microplastics entering the food chain is growing, especially via consumption of bivalves.

There is limited information on the transfer of microplastics from seafood to humans and the potential for implications for human health. A significant knowledge gap in this respect is the absence of bioaccumulation factors for microplastics in commonly consumed types of seafood, which is a prerequisite to establishing the potential human health impacts of microplastics in seafood.[18]

Many wondered how this may impact the industry in the future. However, some held the view that this is a global issue and, although it is concerning, it is not specific to aquaculture, since plastic contamination is likely throughout the entire food chain.

Increase in studies on microplastics in seafood

The industry welcomes the increase in knowledge from scientific studies on microplastics in aquaculture but showed concern about the negative publicity that may arise. Some studies include:

- Industry specific studies
- Ministry of Business, Innovation and Employment (MBIE) funding Institute of Environmental Science and Research (ESR) AIM Study[2]

Many interviewees welcomed the knowledge these studies would bring for improving the growing environment and the marine ecosystem as a whole.

Microplastics as biosecurity risk

Microplastics are also a suspected biosecurity risk, potentially acting as mobile substrates or microrafts for the spread of pathogens and invasive species between environments they would otherwise be absent from. Further studies are needed to clarify this risk and implications for our aquaculture industry and environment.

Accidental loss and unavoidable loss to the marine environment

Stakeholders identified that unintentional loss of plastics to the marine environment does occur. There was equal concern between accidental loss (e.g. lashings not being appropriately collected) and unavoidable loss (e.g. degradation of materials over time producing microplastics and nano plastics). This was accompanied by equal

concern about the effects this was having on the marine environment and the potential negative association with the industry.

Public concern about litter associated with aquaculture

A few of our interviewees mentioned that accidental loss has contributed to some negative feedback from local communities. Although this is alleviated by industry led beach clean ups and clean up response teams, in their view further measures could be taken to minimise loss.

Plastic packaging

Retail and business-to-business packaging are challenges that are not unique to the aquaculture industry. The challenges of plastic packaging occur across sectors, especially in fresh produce. SBN has been tackling packaging in our Plastic Packaging Circular Innovation Programme.

Polystyrene boxes

Polystyrene has been established as a high utility polymer over many years. This is due to its cost, weight, insulating properties, and ease of manufacture. The seafood industry is a heavy user of polyboxes/polybins. They are now being recognised as a major waste management issue.

Polystyrene is essentially non-biodegradable. It takes thousands of years to decompose. It degrades in seawater but does not biodegrade. Small pieces called 'styrene monomers' break down in our oceans. These can be ingested by marine animals, increasing the potential for them to enter the human food chain.

Polystyrene contains styrene and benzene, which under chronic exposure conditions are suspected carcinogens. If allowed to crumble, polystyrene can be blown around, causing pollution and nuisance in the surrounding areas. It is also extremely bulky when it goes to landfill, taking up significant space relative to its weight. Currently, the economics and sustainability of recycling polystyrene in New Zealand remain poor. Because of this, supermarket and food service operators are now actively looking to remove polystyrene from their waste streams.

Many interviewees acknowledged that expanded polystyrene boxes do not have viable end of life solutions. However, some expressed that they have been struggling to find alternatives that meet the functional properties that polyboxes provide (e.g. temperature control, product protection). There was also comments that they remain a regulatory requirement for access into many export markets.

Biofouling impacting the recyclability of material

Many of the long-life materials, such as ropes, floats, nets and baskets are often difficult to clean due to biofouling. This makes it more difficult to find end of life solutions.

Biomaterials

Viable alternative biomaterials are difficult to develop and source, due to the durability needed to survive in the marine environment.

PPE equipment

Used throughout the industry, this is often made from difficult to recycle materials and is generally just landfilled.

Plastic waste opportunities in salmon farming

Feed bags

From our research it is perceived that single use 1 tonne feed bags generate a significant amount of plastic waste in salmon farming. The design of these has been changed from a drawstring bottom designed for reuse, to a

closed bottom that gets dropped on a splitter and emptied into a silo for dispersal. Previously some limited recycling of bags was conducted but has since discontinued.

Nets
These are generally not able to be recycled due to biofouling, complexity of material and a lack of onshore recycling facilities that can clean and recover the materials.

Ropes
Much of the rope used is uneconomical to recycle due to its material complexity and biofouling.

Plastic film liners in distribution packaging
Plastic film is used to line distribution packaging as a shield against contaminants. Liners are single use and currently have no viable end of life solutions.

Plastics waste opportunities in mussel farming

Floats
Due to their large size, biofouling and degradation, mussel floats have previously been uneconomical to recycle. However, since a redesign in transportation, recycling of mussel floats has become more economical and this solution should be rolled out country-wide.

Ropes
Generally cleaning of ropes is done on shore to minimise fibre loss to the environment. However, removal of mussels is done on board and it is not known whether there are mechanisms to catch fibre loss during this process.

End of life for mussel ropes
These are not viable to recycle due to biofouling and difficulty of cleaning. They are usually sent to landfill.

Ties/lashing
Ties are used to attach ropes to the backbone. When ropes are processed, ties are cut and sometimes lost to the marine environment by accident despite protocols in place to minimise loss. Ties that are retained are unable to be recycled and are generally sent to landfill.

Mussocks
Used to attach mussels to ropes, mussocks are designed to degrade into the marine environment. Polyester is added to cotton in mussocks to increase elasticity.

Plastics waste opportunities in oyster farming

Pegs
Plastic pegs used to hold down baskets, etc. often come loose and are lost to the marine environment.

Key stakeholders for plastics in New Zealand aquaculture

Industry bodies

- Aquaculture NZ
- Seafood NZ
- Marine Farmers Association
- Salmon Farmers Association
- Coromandel Marine Farmer Association
- Mussel Farmers Association
- Oyster Farmers Association

Businesses

As our list of interviewees and stakeholders testifies, there are a whole range of businesses actively engaged in or connected to the New Zealand aquaculture industry. These companies operate both across the supply chain (farm through to consumer) and in individual stages of production, processing and distribution.

Governance

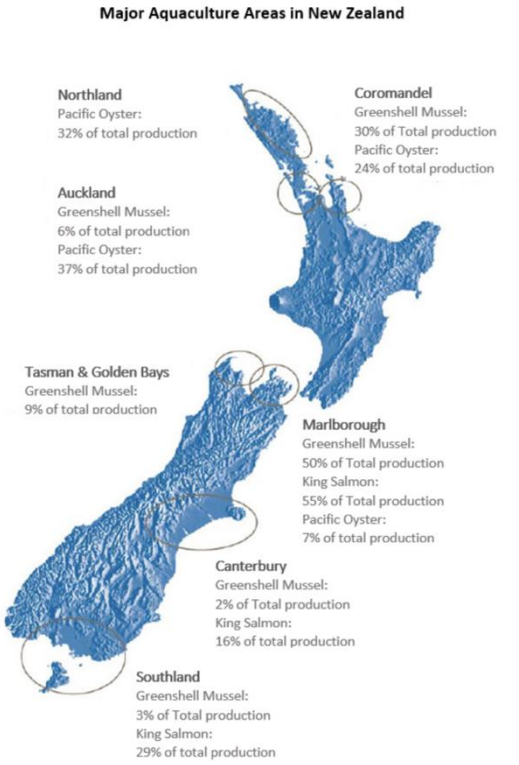
Key ministries:

- Ministry for Primary Industries
    - Fisheries New Zealand
    - the proposed National Environmental Standard for Marine Aquaculture
- Ministry for the Environment
    - The Resource Management Act (RMA)
    - other governing laws
- Ministry of Business, Innovation and Employment (MBIE)
    - The Institute of Environmental Science and Research (ESR) AIM^2 study (see below)

Examples of broader work on plastics and plastic pollution:

- The Ministry for the Environment's Resource Efficiency and Circular Economy Transition Programme (RECET)[19]
- The Office for the Prime Ministers Chief Science Advisor – Rethinking Plastics report[20]
- The international Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal[21]
- Local councils
    - responsibility for granting marine farm consents under the RMA.

The image to the right shows the geographic distribution of marine farms.[22]



Waste infrastructure

- Recycling solutions
    - e.g. Envirowaste, COMSPEC
- Landfill operators

Community stakeholders

- Local community
- Consumers
- Iwi/Māori

Science & innovators

- Scion
    - capability to test 'marine degradation' of materials
    - ability to test presence of microplastics using the accepted methodology of the National Oceanic and Atmospheric Administration (NOAA) in the US
    - development of biodegradable materials[23]
- The Institute of Environmental Science and Research (ESR) (see below)
- NIWA[24]
- Cawthron Institute[25]

Universities

Many universities in New Zealand are involved in the study of aquaculture

- University of Waikato[26]
- University of Otago[27]
- The University of Auckland[28]
- The Nelson Marlborough Institute of Technology[29]
- University of Canterbury

Suppliers

- Equipment suppliers – Quality equipment, Donaghy's
- Feed suppliers - Skretting
- Packaging suppliers
- Feedstock/raw plastic suppliers – some farms make their own floats

Sustainability and innovation within the aquaculture industry

Sustainability is a core outcome of the New Zealand Government's Aquaculture Strategy, including the objective to partner with industry on a transition plan to reduce emissions and waste across the value chain.

The majority of interviewees we spoke to see New Zealand aquaculture as a global leader in sustainable aquaculture and are keen to maintain that title. There was a common feeling that if there are innovative solutions most farmers and others in the industry would be willing to deploy them, even at slightly higher costs.

There is a sense of pride in the natural environment they are operating in and the conviction that they are not intentionally polluting it with plastic waste.

Most feel that the industry is very adaptable and if there's a good solution the industry is willing to make changes. There was a mention that there may be small resistance to change by individuals who like to do things the way they have always been done, but this was considered a minority.

There was a desire for technological solutions that are 'foolproof' to make accidental/careless loss impossible for staff/crew.

There was a general willingness to collaborate on solutions. A few companies working on their own R&D said they would be willing to share solutions if it would improve the industry as a whole.

It was agreed that the power to make change was held largely by business/industry. Local councils had some degree of power during the consent process, but it was indicated that it would be detrimental to add additional measures at consent stage.

Ongoing action on plastics in aquaculture

Government initiatives

The New Zealand Government is a signatory to the New Plastics Economy Global Commitment. This is administered by the Ellen McArthur Foundation in collaboration with the United Nations Environment Programme. It aims to eradicate plastic packaging waste and pollution at the source.

New Zealand Food safety, part of the Ministry for Primary Industries (MPI) has published a risk profile to identify if research is needed to determine the dietary risks associated with microplastics in the environment.[30] The risk profile on microplastics in the New Zealand diet identified that the characteristics and levels of chemical contaminants associated with microplastics in New Zealand are unknown and further research is required to assess the risk to human health. Research is now underway to address this data gap (see below).

The Institute of Environmental Science and Research: Aotearoa Impacts and Mitigation of Microplastics (AIM2) research study

Aotearoa Impacts and Mitigation of Microplastics (AIM2) is a five-year national research programme to determine the impacts of microplastics in New Zealand. It was awarded more than $12.5M in the 2018 round of the Ministry of Business, Innovation and Employment (MBIE) Endeavour Fund. It is the first comprehensive research investigating the impact of microplastics and the threat to New Zealand's ecosystems, animals and people. The project team is working closely with a range of primary sector industry bodies, regional councils and territorial authorities, NGOs, iwi and communities. With 17 scientists working across six institutions AIM2 will significantly improve our understanding of the levels, distribution and impacts of microplastics on Aotearoa New Zealand and its unique ecosystems and taonga. It will also help to further the international knowledge and understanding in this area of research.

The project has three main objectives:

1. Understand what microplastics are in the NZ environment (freshwater, marine, horticultural soils, wastewater treatment plants and how much and what type) - working with MPI and Cawthron to supply fish and bivalves to test for presence in fisheries and aquaculture species.
2. Understand the potential impact of microplastics - how different plastics behave due to their differing chemical additives and polymer combinations, bio-toxicity in the ecosystems, and pathogen transportation. Some microplastics have been there since the 1950s and over time have acquired a biofilm with potential pathogenic microbes.
3. Investigate solutions - scientific/technical and social solutions.[31]

Ministry for Primary Industries - New Zealand Food Safety Research on the Impact of Microplastics in the New Zealand Diet on Human Health

The New Zealand Food Safety research on the potential health risks from exposure to microplastics via the food chain is a four-year research project. The project team will include the Institute of Environmental Science and Research and the University of Canterbury.

The research has three main objectives:

1. The levels of microplastics and their contaminants will be determined in a range of food categories, including mahinga kai (gathered food) the impact of cooking and food preparation on microplastics and their contaminants will be assessed and included in the research. Foods will be selected based on prominence in the diet as determined from the New Zealand Total Diet Study 2016. Other considerations are: risk foods like aquaculture, risk foods due to packaging, popular wild foods, and important markets for New Zealand.
2. The key to establishing whether ingested microplastics present a toxicity concern through food is to determine their properties once consumed and whether microplastics do get absorbed in the gut after consumption of contaminated food. *In vitro* bioavailability studies will assess the absorption rates of microplastics through the human gut.
3. New Zealand's food-based export industries and economy are particularly vulnerable to microplastic contamination as this could result in a food safety risk, potential yield loss, and could have potential trade implications. The assessment on the impact of microplastic contamination to the primary industries will be carried out using (grey) literature, industry, and export data.

Te Mana o te Wai

Te Mana o te Wai is the national korowai (cloak/overlay) that frames and informs the trajectory for immediate and future policy development, and regional freshwater planning. It is a concept that encompasses the integrated and holistic health and well-being of waters as a continuum from the mountains to the sea.

Te Mana o te Wai prioritises the following principles:

- The dual roles of iwi/hapū and the Crown to develop and maintain decision-making processes for water, including mana whakahaere;
- Kaitiakitanga and stewardship practices to sustain water; and
- Manaakitanga and care and respect in providing for the health of our nation.

When Te Mana o te Wai is provided for, the mauri (life-force) of the wai is sustained and the cultural, social, and economic relationship of iwi/hapū and all New Zealanders with the wai is maintained.

Organisational initiatives

A+ New Zealand Sustainable Aquaculture

The A+ Sustainable Management Framework (SMF) is an improvement programme for the New Zealand aquaculture industry. Objectives of the SMF is to better engage with local communities and continuously improve aquaculture environmental practices. There are measures within A+ around waste minimisation initiatives, however no specifics on plastic reduction.

The following are waste initiative comments and results (see image on next page) from A+ companies taken from the Aquaculture New Zealand 2019 Sustainability Report.

WASTE

MANAGING WASTE RESPONSIBLY

SPECIES		2017	2018	COMMENT
All	*'Have staff been trained in best practice measures to eliminate farming debris?'*			
	Farm debris	62%	76%	We'll be helping with training tools, farming guides and workshops to improve further on farm debris minimisation
	'Do you record the amount of waste (in tonnes and/or m3) taken to landfill annually?'			
	Waste audit	22%	33%	The industry is increasing its awareness of the waste it creates but we will seek to facilitate a greater uptake of waste audits in future

"We're re-using feed bags, using paper bags not plastic, reducing the number of soy sauce and wasabi sachets we put out and replacing these with large soy sauce and wasabi sachets"
High Country Salmon

"We monitor the Hoteo River and remove much of the debris which washes down such as old maimai. This forms a significant part of the cubic meters of rubbish we pay to have disposed of each year"
Biomarine

"We're starting down the road toward complete transition to single seed production on net bags so sticks, posts and rails, our biggest waste items, will be eliminated from our business"
Mahurangi Oysters

"We're using a basket/longline system that both improves waterflow through the farms and prevents the accumulation of debris under the stock. We don't use single use plastic in our farming operation"
Waiheke Marine Farms

"Trials continuing with lashing and ropes that can be composted. Sanford is working towards Zero Plastic, and minimising waste through the product and materials we use, training and recycling. We carry out over 150 beach cleans in Marlborough per year, and include agencies such as DOC and the Graeme Dingle Foundation (with the school kids) in some of these clean ups"
Sanford

The Marine Farming Association (MFA)

Sustainability initiatives by the MFA include:

MFA Environment Certification Programme

The MFA has been operating since 1990, and in 2010 established an Environmental Certification Programme which includes objectives to help clean up beaches in the top of the South Island. The programme includes year-round rubbish collection activities, a recycling programme, education of marine farming vessel staff, and regular compliance checks of vessels and farms. It engages with a large number of volunteers from the marine farming industry, including MFA members and marine farming companies that donate their time, vessels and equipment to monitor on a roster basis. This operates in 'collector' areas in the Top of the South, where they also participate in regular beach clean ups.

An environmental mentor

Employed to cover Marlborough and Tasman Bay/Golden Bay. The mentor works with farmers to ensure they are complying within the industry standards.

Waste reduction policy

To reduce waste to landfill (see image on next page).

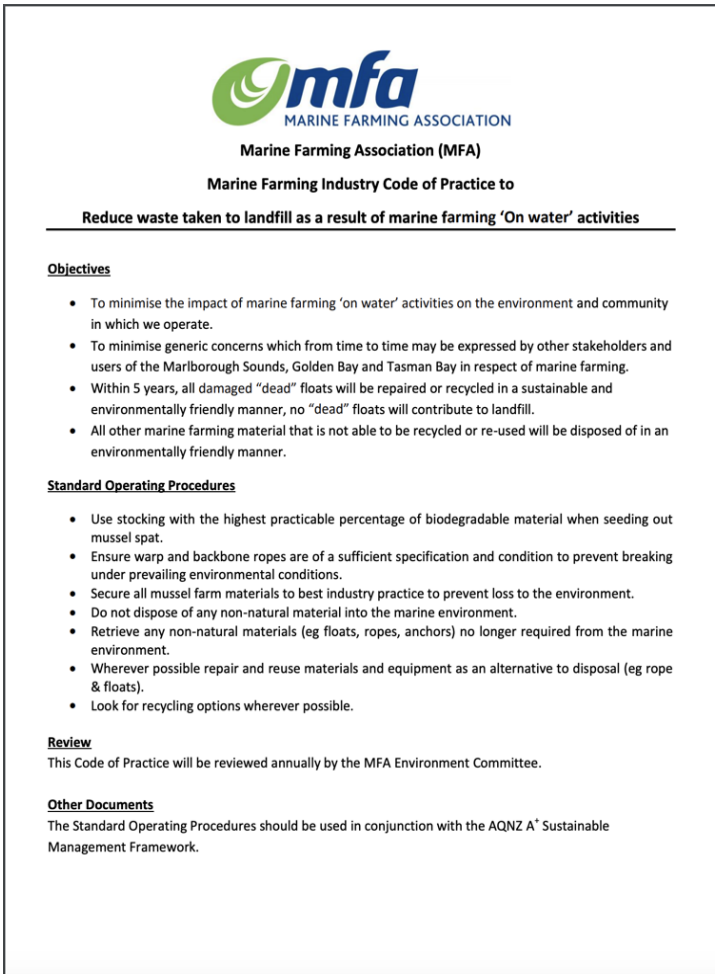
Educational video

To educate companies and their staff on how to be MFA-certified and minimise losses to the marine environment.

MFA Environment & Compliance Committee - Environment Programme Results (2019)

The MFA Environment Programme focuses on areas in which Marine Farming occurs, and includes the Marlborough Sounds, Tasman Bay and Golden Bay. This recorded the collection of a total of 2,695 kg of debris, down from 6,319 kg in 2018. The form used by MFA for beach clean ups needs to be manually analysed for data collection. More specific fields could be added to the form to determine the different typed of debris collected.

For 2019, 1,163 kg or 43% of all debris could be attributed to aquaculture activities. In 2018, 38% was attributable to aquaculture, indicating a slight increase in industry-generated debris. The Marine Farming industry faced considerable staffing shortages throughout 2019. These shortages put pressure on operational vessels and the availability of crews to perform beach clean ups. Potentially this is a reason for the significant decrease in overall collection. Another potential reason for the decrease is that many organisations and environmental groups are also carrying out beach clean ups, meaning there is less rubbish to be collected and reported by MFA.



mfa
MARINE FARMING ASSOCIATION

Marine Farming Association (MFA)

Marine Farming Industry Code of Practice to

Reduce waste taken to landfill as a result of marine farming 'On water' activities

Objectives

- To minimise the impact of marine farming 'on water' activities on the environment and community in which we operate.
- To minimise generic concerns which from time to time may be expressed by other stakeholders and users of the Marlborough Sounds, Golden Bay and Tasman Bay in respect of marine farming.
- Within 5 years, all damaged "dead" floats will be repaired or recycled in a sustainable and environmentally friendly manner, no "dead" floats will contribute to landfill.
- All other marine farming material that is not able to be recycled or re-used will be disposed of in an environmentally friendly manner.

Standard Operating Procedures

- Use stocking with the highest practicable percentage of biodegradable material when seeding out mussel spat.
- Ensure warp and backbone ropes are of a sufficient specification and condition to prevent breaking under prevailing environmental conditions.
- Secure all mussel farm materials to best industry practice to prevent loss to the environment.
- Do not dispose of any non-natural material into the marine environment.
- Retrieve any non-natural materials (eg floats, ropes, anchors) no longer required from the marine environment.
- Wherever possible repair and reuse materials and equipment as an alternative to disposal (eg rope & floats).
- Look for recycling options wherever possible.

Review

This Code of Practice will be reviewed annually by the MFA Environment Committee.

Other Documents

The Standard Operating Procedures should be used in conjunction with the AQNZ A* Sustainable Management Framework.

The Coromandel Marine Farmers Association (Coromandel MFA)

The Coromandel MFA allocates beaches to its members and has requirements for members' participation in Coromandel Beach Debris clean-ups.[32] It was mentioned that data is not recorded particularly well and not collated into any metrics. AQNZ has been trying to roll out an app for beach clean ups called 'Marine Debris Tracker'. The data from the app would automatically upload into an Excel sheet for ease of reporting.

Some concern was expressed about publishing beach clean-up results as it could cause negativity towards the aquaculture industry.

Sanford's pledge against plastic

Sanford has pledged to reduce its plastic usage by 70% by 2025 as part of its 'WHATPLASTIC?' plastic reduction programme. A range of initiatives are in progress, from packaging innovations to the development and progressive phase out of plastic in its retail operations, and ongoing roll-out of operational innovations. In its aquaculture operations this has driven the search for alternatives to plastic ties and ropes and the recycling of

approximately 4,500 polypropylene mussel farm floats each year, of which 4% of floats deemed irreparable are replaced by fully recycled ones.[33]

Other activities and immediate opportunities

Beach clean ups

All interviewees pointed to beach clean ups as a tool the industry was using to combat plastic pollution. Beach clean ups were also seen as an education opportunity for crew to increase care taken when on farms. Interviewees stated a 60:40 ratio of general litter to aquaculture litter from debris collected in beach clean ups, with a decreasing trend over recent years. Interviewees also indicated that there was a coordinated effort in how the beach clean ups were carried out using wave patterns and industry wide beach allocation to ensure clean ups are efficient.

Reuse

This refers to the action or practice of using an item again, whether for its original purpose (conventional reuse) e.g. the reuse ropes and nets over multiple cycles or to fulfil a different function (creative reuse or repurposing). It should be distinguished from recycling, which is the breaking down of used items to make raw materials for the manufacture of new products. From the interviews it seems creative reuse is already commonplace, with the following examples:

- Rope used by landfill operators to hold caps down
- Floats used at home as planter boxes or other uses
- Apparently, there is a book in circulation entitled: *101 uses for old Mussel Floats*
- Nets have been reused in bird aviaries
- Nets used as trailer tie downs

Repair (nets and floats)

Key stakeholders described how repair is commonly undertaken to extend the life of aquaculture equipment. Under MFA certification repair comes first for any equipment being used. Float and net repair were the most commonly mentioned repairs made to plastic equipment.

Oyster FlipFarms

This is a complete redesign of traditional oyster farming that was designed out of necessity and frustration from lost gear. This is promoted as: “Robust is a must! Gear loss saps both your morale and your bank balance”. The FlipFarm system permanently attaches the baskets to the lines which are 24mm polypropylene rope, tested for

40 years in the New Zealand Greenshell mussel industry. The opportunity for gear loss or damage is significantly reduced. Maintenance on gear is almost eliminated, however in the unlikely event of gear damage, such as a high-speed vessel collision, all of the components can be replaced individually."[34]

Regular and proactive net/rope integrity testing

This is an industry practice that aims to retire and/or repair equipment before it breaks, to minimise accidental loss.

Mussel industry servicing ropes on land to minimise fibre loss

This includes having gully filters in place to capture fibre loss. It's understood that this is a stipulation of the consenting process.

Sustainability reporting

Many of the larger organisations undertake sustainability reporting highlighting initiatives being taken to minimise waste.

Recycling nets into carpet

New Zealand carpet is being made from fishing nets and other recycled nylon waste.[35]

Alternatives to polyboxes

These are being explored and trialled throughout the industry:

- Cardboard
- Zealafoam[36]
- Woolcool[37]
- FishCap [38]
- TempGuard[39]

Addressing waste from PPE

- Gumboots into playground mats (Moana)
- Use of local recyclers for some items (New Zealand King Salmon)
- TerraCycle (although this would involve shipping to the United States)[40]

Float recycling

Emerging from a 2018 Smart+Connected Aquaculture workshop, representatives from key mussel producing companies teamed up to identify how to recycle floats. Initially they were looking into investing in a mobile service that could travel between areas to clean and shred floats, however costs and compliance requirements were too high.

Instead, they redesigned a trailer to accommodate more floats, improving transport capacity from 6 to 11 tonnes per trailer load and, significantly reducing transport costs. Floats are cut in half and sent on the trailers to COMSPEC in Christchurch where they are cleaned, shredded and extruded into pellets. The recycled pelletised material is then shipped to Vision Plastics, which is helping to fund the trailers' frames and co-ordinating deliveries to the recycler, for introduction into non-critical products such as pipes, roading material, protection for underground power cables and other products.

Mussel farmers that return floats are rebated at ~$350/ tonne. This has the capacity to be scaled-up nationwide with discussion underway with recycling processors in both Christchurch and Auckland.

Fish bin recycling
Fish bins with serrated bottoms used on conveyor systems in Salmon farming are being recycled by COMPSEC in Christchurch.

Float recovery
Despite their best efforts, mussel farmers periodically lose mussel longline floats. This represents a reputation risk and a financial loss with floats costing ~$130-150. A reporting system is in place that sends teams of volunteers out on boats to collect any floats found.

Crew training
This specifically includes techniques to minimise accidental loss of aquaculture equipment. This is included in the A+ programme and is also a MFA Environment Certification requirement.

Eliminating peg use in oyster farms
Pegs used in attaching baskets can come loose and be lost to the environment. There have been suggestions to eliminate peg use altogether.

Artificially intelligent salmon feeding
The use of technology including underwater cameras helps to more closely match optimum feeding, meaning less waste feed and therefore less plastic use.

A new Artificial Intelligence Institute with an initial focus on the local aquaculture industry has started in Nelson after a $3.4 million loan from the Provincial Growth Fund.[41]

100% cotton mussocks
Mussocks can contain blends of polyester. However some use 100% cotton, which is more benign in the marine environment.

Research and development into natural bio-based alternatives to aquaculture plastics
This is underway by industry and Scion, however due to commercial sensitivity details are not yet available for public release.

Reuse of one tonne mussel bags and other containers or baskets in processing and distribution

Trials of alternative rope materials
This has included:

- wool materials, which only lasted 12 weeks, and was a potential issue concerning the possible environmental impact of the treatment the rope requires
- using recycled content did not provide the strength of rope required
- steel cable has been tried but hasn't performed well.

Interviewees indicated that hemp rope was once used in mussel farming, apparently treated with tar, which had potentially harmful effects on the mussels and surrounding environment. The hemp ropes lasted around two years, less than synthetic ropes, and were difficult to get back onto the boat. This last issue would now be insurmountable as ropes are becoming longer and thicker and need to be lightweight.

Primary Packaging

Extensive work is being done on primary packaging across the sector. For example, New Zealand King Salmon is a signatory to the New Plastics Economy Global Commitment and working towards all plastic packaging being reusable, recyclable or compostable by 2025.

Phasing out, replacing and recycling single-use plastic products and polystyrene bins

Moana New Zealand is taking steps to reduce single use plastic. Its recycling scheme has diverted 22 tonnes of waste from landfill to date and an on-site waste audit programme is identifying further opportunities to minimise and reimagine waste.

Other local and international activities

Shredding mussel ropes (including bulk bag) for recycling[42]

European investment in bio-based ropes for aquaculture[43]

European system for discarded commercial fishing gear collection[44]

UNEP Marine Plastics Report[45]

Seafood Business for Ocean Stewardship (SeaBOS)[46]

The Aquaculture Stewardship Council report: Marine Litter and Aquaculture Gear[47]

The United Nations Voluntary Guidelines on the Marking of Fishing Gear[48]

Generating solutions, priorities, and ways forward:

Workshop summary

On 29 May 2020 SBN facilitated a half-day workshop to share ideas and generate inspiration for how to minimise plastic waste in the sector. This was originally planned to be an in-person workshop in Nelson, however due to the unforeseen circumstances from Covid-19, it was adapted to be an interactive online workshop.

Moving to an online format enabled attendance from across New Zealand, with over 40 representatives spanning the aquaculture industry, governing bodies, science & innovation, and infrastructure.

SBN used the workshop to share key findings from initial stakeholder engagement, identify any additional initiatives undertaken by the industry and develop next steps for tangible solutions to help eliminate plastic waste in the sector.

The workshop was facilitated by SBN in multi-stakeholder mixed groups and product-line specific groups.

Scene setting

In the first part of the workshop we heard from science and industry experts on various aspects of the role and challenges of plastics in aquaculture. Speakers included:

Stephen Harris
Founder of Maui's Ark and the former Special Representative of the Commonwealth Clean Ocean Alliance
A global perspective on the opportunity for the NZ aquaculture sector to lead the world on addressing marine plastic waste associated with the sector

Olga Pantos
The Institute of Environmental Science and Research (ESR)
What are microplastics, what we know about them and what we are hoping to learn - within a NZ context

Karen Mant | Ned Wells
Aquaculture NZ | Marine Farmers Association (MFA)
A+ Improvement Programme, and plastics from aquaculture being found in NZ beach clean ups

Robert Fowler
Comspec
Learnings from recycling plastic aquaculture equipment – what's recyclable, what's not and what to use in the future

Francesca Goodman-Smith
Foodstuffs NZ
A plastic waste reduction distribution and retail perspective

Liz Butcher
Ministry for the Environment
The Government's role in addressing plastic waste

James Griffin
Sustainable Business Network
Circular innovations tackling plastic waste – eliminate, innovate, circulate

A draft vision for plastic use in aquaculture

To begin to chart a visionary direction for addressing plastics in aquaculture, attendees were tasked with the following exercise:

"You have been tasked with developing a demonstration aquaculture farm and processing plant on and next to one of NZ's most renowned marine reserves.....a panel of global key stakeholder experts and influencers are scheduled to visit in five years' time to assess how plastic is being used and what impacts it is having on the pristine environment. What do you tell the panel when they arrive?"

The participants' responses to this challenge identified the following ideas:

Visionary aspirations

- 100% of plastics used should be reusable, recyclable or safely marine biodegradable
- Collaborative efforts across the industry, around a central goal of a circular economy for aquaculture plastics that includes recyclers, science/innovation, governance and business, are used to design of solutions
- Plastic, including microplastics, escape into the marine environment is minimised
- Farm environmental plans include a plastic management strategy
- Collect necessary data to understand the NZ context and ensure informed decision making
- Create and scale reusable systems in the processing and distribution of aquaculture products

A potential draft vision for the sector:

World Leaders in Plastic-Waste-Free Aquaculture

New Zealand will be a world leader in plastic waste free aquaculture. Industry collaboration and innovation will provide radically redesigned systems for zero-tolerance to plastic loss

Plastics have been designed out wherever possible. Plastics that remain are contained in continuous closed cycles of reuse.

Stringent environmental management systems provide a constant and transparent stream of monitoring data. This provides full assurance for customers, partners, local communities and government agencies alike.

What's needed to achieve the vision

- Designing materials and products from the outset to work in this new system
- Full auditing, assessment and tracking of plastic inputs, use and loss across the sector
- Identifying abrasion and breakdown points on equipment and addressing them to prevent loss
- Ensuring plastics used are from recycled/renewable sources and are recycled in practice
- A coordinated approach between all key stakeholders with the goal of plastic pollution prevention
- Investigation into natural fibres/alternative materials from a whole of sector perspective
- Thoroughly considering and mitigating potential unintended consequences of alternative materials

- GPS tracking of equipment with systems in place to collect escaped items
- Technology to trace where plastic comes from and where it ends up (e.g. radioactive labelling)
- Research into development of PPE recycling schemes

Roles of key stakeholders

All stakeholders must collaborate across the entire industry to ensure co-ordinated, fit for purpose practical solutions are developed with urgency.

Suppliers:

- Taking responsibility for environmental impacts of products across the whole life cycle, including end of life
- Investigating product stewardship initiatives and schemes including reuse as well as recycling
- Collaborating with other stakeholder groups to develop practical NZ based solutions
- Communicating the end of life options at point of purchase

Farmers:

- Developing procurement policies to minimise unnecessary or problematic plastic entering the farm
- Adding plastics to farm environmental plans and report on types used and minimisation of waste achieved
- Collaborating with other key stakeholder groups on practical solutions
- Initiating change at first opportunity to prevent plastic leakage
- Working to strive past best practice standards

Processors & Distributors:

- Being proactive and seeking opportunities to use examples from external trials for aquaculture applications
- Looking to other sectors for opportunities on how to improve packaging throughout the supply chain

Innovation & Science:

- Cross-fertilising relevant work in other sectors into aquaculture sector
- Considering applications across the full system when developing solutions
- Collecting necessary baseline data on plastics to measure impact

Governance:

- Funding and investing in R&D, infrastructure and building sound data collection
- Employing regulatory levers to assist and incentivise best practice and further innovation
- Building on the A+ programme to develop its scope to address plastics specifically

Re-processors:

- Leading development of necessary infrastructure to deal with essential plastics
- Seeking opportunities to educate and collaborate on end of life solutions in aquaculture

Enabling conditions

During the workshop attendees identified the following as conditions that would enable the vision to be met:

Area	Considerations and potential actions
Policy/Legislation	• Develop a uniting industry policy, centred around an industry-led 2025 commitment for tackling plastic waste in the sector • Investigate related industry policies (e.g. wild fisheries) to identify any cross-industry relevance • Consider implementing a mandatory system for reporting plastic equipment loss • Introduce a plastic waste minimisation performance rating for products coming to market • Provide incentives preventing plastic waste in the consenting process, based on a practice from Norway
Certification/Codes of conduct	• Develop existing certifications to specifically address plastic waste
Education	• Employ an industry sustainability representative to focus on waste/plastic reduction throughout the sector • Develop and augment best practice guidelines for plastic use, particularly for more dynamic environments • Support community initiatives to educate, raise awareness and remove plastic waste and other litter from land adjacent to aquaculture facilities • Investigate developing or utilising an existing app for ease of collating beach clean-up data – investigate linking with 'Litter Intelligence' work from Sustainable Coastlines • More 'grass roots' education around preventing plastic waste • Education on specific and practical methods that improve waste reduction e.g. different ways of using ties
Innovation	• Investigate if a better system can be developed to tackle the issue of plastic pollution at source, rather than tackling the symptoms. For example, a float system that uses pegs that can be reused instead of lashings. • In the interim innovative recycling opportunities need to be developed
Funding	• Identify broader funding opportunities to assist with developing plastic waste minimisation initiatives
Infrastructure	• Collaborate to 'join-up' existing infrastructure e.g. 'Grind the floats' collaboration to recycle mussel floats • Specifically investigate how to overcome bio-fouling of ropes as a limitation to recycling • End markets for recycled materials need to be developed and supported to drive infrastructure development
Baseline Data	Considerations: • Some data is available (e.g. used net and float data) • Individual businesses have this knowledge, but not at a sector level • Transparency on individual business' plastic use would create a 'burning platform' for action • A national system for data collection would be required • Volumes purchased could be aggregated but consideration is needed to track reuse, recycling, landfill and loss into the environment • Data gaps shouldn't prevent action • The sector needs better knowledge on the potential risks related to micro and nano plastics and how NZ compares globally

Selected priority to progress

During the workshop a group of key industry stakeholders identified the need for a uniting sector-wide commitment;

Establish an industry led 2025 commitment for tackling plastic waste in the sector.

This would provide a galvanising focus for the sector and a strategic framework for developing and coordinating the multiple opportunities and considerations outlined.

A commitment would need to be part of a comprehensive sector led and supported plan, with specific targets for elimination, reduction, reuse and recycling.

Specific opportunities for the sector to reduce plastic waste

This section is based on the key three elements framework for addressing plastic waste put forward by the Ellen MacArthur Foundation for its New Plastics Economy movement.

Eliminate the plastic we don't need.

Innovate to ensure the plastics we do need are reusable, recyclable or compostable.

Circulate all plastic items we use to keep them in the economy and out of the environment.

The framework has been used to identify new, and build on existing, solutions to key plastic opportunities across the sector.

The following tables are the outputs from applying this framework in the workshop.

Opportunities to change plastic use in Greenshell Mussel production	Brainstorm of potential solutions and initiatives		
	Eliminate	Innovate	Circulate
End of life for bulk bags	- Invest in heavier duty materials to extend life and prevent tearing	- R&D into bulk bag design	- Design bulk bags for recycling in NZ - Reuse/repair to extend life
End of life solutions for ropes		- Enable collaboration both locally and overseas for R&D into alternative materials that have sound end of life solutions	- R&D into an economic removal of biofouling to allow for effective recycling via a collection system, cleaning and then shredding
Scaling end of life solutions for floats		- Use high grade plastics to increase float life span (cost benefit analysis)	- Improve the process for removing biofouling to make recycling easier - Scaling up the float recycling scheme
Ties/ lashings escaping into the environment	- Greater education and stricter adherence to best practice for cutting and collecting ties/lashings	- R&D into a new attachment mechanism for floats that removes the need for ties/lashings e.g. clamping (SNS float) - Design lashings/ties to be benign to the marine environment e.g. biomaterials	
Floats escaping into the environment	- Eliminate the reuse of old ties as they break more often and are lost to the environment	- GPS mark floats to enable track & trace	
Ropes fraying/ abrasion -fibres escaping to environment	- Continue with regular targeted beach clean ups Regular and proactive integrity testing - minimises breakage and loss to environment	- Industry-wide coordinated effort looking at alternative materials e.g. biomaterials, metals, hemp etc - Design ropes to be more visible and easier for collection/ identification of time for retirement	
PE blended mussocks breaking down in the water		- Redesign mussocks with alternative materials e.g. 100% cotton or bio-plastic blends	

Opportunities to change plastic use in King Salmon production	Brainstorm of potential solutions		
	Eliminate	Innovate	Circulate
Pen components lost to the environment - not a main issue	- Regular targeted beach clean ups - Eliminate plastic by using steel pens - Regular and proactive integrity testing - minimises breakage and loss to environment	- R&D into alternative materials (biomaterials, metals) with end of life solutions - Reduce net volume and plastic use - Copper based nets	Reuse/ repurpose old/retired nets for horticulture
End of life for nets- microplastics from wear + tear		- Design nets to be biodegradable	- Recycle nets into different products e.g. playground materials, retaining materials, carpet tiles
End of life for feedbags	- Use drawstring feedbags and send back to supplier for reuse - Encourage product stewardship from suppliers - Repurpose feedbags sector wide – e.g. mussel bulk bags	- Design a centralised bulk feed distribution for salmon (replacing feed bags with silos)	- Work with suppliers and recyclers to redesign feedbags to fit in NZ recycling system
End of life for fish bins	- Scale & automation, using tankers, handling		- COMSPEC Christchurch able to recycle HDPE fish bins
End of life for pen components		- R&D into alternative pen materials (biomaterials, metals) with end of life solutions	- HDPE feed pipes able to be chipped and recycled
End of life for ropes		- Colour code ropes by year to allow for retirement process prior to abrasion/ wear - Design ropes to be more visible and easier for collection/ identification - R&D into alternative rope material (biomaterials, metal etc)	- Recycle ropes in industry wide collection for cleaning and shredding

Opportunities to change plastic use in Pacific Oyster production	Brainstorm of potential solutions		
	Eliminate	Innovate	Circulate
End of life solutions for baskets	- LCA of flip farms vs traditional farming methods – cost benefit analysis of using more plastics	- R&D into alternative basket material (biomaterials, metal, compostable etc)	- Ensuring baskets are recyclable in NZ
Loss of pegs to the environment	- Eliminate pegs completely	- Pegs made from fully marine biodegradable materials	
End of life solutions for bins/ crates			- HDPE fish bins able to be recycled at COMSPEC
End of life solutions for ropes		- R&D into alternative materials for ropes (e.g. steel, biomaterials etc)	
Microplastics in Oysters	- Beach clean ups and education campaigns to stem the source of plastic pollution from land-based activities	- Oysters to sit in fresh water to purify - Move Oysters to clean sites 2-3 weeks prior to harvest	

Commonalities across product groups:

- Requirement for **greater education** on plastics and their specific impacts to enable more informed decision making
- Desire across the industry to **eliminate single use items**
- A **collaborative approach** to R&D especially in the investigation into marine biodegradable alternatives. It appears efforts are currently relatively isolated and would benefit from a whole of system coordinated approach
- Any initiatives that are considered for implementation need to be understood well and avoid any unintended consequences.

Industry wide opportunities:

Industry-wide opportunities	Brainstorm of potential solutions		
	Eliminate	Innovate	Circulate
End of life for PPE	- Use the same products throughout the industry to enable economies of scale for solutions - Use of screens to eliminate the need for some PPE - System changes to use less PPE in appropriate spaces	- New end of life applications for PPE - e.g. Moana - gumboots into playground mats	- TerraCycle offer recycling solutions for PPE – offshore - Buy/ co-design PPE suitable for recycling in NZ
Microplastics entering product	- Education and advocacy to community to reduce plastics entering from land-based activities - Beach clean ups to try and reduce source of microplastics		- Education on what materials are able to be recycled and life span of materials for those in procurement positions
Management systems not specific to plastics	- Transparency of beach clean-up information to create external pressure to find solutions - Create policy addressing plastics use		- Educate those in purchasing positions on NZ's recycling capability so they can make informed decisions.
Logistics & distribution packaging	- Eliminate plastic packaging by selling/marketing whole oyster, whole mussels and public education about impacts of plastic - Phasing out, replacing, recycling single use plastic products - Reusable solutions to pallet wrap e.g. Palletite - Elimination of bin liners used in salmon processing	- Open sourced testing of alternatives to polyboxes (e.g. Zealafoam, Woolcool, Fishcap, TempGuard)	- Ensure any traditional plastic packaging that is used fits in NZ's recycling system

Prioritisation of the solutions

During the workshop attendees were asked to identify which current initiatives and potential solutions should be prioritised going forward:

Greenshell Mussels

High Impact / Low Viability	High Impact / High Viability
- Transparency of beach clean-up information - needs discussion - Designing ropes to be more visible and easier for collection/ identification of resin code - Sustainability reporting with plastics targets - Alternatives to polyboxes (e.g. Zealafoam, Woolcool, Fishcap, TempGuard) - Reusable solutions to pallet wrap	- New end of life applications for PPE - Education on best practice for lashings / ties (e.g. MFA training videos) & crew training to minimise loss of all equipment - Beach clean ups and float recovery programmes - R&D into a new attachment mechanism for floats that removes the need for ties/lashings e.g. clamping (SNS float) - R&D into bulk bag design - Advocacy for land-based solutions to mitigate plastic escaping from on-land practices - Introducing internal procurement policy - Phasing out all single use / problematic packaging in production, processing & distribution - Upscaling the float recycling scheme - Investing in higher quality plastics to extend life and recyclability for all equipment
Low Impact / Low Viability	Low Impact / High Viability
- Phasing out, replacing, recycling single use plastic products - Redesigning mussocks with alternative materials e.g. 100% cotton or bio-plastic blends	

Selected priorities to progress

Upscaling the float recycling scheme

Aim

Every float produced by the industry is recycled at end of life.

Key steps

- Appropriate funding to kick-start the scheme and investigation into how to achieve an economic model for all stakeholders (farms, processors, recyclers)
- Desire for the initiative to be driven collaboratively by AQNZ, farmer and recyclers

- Sector-wide opportunity in using common plastic types across products to reduce recycling complexity and cost and increase scale of recyclate

First step
AQNZ to set up discussion with MFA and recyclers to identify specific barriers to scaling operations.

Development of new float attachments

Aims

- No lashings/ties lost to the environment
- Minimising/eliminating the landfilling of ties and lashing
- More secure floats

Key steps

- Funding/ resourcing to enable proper research and change
- Open sourcing of the solutions so everyone can access them
- Incentives for farmers to follow best practice
- Key stakeholders required from suppliers, science & innovation, and industry

First step
Bring together all currently working on the array of alternative solutions across the sector (biomaterials, hemp, steel, clamping floats) to coordinate and collaboratively find a solution.

King Salmon

High Impact / Low Viability	High Impact / High Viability
- Repurposing used nets	- Reducing retail packaging - Feedbag recycling/ elimination - Elimination of bin liners - New end of life solutions for PPE
Low Impact / Low Viability	**Low Impact / High Viability**
- Recycling ropes by centralised collection for cleaning and shredding	- Sustainability reporting - Recycling fish bins - Regular targeted beach clean ups

Selected priorities to progress

Addressing processing & distribution plastics

Aims

- No liners to be used in distribution packaging (polyboxes or replacements)
- Establishing a range of options for recycling facilities
- A 50% reduction in PPE consumption

Key steps

- Formalising these issues as an agreed plan
- Design thinking to go beyond substitution
- Collaboration to ensure industry-wide shared solutions and adoption
- Reviewing post Covid-19 PPE needs

First step

Establishing sub-sector forum

Pacific Oysters

High Impact / Low Viability	High Impact / High Viability
- Moving oysters to freshwater to try and purify from any microplastics - Pegs made from fully marine biodegradable materials	- Life Cycle Assessment to understand the full environmental cost versus benefits of materials (including alternatives to plastics) used in farming practices - Eliminate plastic packaging - Move away from pegs completely - Education for farms on what materials are able to be recycled and life span of materials
Low Impact / Low Viability	Low Impact / High Viability

Selected priorities to progress

Understanding the full environmental cost versus benefits of materials (including plastics and alternatives) used in farming practices via a life cycle assessment (LCA)

Aims

- Determine the environmental impacts versus benefits of different material types, including plastics and alternatives, across the value chain

Key steps

- Understand the specific scope of the information required
- Identify key and willing stakeholders and form working group
- Identify funding sources

Key involvement
Industry, government, research organisations and suppliers

First step
Establish business case for funding.

Eliminate plastic packaging by selling the oysters whole (unshucked) by educating NZ consumers

Aims
Minimise use of plastic packaging across the supply chain

Key steps

- Consumer education
- Working with/collaborating across supply chain

Key involvement
All parts of the supply chain – retailers, suppliers, processors, marketing, consumers, etc.

First step
Establish an industry wide group, including retailers, to work through in detail

Stop using pegs

Aims
Plastic pegs eliminated, or replaced with a marine-safe biodegradable alternative

Key steps

- Open source solutions
- Educate farmers so they can understand the need for change
- Incentivise elimination of pegs in farming practices

Points of influence

Industry outreach and communications

When asked how to get new innovations or other news across the industry, interviewees identified the following ways in which action and innovations on plastic use could be shared more widely:

- Annual conferences – Aquaculture New Zealand, Marine Farming Association and Seafood NZ
- Monthly industry meetings – most associations have monthly or bi-monthly meetings
- Facebook/social media accounts and groups
- AQNZ, MFA, Seafood NZ magazines – well-read throughout the industry
- Email – in this industry "everyone knows everyone"

Rules, regulation and certification

Insurance policies

A few interviewees stated that for their insurance policies they were required to do regular testing of ropes and nets to reduce chances of breakages and loss of product.

Government policy

Government and local authorities will continue to shape the aquaculture industry in New Zealand through the consenting process, related local government regulations and policies and the administration of the Resource Management Act (RMA).

In addition, the Ministry for the Environment's Resource Efficiency and Circular Economy Transition Programme (RECET) includes proposals to:

- Expand and increase the Waste Levy expansion
- Improve the nation's resource recovery infrastructure and systems
- Lead adherence to The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal
- Expand and increase regulated product stewardship.

Programmes and Certifications

The inclusion of the plastics issue in third-party certification aquaculture standards is an important driver for positive progress.

During stakeholder interviews the following certifications were acknowledged:

A+

The A+ sustainable management framework is intended to enable the New Zealand aquaculture industry to better engage with local communities and continuously improve its environmental practices, while strengthening global demand for New Zealand seafood.[49] Many interviewees pointed to the A+ improvement programme as being a key vehicle for introducing a framework to minimise plastic loss and promote best practice. AQNZ has been developing reporting tools for A+, and aims to internally assess all companies, with 10 companies being third party assessed annually.

MFA

The MFA Environmental Certification Program is designed to recognise and record active participation in and agreement to the objectives of the MFA Environment Program which operates in the 'top of the south'. This includes adherence to the Industry Standard Operating Procedures and Codes of Practice.[50]

Best Aquaculture Practices (BAP)

The BAP Certification is intended to verify that producers are following best practices to deliver farmed seafood safely and responsibly. It addresses four key areas of sustainability (environmental, social, food safety, and animal health & welfare) at each step of the aquaculture production chain.[51]

The International Organization for Standardization (ISO)

There have been nine ISO standards published under the direct responsibility of the ISO Technical Committee working on fisheries and aquaculture. These include:

- ISO 12875:2011 Traceability of finfish products — Specification on the information to be recorded in captured finfish distribution chains
- ISO 12877:2011 Traceability of finfish products — Specification on the information to be recorded in farmed finfish distribution chains
- ISO 12878:2012 Environmental monitoring of the impacts from marine finfish farms on soft bottom
- ISO 16488:2015 Marine finfish farms — Open net cage — Design and operation
- ISO 16541:2015 Methods for sea lice surveillance on marine finfish farms
- ISO 18537:2015 Traceability of crustacean products — Specifications on the information to be recorded in captured crustacean distribution chains
- ISO 18538:2015 Traceability of molluscan products — Specifications on the information to be recorded in farmed molluscan distribution chains
- ISO 18539:2015 Traceability of molluscan products — Specifications on the information to be recorded in captured molluscan distribution chains[52]

The Aquaculture Stewardship Council (ASC)

The ASC's current standards set criteria for dealing with plastic. They include various requirements for certified farms to implement policies for waste reduction and recycling and ensure responsible storing and disposal of waste.

Going forward, the ASC is also reviewing the need for new criteria/indicators specifically targeting the issue of marine litter, plastics and ghost gear. This would be implemented in future revisions of its standards or guidance documents.

In the future, ASC certified producers will be required to carry out a risk assessment of potential plastic contamination and pollution, and to implement mitigation actions to minimise the impact at the farm and its surroundings. Farms will need to record all used and disposed plastic material. They should implement a plastic waste monitoring programme to ensure waste is disposed in a responsible manner, recycling when possible.[53]

Potential funding

Waste Minimisation Fund

The Waste Minimisation Fund , administered by the Ministry for the Environment, provides funding for projects that promote or achieve waste minimisation. This helps to increase resource efficiency, reuse, recovery and recycling, and decrease waste to landfill.

Local councils also provide funding for waste minimisation initiatives.

Ministry of Primary Industry's Sustainable Food & Fibre Futures (SFF Futures)

SFF Futures supports problem solving and innovation in New Zealand's food and fibre sectors by co-investing in initiatives that make a positive and lasting difference. Current seafood and aquaculture projects supported include the transformation of New Zealand *Undaria pinnatifida* seaweed from a costly mussel-industry pest into a sustainable, high-value agricultural product for the global market. It may be worth considering further applications for innovations related to plastic use and pollution reduction.[54]

Callaghan Innovation R&D Grants

Callaghan Innovation offers a range of R&D funding to add scale, depth and return to R&D investment.

Conclusion - The way ahead

From our work with New Zealand's aquaculture sector, it is clear there is a shared aspiration to step up to the challenges presented by plastic use in the industry. This forms the basis to consolidate and expand on the innovative collaborations that are already underway, and to create new ones to further tackle these issues.

To that end, we have worked towards creating a draft vision for plastics in aquaculture and outlined the immediate next steps and some of the steps beyond.

There is a shared aspiration to embrace the opportunities presented by the need to tackle plastic waste in the industry. This can form the basis to consolidate and expand on the innovative collaborations already underway, and to create new ones. It is imperative that we underpin these aspirations with a clear commitment to goals in a given timeframe. SBN recommends further work on a 2025 Plastics in NZ Aquaculture Commitment for the entire industry. This would build on the work done here, and the overarching framework we have begun to develop.

This is an opportunity for New Zealand aquaculture, to get ahead of any overseas competition, maintaining its presence as a leader in sustainability. Integrating the principles of Te Man o te Wai will also help protect the mauri of water – its life-supporting capacity.

There are ample reasons to be confident the industry can experience major successes in this area in the coming months and years, and meet its aspiration of becoming a world leading plastic waste free system.

List of interviewees - Stage 1: Stakeholder engagement

Dave Taylor	Aquaculture NZ
Karen Mant	Aquaculture NZ
Zane Charman	Aquaculture Projects
Mike Holland	Clearwater Mussels
Tom Hollings	Coromandel Marine Farming Association
Karl French	High Country Salmon
Dean Condon	Kono
Ned Wells	Marine Farming Association
Olga Pantos	ESR
Maegen Blom	Mills Bay Mussels
Vince Syddall	Moana
Mark Preece	New Zealand King Salmon/NZ Salmon Farmers Association
Steph Hopkins	MPI - NZ Fisheries
Joe Franklin Jnr	Quality Equipment
Jaco Swart	Sanford Limited
Mike Mandeno	Sanford Limited
James Higgins	Sanford Limited
Kate Parker	Scion
Dawn Smith	Scion
Lanice Waitai	Taniwha Oysters Limited
Sally Spencer	Vision Plastics
Robert Fowler	COMSPEC

List of Attendees – Stage 2: workshop

Steph Hopkins	MPI – Fisheries NZ
Beth Davie	MPI – Agriculture and Investment Services
Dave Taylor	Aquaculture NZ
Karen Mant	Aquaculture NZ
Zane Charman	Aquaculture Projects
Ned Wells	Marine Farming Association
Paul Creswell	MPI - Fisheries NZ
Dean Condon	Kono
Peter Vitasovich	Whakatohea Mussels (Opotiki) Ltd
Peter James	James Marine
Scott Gillanders	MacLab
Mark Preece	New Zealand King Salmon
Jaco Swart	Sanford
Jemma McCowan	New Zealand King Salmon
Rick Ramsay	Mount Cook Alpine Salmon
Ben Divett	Akaroa Salmon
Aine O'Neill	New Zealand King Salmon
Pene Waitai	Taniwha Oysters Limited
Tom Hollings	Coromandel Marine Farming Association
Will McKay	Biomarine
Emmanuel Malpot	Moana
Michelle Cherrington	Moana

Peter Longdill	Sanford
Paul Gurr	New Zealand King Salmon
Owen Fisher	New Zealand King Salmon
Sally spencer	Vision Plastics
Hamish Oakley	Donaghys
Baz Henare	Cookes
Matt Wooley	Cookes
Olga Pantos	ESR
Kate Parker	Scion
Dawn Smith	Scion
Sarah Heine	Biopolymer Network Limited
Rachel Barker	Plastics NZ
Robert Fowler	COMSPEC
Liz Butcher	Ministry for the Environment
Rachel Chiaroni-Clarke	Office of PMCSA
Stephen Harris	Maui's Ark
Julien Vignier	Cawthron Institute
Sandra Evers	Aroma Aquaculture

Appendix 1

Plastics by resin identification codes

(1) Polyethylene Terephthalate (PET) is a clear, tough, solvent resistant, barrier to gas and moisture, softens at 70°C. PET is a thermoplastic polymer resin and is commonly used for fibres for clothing, containers for liquids and foods, thermoforming for manufacturing and in combination with glass fibre for engineering resins. It retains high value in recycling streams and is commonly recycled into things like pillow and sleeping bag filling, clothing, soft drink bottles and carpet.

(2) High-Density Polyethylene (HDPE) can be hard to semi-flexible, it is resistant to chemicals and moisture, has a waxy surface, opaque, softens at 135°C, easily coloured, and can be processed and formed. HDPE is a thermoplastic polymer produced from the monomer ethylene that withstands heat and cold well. HDPE has long virtually unbranched polymer chains which makes them dense and thus, stronger and thicker from PET. HDPE is used to produce bottles for milk, cleaning products, cosmetics, buckets, rigid agricultural pipe, and milk crates. It retains high value in recycling chains and is often recycled into things like recycling bins, compost bins, buckets, detergent containers, posts, fencing and pipes.

(3) Polyvinyl Chloride (PVC) is a thermoplastic polymer and comes in two basic forms: rigid (PVC-U) and flexible (PVC-P). The rigid form is strong, tough, can be clear, can be solvent welded, softens at 75°C and is used in construction for things like pipe and windows, as well as other applications like making bottles, non-food packaging, food-covering sheets, and bank cards. It can be made softer and more flexible by the addition of plasticizers (PVC-P), the most widely used being phthalates. Its properties are flexible, clear, elastic and can be solvent welded. In this flexible form, it is used in things like plumbing, electrical cable insulation, imitation leather, flooring, signage, inflatable products, and many applications where it replaces rubber. PVC is one of the least recycled materials and is often considered as the most hazardous plastic. The use of it may leach a variety of toxic chemicals such as bisphenol A (BPA), phthalates, lead, dioxins, mercury, and cadmium. PVC is rarely accepted by recycling programs and best to be avoided.

(4) Low-Density Polyethylene (LDPE) Linear Low-Density Polyethylene (LLDPE) is a thermoplastic polymer and is primarily used in soft plastic film applications because it is tough, flexible and relatively transparent. It is not commonly accepted by kerbside recycling schemes as it is difficult to sort from other materials. In commercial settings, LDPE and LLDPE films are commonly recycled as there is consistent scale and cleanliness. It is often recycled into things like rubbish bin liners, pallet sheets, slip-sheets.

(5) Polypropylene (PP) is a thermoplastic polymer and is hard but still flexible, has a waxy surface, softens at 145°C, translucent, withstands solvents, and is very versatile. It is commonly used in things like dip pottles and ice cream tubs, potato chip bags, straws, microwave dishes, kettles, garden furniture, lunch boxes, blue packing tape, automotive parts. Recycling PP is likely to become more common as it is a versatile and increasingly common material. It can be recycled into things like pegs, bins, pipes, pallet sheets, oil funnels, car battery cases and trays.

(6) Polystyrene (PS) and Expanded Polystyrene (EPS) is a thermoplastic polymer. PS is glassy, rigid, brittle, opaque, semi-tough and softens at 95°C. EPS is foamed, lightweight, energy absorbing and heat insulating. Since polystyrenes are lightweight and easy to form into plastic materials, it also breaks effortlessly, making it more harmful to the environment. Beaches all over the world are littered

with pieces of polystyrenes, endangering the health of marine animals. PS and EPS are commonly used for food containers, disposable cups and bowls, packaging, in bike helmets, take-away clamshells, foamed meat trays, protective packaging for fragile items, insulation, insulation panels. When exposed with hot and oily food, PS and EPS could leach styrene that is considered as brain and nervous system toxicant, it could also affect genes, lungs, liver, and immune system. For this reason, PS and EPS have low recycling rates as it is difficult to find end markets.

(7) Miscellaneous Plastics the remaining plastics include: polycarbonate, polylactide, acrylic, acrylonitrile butadiene, styrene, fiberglass, nylon and degradable plastic e.g. PLA. Of course, there are many differences in the plastics classified as miscellaneous by recycling programmes. This includes all other resins, multi materials (e.g. laminates) and degradable plastics. The properties of number 7 plastics are dependent on the plastic or combination of plastics. It is not very easy to break down these plastics once they are created unless they are exposed to high temperatures. This means they are nearly impossible to recycle.

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