



An Investigation into the Viability of Recycled Polyester
from Recycled Polyethylene Terephthalate (rPET)
as a commercial and sustainable fibre for production in the UK

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SCHOOL OF TEXTILES AND DESIGN

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Press

This work has generated the interest of local media and has been documented on the Heriot Watt Website and in the Borders Telegraph (issue April 04, 2018).

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Glossary of Terms

rPET	Recycled Polyethylene Terephthalate
vPET	Virgin Polyethylene Terephthalate / "Virgin Polyester"
CSR	Corporate Social Responsibility
LCA	Life Cycle Assessment
AFIRM	Apparel and Footwear International RSL Management Group
RSL	Restricted Substances List
USA	United States of America
REACH	Registration, Evaluation, Authorisation & restriction of CHemicals
EU	European Union
FAST	Fabric Assurance by Simple Testing
KIMO	<i>Kommunenes Internasjonale Miljøorganisasjon</i> [Norweigan] (Local Authorities International Environmental Organisation)

Units of Measurement

mm millimetre

Pa Pascal(s)

kPa kiloPascal(s)

N Newton

CN CentiNewton

/g.m² per gram per metre squared

µm micrometer

gf/cm² gram-force per square centimetre

Abstract

This work investigated the viability of recycled polyester from recycled polyethylene terephthalate (rPET), particularly rPET bottles, first in context of performance relative to virgin polyester (vPET). Two equivalent fabrics were developed from rPET and vPET (control) yarn to measure the objective performance through lab tests.

The potential social and environmental impacts of introducing an ocean-waste-to-rPET production model were then investigated through surveying those in the fishing industry to gauge willingness, motivation and limitations for ocean waste collection. This was supported by a case study of KIMO UK and environmental assessment through existing literature.

Through consideration of rPET's surprising out-performing of vPET, an emerging willingness to participate in ocean-waste solutions from the fishing sector and potential environmental benefits, a preliminary, tentative case was built in favour of sustainably introducing such a commercial model to the UK.

1 Chapter 1: Introduction

1.1 GENERAL INTRODUCTION AND BACKGROUND INFORMATION

Recycled polyester, derived from polyethylene terephthalate (PET), has caught the attention of academics and designers - such as Calvin Klein (Spedding, 2016) and Stella McCartney (2017) - alike, and is argued to pose a solution to the high-impact fibres which the industry relies on, such as polyester and cotton – with 55% and 27% respective market share as of 2015 (Textile Exchange, 2016). However, rPET (recycled polyethylene terephthalate) is not yet widely available at a commercial, and particularly mass-market, level. This fibre remains a leading example in the emerging recycled fashion fabrics market -with production in China alone cited by He *et al.* (2015) as reaching millions of tonnes- and is argued to boast mechanical benefits in its finished form compared with major sustainable competitor organic cotton (Telli and Babaarslan, 2017). The life-cycle of the polymer also poses interesting questions, as it is widely used in disposable products, such as soft drinks bottles, and has high potential -when the waste is used as a raw material- to reduce waste to landfill, or oceans. With the demanding question of ocean pollution and lack of resources pressing the textile industry for alternative raw materials, it seems that rPET offers an idealistic, two-pronged solution, in that it reduces waste and also, in theory, the environmental impact caused in the production of new raw materials. The benefits have been praised by many researchers and the author questions therefore the potential limitations of this fibre in textile use which, along with low oil prices, may be withholding the growth of its share in the textiles market as compared to virgin polyester. (Textile Exchange, 2016)

Theories on the delay in recycled polyester gaining a strong market share in the mass textile market include consumers' negative perceptions of recycled materials (presuming lower quality, for example), harmful side effects of the recycling process on local environments or on consumers, economic set-backs through loss in profit margin or investment (for instance, in sourcing and building relationships with new suppliers), a lack of access to or difficulty in acquiring the raw material (consumer waste not being a naturally renewing resource), issues in textiles finishing or garment production or, simply, the industry's unwillingness to change.

While researching the market, the author found a lack of fashion brands using recycled polyester in their products, and many less running a dedicated, varied range of rPET products. Most rPET products existed as stand-alone items, in novelty ranges. Recycled polyester is not a common household textile, despite the extensive academic research carried out into the benefits of its use in the past two decades.

This study attempts to compile a rounded evaluation of rPET textiles derived from post-consumer plastic bottles. This work aims to fulfil a void in existing research, considering the utility and life-cycle of this product in textile-specific terms in one paper focused on three areas: mechanical performance of rPET fabric (in comparison to that of virgin polyester), possible social benefits to introducing an rPET production chain on fishing communities and the environmental impact of rPET textile products. These areas have been chosen for their decisive weighting in the evaluation of the material as a commercially viable and sustainable product, and due to the ability to investigate them with the time-frame and resources available. More areas could be considered in a fuller evaluation and possibly

highlight unmentioned limitations to this production model, and these will be discussed in Chapter 7.

To measure the performance of rPET fabric against vPET (virgin polyester) fabric, samples of each in matching quality will be tested to commonly used standards, considering those used by quality departments in textile firms and those most relevant to existing research.

Concerning social impact, this study will take focus on how the introduction of an rPET production industry could benefit local fishing communities, using the United Kingdom (UK) market as an example. This direction is inspired by firms such as SEAQUAL (Spain), whose business model is built on employing fishermen in communities affected by fishing quotas or low catch numbers to retrieve the raw material needed for rPET yarn.

The positive predictions of this model appear three-fold: jobs are retained and potentially created, benefiting not only the local economy but also creating immeasurable social benefits by way of cultural identity preservation and emotional welfare; plastic waste is removed from the ocean, creating the knock-on effect of preserving habitat and marine ecosystems.

The environmental impact of the rPET material will be evaluated existing LCAS, measured against the goal of achieving a closed-loop cycle. This will establish the value of rPET textiles as environmentally beneficial or harmful (both to local communities as a direct result of production and to the greater environment and consumers – for example through off-gassing).

1.2 RESEARCH AIM AND OBJECTIVES

The aim of this research is to investigate the viability of recycled polyethylene terephthalate (rPET) as a commercial and sustainable fibre for use in textiles, in the context of three areas: performance, social impact and environmental impact.

The specific objectives will be:

1. to carry out a thorough review of recycled polyester, the environmental impact of recycled polyester production, properties and use;
2. to survey local fishermen and interviews those in key positions in the fishing industry to investigate the potential impact of opening the recycled polyester market in the UK - using ocean-recovered plastic waste as a raw material;
3. to carry out laboratory tests to measure the mechanical performance of the rPET end-fabric, using virgin polyester as the control material; and
4. to make conclusions and recommendations for future research.

2 Chapter 2: Literature Review

2.1 GENERAL AVAILABILITY AND AWARENESS OF RPET TEXTILE PRODUCTS

2.1.1 AVAILABILITY OF THE RAW MATERIAL

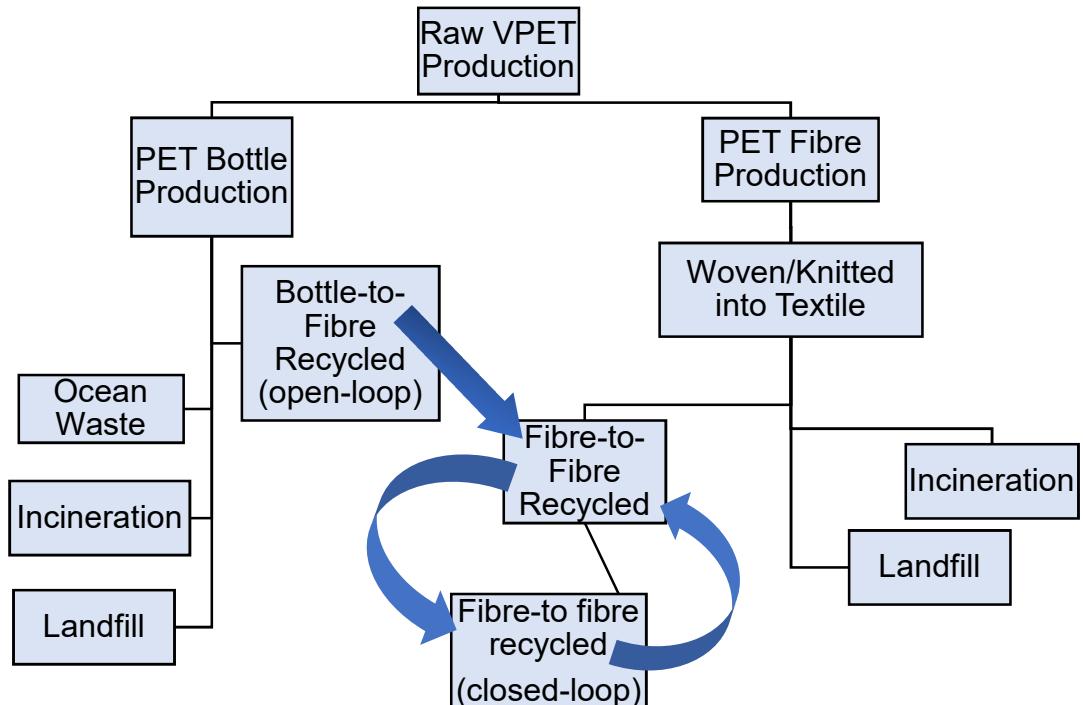
Many sources (Hardesty, B. D. and Wilcox, C., 2015; Parley, 2017) cite Jambeck *et al.* (2015)'s estimation of 8 million tonnes as the most accurate figure of plastic waste which enters oceans each year. In the UK alone, a Mintel Market Sizes (2017a) report demonstrates a market volume of 3.1170 billion litres in bottled water for 2016. This data represents only a segment of total plastic bottle consumption figure for the UK, as it excludes figures from carbonated soft drinks, sports drinks and energy drinks (these categories are not broken down to distinguish sales of cans from PET bottles). Consumption of, and resulting pollution from, plastic bottles is recognised as a global issue and Mintel Market Sizes (2017b) cites 29 litres per annum as the global average in bottled water consumption, per person. Mintel note also that figures exclude significant sales in markets such as India, where bottled water is mainly sold in undocumented quantities by street vendors. The general trend indisputably proves a plentiful supply in existing raw material for rPET yarn production – that is, plastic waste from PET.

It is also difficult to build an accurate estimation of available raw material for rPET's specific production process, as these figures do not include historical waste, and Jambeck *et al.*'s are not specific to PET or plastic bottles, the ideal waste material for recycling. Textile-to-textile recycling is less researched, and often cited as less viable in the context of existing recycling technology than a bottle-to-fibre process. (Shen *et al.*, 2010) Another immediate issue with recycling polyester from existing textiles is the contamination of the original polyester:

either through dyes, finishing processes, unintentional by-products or by the common decision to use polyester in composition with another fibre, such as cotton. Textile products designed with a multi-fibre composition make the recycling process less energy- and cost-effective: particularly wasteful in the case of cellulosic and synthetic combinations, as Braungart and McDonough (2008) discuss when differentiating between “technical nutrients” and bio-positive material, to be further discussed. Surveying existing products on the market, fashion manufacturers such as Royal Apparel (2017) are seen to be using rPET in “eco-blends”, for example with organic cotton. This decision may be attributed to achieving certain aesthetic qualities or fabric handle; it increases the harm caused in the product’s overall life-cycle. The prevalence of multi-fibre products in brands which place a marketing emphasis on sustainability suggests a lack of research into the long-term impact of the product, and of consideration for the post-consumer stage of the product’s life-cycle. Jeffery Hogue, chief sustainability officer at C&A, offers that such examples represent a gimmick, with novel marketing value, and suggest a lack of long-term commitment to environmental sustainability in the firm (Edie, 2017). At present, only 1% of textile waste ends up as part of a textile-to-textile recycling process. (Mintel Academic, 2017) As well as representing an uncapitalized resource, this negligible figure represents mismanagement of waste at local and national levels, and is also fuelled by firms’ reluctance to invest in ‘take-back’ programmes – suggesting that a historical pessimism prevails, resulting from cases such as that of German sportswear firm Vaude, in which consumers failed to engage with such an attempt to develop a closed-loop cycle, and the programme was forced to end prematurely (Shishoo, 2015).

There is much to be done in terms of developing clean, economical methods of recycling the typical existing polyester product in a textile-to-textile cycle, but the increasing prevalence of rPET suggests advance and potential in this area. The first step is to establish an open-loop, bottle-to-fibre recycling method.

Figure 2-1 Simplification of Life-cycles, adapted from Shen et al. (2010)



Few firms make claims such as Japanese Teijin, who propose that their recycled polyester textile product is fit to re-enter the industry post-useful life as part of a closed-loop cycle (Teijin, 2017) and are credited by Venkatachalam *et al.* (2012) as producing “state of the art” technology to do so. This system has evidently been developed using the Teijin’s Eco Circle research and innovation body, and financially backed by Teijin’s pre-established conventional textile products. That Teijin retains dominance of the high-quality market suggests strong barriers to entry by way of investment in capital and research.

Closed-loop cycles and selecting criteria against which to measure rPET fibre in terms of environmental effectiveness will be further discussed in the dedicated Environmental section of this chapter (section 2.3).

2.1.2 PRODUCTS IN MARKET

The author found that, through sourcing test materials, there was a lack of dedicated rPET fabric suppliers. Most firms were discovered on Taiwan Trade, suggesting either strategic costing as a reason for choosing to manufacture there or the result of knowledge-sharing or innovation which has yet not yet spread to Western markets.

Manufacturers of end-fabric or yarn in rPET were particularly sparse in Europe, with a few successful examples as follows: REPREVE, Bionic Yarn, and Morssinkhof. These represent examples of dedicated, vertical supply chains. In the UK, Camira (2016) produce upholstery from recycled plastic material but there is no evidence of any attempts to establish a vertical supply chain or cluster group. This chapter will investigate whether there is potential for a competitive advantage using rPET production in this market.

One observation on the availability of rPET products is that many more examples of basic products such as accessories, furnishing and workwear exist than high-value apparel products. This could be for many reasons, such as lower switching costs in training, less risk involved or, as the author fears, limitations in the mechanical performance characteristics (such as those affecting handle, dyeability, elastic recovery which are important in apparel end-use) of rPET end fabric.

The general trend of commercial rPET products points towards its use in speciality brands, or novel ranges for established brands. Usually coupled with a CSR-heavy marketing message, it is still in the “Introduction” stage of a fashion trend, using the classifying method from Posner, H. (2011, p.91) and as yet goes unused by most high street brands or high-end fashion retailers. The sportswear market appears to offer the most promise in rPET advancement, which may be attributed to this market’s target audience placing a higher weighting on environmental concerns than the average consumer. (Shishoo, 2015).

The observations made from commercial claims and information directly sourced from firms’ own branding material, as outlined so far, require careful consideration as they does not present concrete, peer reviewed evidence, or even confirm the use of 100% rPET in the product. The author considers commercial claims purely to build an understanding of the awareness of rPET’s existence in the global apparel market and firms’ willingness to advertise its use, particularly within the UK.

Although there is no figure available on the actual quantity of existing authentic rPET textile products, there is an undeniable growing awareness of this fibre and its potential for green marketing which can be seen in the industry. To summarise availability, the fibre has neither begun to build a significant market share in comparison to market leaders such as cotton or vPET, nor build a ‘house-hold name’ level awareness by way of mainstream commercial success.

2.2 PERFORMANCE CHARACTERISTICS OF RPET

2.2.1 INTRODUCTION

There is limited academic literature available on the performance characteristics of rPET in textile form. Most studies are concerned with rPET's performance in low-value commodities, such as cement – or in the case of Patnaik *et al.* (2015), thermal and sound insulation: wherein rPET's performance was lesser than organic fibres' (whose properties are inherently preferable for insulation) only by tiny increments. However, several studies on the material investigate performance qualities which are either directly concerned with, or could be applied to, textile products.

2.2.2 TENSILE STRENGTH

Telli and Babaarslan (2016) produce relevant work in studying rPET denim against competitor sustainable fibres, including recycled cotton. They cite rPET as the best performing 'green' denim by a large margin, boasting high tensile strength, tear strength and elongation at break. This study however offers no comparison to vPET denim.

Bedell *et al* (2017) strongly conclude that rPET strengthened polyurethane (PU) automotive foams to a higher degree than other tested PU compositions, including a control vPET. This was shown through increased maximum force at break and tear strength. This work is limited in its onus on a low-value product, and by a lack of information on rPET sourcing or recycling method; the supplier-provided table also indicates that tested fibres were composed of both recycled and bio-based content. A recurring compromise noted in this study lies in the increased compression modulus of rPET under pressure, which again equates to a stiffer fabric – and in this instance, less comfort for the consumer.

Meri *et al* (2014) contradict this through testing of rPET polymers, emphasising the importance of multi-composition: requiring the addition of montmorillonite clay (MMT) to improve strength. The author seeks solutions without multi-composition in the aim of achieving a closed-loop cycle. Pegoretti *et al* (2004) conclude that rPET has detrimental effects to yield strength in ammonium clay nanocomposites, whilst Chen *et al* (2017)'s more recent work ranks rPET as the most successful addition to rice-husk nanocomposites, arguing that produced recycled clays are comparable to their industry standard counterparts.

Strength outcomes differ widely on authors' control sample decision and context of end-use.

2.2.3 FABRIC HANDLE

Commercial and media sources suggest one issue in the final product of rPET textiles is poor fabric handle, which can be unattractive in many applications: particularly apparel end-use when ease of movement and comfort are of optimum concern. For instance, in a collaboration between Adidas and ocean waste innovation collective Parley (2016), re-call and re-development on sports footwear from rPET plastic bottles has been undertaken (Mills, 2015), with the suggestion that further refining is necessary for recycled products to be mass manufactured and achieve commercial success. The beta model of the first shoe design was criticised for its "unforgiveable stiff" feel (Rhodes, 2016). No full rPET footwear range has since been released.

Telli and Babaarslan (2017) again fulfil an academic gap in research, confirming stiffness in objective tests as an rPET weakness, discovering also that bending rigidity increased (worsening stiffness) after washing.

2.2.4 IMPACT OF RECYCLING, RECYCLING METHOD

The research of Tabone *et al.* (2010) uses life-cycle assessment (LCA) and ranks vPET least favourably in terms of damage incurred during production, as compared with other common textile fibres. The results do shed some light on positive attributes of the fibre's molecular make-up; polyester, despite its limitations, had the highest-ranking recovery rate by percentage and suitability for recycling. Although this does introduce the issue that the production of rPET counts the harmful effects of the original fibre's production under its carbon footprint and overall environmental assessment, it does prove some usefulness by way of recycling existing fibres, in suggesting that high quality second-life (and potentially, indefinite number of life cycles) materials can be produced.

He *et al.* (2015) credit rPET fibres, in a crucially relevant study in direct comparison with vPET fibres, as having the potential for higher tensile strength and greater elongation at break but point out that, due to strain on the fibre during first use and the mechanical recycling process the orientation of the fibres may be distorted in the recycled alternative. In this study rPET's other benefits are considered in overall assessment, with mention to a reduction in pollution, waste and production cost.

Although recycling method is unmentioned, Srithep *et al.* (2011) regard rPET in their research as showing poor tensile properties, and share conclusions with later work of Makkam and Harnnarongchai (2014), suggesting the addition of chain-extenders were necessary to improve rPET at molecular level, for better suitability to recycling.

The work of Kang *et al.* (2012) draws a direct comparison between the performance of rPET and vPET sheets, concluding that the recycled material was of lower quality. However, they do cite the use of the mechanical recycling process (as opposed to the higher quality resulting chemical method) as a key factor in producing low performing rPET textiles. This trend emerges in many studies (Shen *et al.*, 2010; Venkatachalam *et al.*, 2012; He *et al.*, 2015; Shishoo *et al.*, 2015), and Kang *et al.* highlight the mechanical recycling process as the most common stage of contamination in the production of recycled fibres. This work also referenced positive articles concerning the cost advantage of producing rPET as opposed to vPET: that of Madival *et al.* (2009) which applies to the production of plastic bottles and Franklin Associates (2009), whose work assesses rPET production for clamshell containers.

Tan *et al.* (2011) review chemical recycling methods regarding concrete end-use, determining that acute control of parameters such as temperature and addition of silane treatment were necessary in producing a suitable tensile strength in rPET, again insisting on composite samples.

Japanese manufacturer Teijin produces rPET yarn which is sourced by reputable retailer Patagonia and credited by Shishoo (2015) as reaching a quality level equivalent to that of vPET yarn. This retaining of performance is credited to Teijin's chemical recycling methods.

2.3 SOCIAL IMPACT

Introducing rPET production into a market may incur a positive social impact for local communities and may be adapted to serve national issues.

2.4.1 SOCIAL BENEFITS AS A BY-PRODUCT OF WASTE REDUCTION

The production of rPET theoretically reduces land-fill and pollution resulting from PET (as outlined in Section 2 of this Chapter). This has the potential to aid developing economies, in particular those where effective waste management has not been developed to meet national output and has the potential add-on effect of creating jobs.

India's waste system serves as a useful case study of health and social problems caused by a waste industry which holds a significant share in the nation's job market but remains poorly managed. (Kumar *et al.*, 2017) It also highlights the opportunities for national social development through improved waste management: providing better working conditions and immeasurable job satisfaction through more skilled jobs and scope for career development, as well as improving health conditions. rPET is cited as an opportunity for capitalising on this. (*Business Wire*, 2015)

2.3.1 POTENTIAL BENEFITS FOR FISHING COMMUNITIES

For those fishing communities facing the effects of over-fishing (quotas, job loss, even loss of species), rPET is a solution as a theoretically regulation-free resource; the more fished for, the better. Collection of ocean waste as raw material for rPET production provides benefits both for the local environment and local economy, providing industrialists who see growth as a main goal a source of potential abundance.

This can be seen in practice with the development of Spanish firms SEAQUAL and ECOALF. With the environmental aims of the textile manufacturers incorporated into all levels of strategy, these firms seek to benefit from both

positive consumer associations and a supply of unregulated, waste-reducing materials. As described in promotional material in both websites, SEAQUAL and ECOALF aim to protect local fishermen from the threat of unemployment through the application of their existing skill set to an innovative profession. The development of vertical supply chains has the potential to attract production clusters, examples of which have been proven to benefit both local economy and community. (*The Economist*, 2017)

Deploying commercial fisheries to collect PET waste has the potential to reduce over-fishing and create a positive knock-on effect for marine eco-systems. This will be taken as a significant consideration going forward with the environmental evaluation of rPET, in context of the immediate threat that over-fishing poses to the environment, with Parley (2017) estimating that commercial fishing at current rates will result in the absolution of the trade by 2048.

2.3.2 POSSIBILITIES FOR BRITAIN'S FISHING INDUSTRY

When the UK market is considered as a potential entrant for the rPET market, the effects on the fishing industry and on local fishing communities are interesting. With overfishing reducing fish numbers, the introduction of an rPET production line could provide longevity for the industry.

Responses to Brexit concerning the fishing industry are mixed, but credible predictions at present share the view that this industry will be strongly affected by the loss of EU fishing policy and tariff barriers and in need of new strategy. (Blitz, 2017; Parliament, House of Commons, 2017; OECD, 2017) Lack of access to the research bodies which inform decisions on quotas may result in irresponsible fishing. (*The Financial Times*, 2017) If the fishing community is placed under

extreme threat, the potential social impact lies not only in increased unemployment - which is a particular issue in less industrialised areas such as fishing towns, where access to re-training and new employment is more limited than in urban areas (*The Economist*, 2017).

The introduction of an rPET production cluster then offers a potential solution to existing and future problems in the UK's fishing industry. Not only does approaching Brexit prompt good timing for re-structuring, but the gap in the European market as outlined in Section 1 of this Chapter suggests a competitive advantage for first-to-the-post rPET yarn production.

The idea of having a full cluster, ie., Fibre-to-garment chain, is a loose theory as debates on the potential for a 'Made In Britain' revival remain heated as the UK faces issues such as lack of skilled textile manufacturers, an inefficient workforce and an unstable currency. (The British Fashion Council, 2009; OECD, 2017)

However, this arguably has the potential to capitalise on consumer's expectations for sustainability and drive the re-shoring of textile production in the UK.

2.4 ENVIRONMENTAL IMPACT

2.4.1 PRODUCTION PROCESS OVERVIEW

The most straight-forward environmental benefit of rPET yarn production lies in its diverting of plastic waste from landfill, incineration or ocean disposal. Outdoor apparel retailer The North Face, for instance, is estimated to have stopped around 42,000 plastic bottles becoming waste material through the production of one style alone (the Denali fleece) in 2010. (Shishoo, 2015) This figure is representative of a product which is not fully constructed from consumer-waste

(10% of the yarn was derived from this) and so in fact underestimates the potential benefit of an rPET product constructed from 100% consumer-waste.

This case highlights a further potential avenue for through using post-industrial waste PET (making up 90% of the Denali product's composition); The North Face are estimated to have used this method to avoid 500 gallons in gasoline (Shishoo, 2015).

A decrease in vPET production is another theoretical advantage to using rPET fibre as an alternative. The environmental effects of this include reduced use of non-renewable petroleum (used to produce the polymer), additive chemicals used in production and potential carbon emissions by transportation from fibre-site to yarn supplier. One promising trend present in new-start rPET manufacturers is the use of vertical supply chains; ECOALF and SEAQUAL claim to, through in-house (SEAQUAL, 2017) or collaborative methods (ECOALF, 2017), source both raw material, design and production within Spain. One potential drawback the author notes is that there are no studies available on whether an increased demand in rPET would not in fact increase global production of vPET over time.

When rPET is sourced from ocean waste, not only can vPET impact be reduced, but active benefits result for marine life and local communities. This can take the shape of reducing the effects of water pollution, from physical damage to aquatic habitat, protecting seabirds and other marine life from ingesting plastic (Fishwick, 2018) and reducing contamination of water supplies from polyester's by-products (Carrington, 2017).

There is a clear risk to human and wildlife health through polyester contamination (both in water and airborne pollution). In the case of rPET, the author draws particular attention to the incidence of heavy metal contamination, with a significant number of existing studies highlighting this as a potential dangerous side-effect.

Whitt *et al.* (2012) studied the levels of heavy metal content in rPET second cycle packaging, recycled for identical use and therefore not requiring any manipulation in the recycling process – and so produced results relevant to other applications. Heavy metals are listed as key concerns for human toxicity by organisations such as Apparel and Footwear International RSL Management Group (AFIRM) (2015) and the department of Registration, Evaluation, Authorisation & restriction of Chemicals (REACH), EU. The European Chemicals Agency (ECHA), with a REACH database, lists cadmium in its pure and combined forms – for instance, cadmium carbonate (ECHA, 2018) and cadmium oxides (ECHA, 2017) - on the “List of Substances of Very High Concern” for its inherent carcinogenic property. Cadmium appeared in all contaminated samples tested by Whitt *et al.* Other heavy metals found were lead, chromium and antimony, all of which pose risks to human health by way of toxicity. The authors compared their findings against the regulations set out in California’s Proposition 65 (Office of Environmental Health Hazard Assessment (California), 2016), which is generally regarded in industry as a strict standard and found that none of the tested samples reached the 100 ppm limit set on total heavy metal content. However, Whitt *et al.* go on to highlight a limitation to their own work in that the results measured the total content present at time of testing and so give no data on the actual release of heavy metals during use. In that respect, using Proposition 65 as a scale for

determining the toxicity of a product could be considered a limitation in itself, as simply restricting the quantity of a substance in a finished product poses no guarantee that a toxic or harmful dosage will not be emitted under reactive circumstances. No matter the tests carried out or guidelines drawn up, the only sure guarantee that a product will not emit harmful levels of toxic substances is to develop a product that is intrinsically free from toxins.

The work of Shen *et al.* (2010) points out a key factor missing in traditional LCA techniques; in determining the full, accurate impact of a recycled fibre's working life, the negative impact incurred during the production of the initial fibre should factor in to the overall assessment. This does give rPET an immediate disadvantage in ranking against other sustainable fibres, when compared to those which can be produced without such issues as those created during polyester production. For instance, the potential market share of rPET is threatened by "cleaner" green competitors such as organic recyclable cotton, with an organic cotton t-shirt recently becoming the first, and at time of writing: only, apparel product to be certified with the Gold Level Cradle-to-Cradle award (Business of Fashion, 2017).

2.4.2 LCA DEBATE

Sandin and Peters (2018) evaluate all peer-reviewed LCAs on recycling and reusing of textile to date, highlighting a lack of regard to social impact, a dominance of recycled cotton investigation and a lack of Bottle-to-Fibre method (as this work intends to research) as compared to Fibre-to-fibre. This confirms the author's early literature conclusions. Sandin and Peters also contribute the suggestion that reuse is inherently more effective a waste management

technique, avoiding the energy consumption and other processing impacts of recycling.

Bedell *et al.* (2017) also use environmental assessment to structure their case in presenting rPET as a viable automotive foam. The suggestive nature of their ideas around achieving a closed-loop cycle demonstrates the depth of further research needed in this area. Rightly highlighted here also is the need for rPET to reduce vPET demand enough to reduce petroleum extraction and have a maximum positive impact.

Ingrao *et al.* (2014) reaffirm that rPET's key environmental potential lies in effectively reducing emissions associated with vPET production. This study undergoes the most recent thorough objective measurement of rPET's impact (since that of Shen *et al.* [2010]), in context of vPET alternative, to date. Using a wide range of metrics to evaluate rPET, an overall damage score was created (0.000299pt), which compares favourably to raw non-renewable resources, but still demonstrates some harm level. Interestingly, the authors chose to deduct associated damage avoided through a replacement of vPET production to produce an overall negative figure (-0.000725pt).

However, to absolve rPET of responsibility for PET production limits the potential ambition of achieving a truly clean product. Although Ingrao *et al.* demonstrate successful improvement to the overall figure through renewable energy use and cleaner transport methods (energy and air-transport resulted in greatest impacts to 'Climate Change' and 'Human Health'), the author recommends pushing rPET's damage score lower still by innovating local sourcing and production

methods where possible to decrease overall mileage – and developing cleaner, energy-efficient recycling methods.

2.4.3 THE CRADLE-TO-CRADLE APPROACH

The direct environmental effects of using rPET as opposed to vPET are ultimately preferable in theory, but it is important to measure rPET's environmental impact against ambitious criteria; as *Shen et al.* (2010) explain: Cradle-to-Grave LCAs are increasingly considered outdated, and this use of this traditional method in product development or materials selection inherently pessimistic, as the end product is designed with an end (via disposal) to useful life from the offset. Braungart and McDonough (2008), as the researchers globally credited with the coining of “Cradle-to-Cradle” and the successful introduction of cradle-to-cradle systems into many business chains, demonstrate that to enable a product to exist in a closed-loop cycle, considerations must be taken to design it for safe and effective return to the production site, or to the soil. With the synthetic nature of PET, the goal is to safely and effectively recycle the product to reproduce a polymer which is of equal quality to the original. It can then be proven to function as a “technical nutrient”, as Braungart and McDonough use to describe non-biodegradable products which can be re-moulded and re-used in their pure form.

The author notes a significant lack of consideration in standard LCAs for one area of the fibre's life cycle: the textile product's post-purchase phase, i.e., how the consumer treats it considering washing, useful life span, and disposal. This stage has been proven in dedicated individual assessments to carry a significant environmental impact. For instance, Mintel Academic (2017) estimates that 500,000 tonnes in plastic ocean waste accumulate each year through washing clothes with plastic micro-fibre finishes. Currently available LCAs may not

represent fully accurate estimations of rPET environmental impact without taking this stage into account.

As Braungart and McDonough point out, the design of a product for a truly beneficial closed-loop cycle demands building the intent into the product at the initial design stage.

Some researchers, such as Venkatachlam *et al.*, argue for instance that polyester is not optimally suited to recycling in fibre form, and that it significantly degrades with each cycle of standard-method recycling (Venkatachlam *et al.*, 2012). Whilst bottle-to-yarn is an optimistic example of upcycling (in that a low value, single-use product is recycled into one of higher value), its usefulness is thwarted if it is only suitable for one or two cycles before land-fill/incineration. The product is not diverted from landfill but merely delayed on its course. The date of this publication does reduce the relevance of the overall assessment, but the work highlights key issues in performance which may be useful considerations for those developing more effective recycling methods: poor moisture permeation in the final fibre, unwanted substance formation (for example, acetaldehyde) and discolouration.

At the time of *Cradle to Cradle*'s initial publication (2008), a clean method of recycling polyester was not yet possible, but many advances have been claimed by way of chemical recycling, as highlighted in Section 2 of this Chapter.

2.4.4 INHERENT LIMITATIONS

On the whole, environmentalists remain undecided on rPET's ranking, in an age of green fibre innovations and sustainability efforts' use as a competitive marketing tool (McKinsey & Company, 2018). Its inherent limitations are derived from assuming responsibility for the negative impacts of the original fibre's

production from crude oil, and it stands in competition with up-and-coming biopolymers, which offer an active benefit to the environment. (Business of Fashion, 2017)

2.5 SUMMARY

Reviewing the literature has concluded that the value of rPET fibre varies in all aspects (performance, environmental and social impact) depending on a number of factors including: recycling method, composition and end-use. Much is to be done in the area of analysing rPET's characteristics as distinguished from vPET, while a whole LCA in the context of a fashion-specific product and post-consumer is yet to be published (although this is restricted by lack of fashion products). The key gap in existing research which this work will investigate lies in the amalgamating of the 3 key disciplines discussed, bringing rPET in textile context into review to determine the potential for positive benefit and, ultimately, commercial success. Going forward, the potential for rPET production to be introduced into the UK market in particular will be discussed.

3 Chapter 3: Methodology

3.1 INTRODUCTION

This chapter outlines the research methods taken: first to determine the performance of recycled polyester in fabric form as compared to virgin polyester and secondly, to gain an understanding of the potential social impact of introducing a commercial ocean-waste-as-recycling-material model, with singular focus on existing members of the fishing industry.

3.1.1 FABRIC DEVELOPMENT

r-PET yarn was provided by Morssinkhof Sustainable Products. Hailide Fibers Europe supplied an equivalent quality v-PET yarn. Both r-PET and v-PET samples were woven on a dobby hand-loom. A 1x1 plain weave structure was used and all production carried out by the author, to minimize bias resulting from finishing methods used by different manufacturers. (See Table 3-1) Fabric production was controlled and synthesised in attempt to ensure that yarn production was the one variable: one recycled from PET bottles, the other an industry standard vPET.

Table 3-1 Developed Fabric Specifications

Characteristic		r-PET Test Sample	v-PET Control Sample
Fabric Code		R	V
Fibre composition		100% recycled polyester (rPET)	100% virgin polyester (vPET)
Colouration		Undyed; bottle light-blue	Yarn dyed, white
Fabric structure		1 x 1 Plain Weave	1 x 1 Plain Weave
Fabric sett, No. of yarns/cm ²	Warp (ends)	16	16
	Weft (picks)	8	9
Linear density (yarn)		1100 dtex	1100 dtex
Filament count		210	192
Weight		315 grams per square metre	300 grams per square metre
Fabric width		31 cm	37 cm

Given the high density of both yarns, and their suitability to heavy-duty applications the characteristics measured were chosen for their relevance to durability and strength. These characteristics were also highlighted as causing debate during the literature review.

3.2 OBJECTIVE MEASUREMENT TECHNIQUES

Lab tests were performed using R as test fabric and V as control. These were used to measure the performance of recycled polyester. All samples were conditioned in lab at 20°C and 65% relative humidity, according to BS EN ISO 139:2005+A1:2011, for 18 hours before testing.

3.2.1 MAXIMUM FORCE – TENSILE STRENGTH

R and V were tested for maximum force (N) at break via the strip method, according to BS EN ISO 13934-1:2013. Due to limited yardage, samples of 200mm by 50mm were used with a 100mm gauge and a tearing speed of 100mm per minute. 3 samples across warp and 3 across weft were cut for each fabric.

3.2.2 MARTINDALE - ABRASION RESISTANCE

Fabrics R and V were tested for abrasion resistance on the Martindale machine, in accordance with BS EN ISO 12947 (1999). 795g weights were used to place a 12kPa pressure load on the samples. Due to the fraying nature of both fabrics, 39mm radius circular samples were cut using a laser cutting machine.

3.2.2.1 FABRIC BREAKDOWN

2 samples each of R and V were tested to 70,000 revolutions for yarn breakage and change in appearance, according to BS EN ISO 12947-2:(2016). Photographs were taken to document visible change in pilling or fabric structure at each interval and samples were inspected for yarn breakage.

3.2.2.2 MASS LOSS

2 samples each of R and V were tested to 75,000 revolutions for yarn breakage and mass loss, according to BS EN ISO 12947-3:(1998). The mass of each sample was recorded before testing and at intervals specified in the standard, for

fabrics known to survive 50,000 revolutions without yarn breakdown. Samples were also inspected for yarn breakage.

3.2.3 FABRIC ASSURANCE BY SIMPLE TESTING (FAST) METHODS

Fabrics R and V were tested using CSIRO (Australia)'s FAST methods on FAST machinery, according to methods specified in CSIRO Australia's FAST Instruction Manual. Due to technical issues, the accompanying FAST operating system and printer were unavailable for use and so results were recorded manually.

3.2.3.1 FAST-1 COMPRESSION

R and V were tested on the FAST-1 Compression Meter, with CSIRO FAST designated weights, to determine fabric thickness and variation in thickness under pressures of 196Pa and 9.8kPa. The percentage change in thickness between the higher and lower loads was calculated. This indicates the integral structural stability, as well as the consistency across a length of fabric. Samples were cut to 100mm by 50mm prior to testing.

Table 3-2 FAST-1 Compression Procedure

1	The compression meter was calibrated to remove dust before testing. The machine was set to full load at 9.8kPA (all weights placed) and a piece of clean paper dragged from underneath the loading plate. This was repeated until a 0.000mm reading was achieved.
2	With the black ring turned to neutral position (0 load), the first sample was placed on the electronic reader underneath the loading plate.

3	The small weight was placed onto the loading plate to achieve a pressure of 2gf/cm ² (196Pa).
4	The black ring was turned slowly to pressure position, applying 196Pa pressure to the sample.
5	Following a beeping sound, a stable reading of the sample's thickness (mm) was displayed and recorded manually.
6	The black ring was turned again to neutral position, and the large weight placed on top of the smaller weight to achieve a combined pressure of 100 gf/cm ² (9.8kPa).
7	The black ring was returned to pressure position, to apply the 9.8kPa pressure to the sample.
8	Follow a beeping sound, a second reading of the fabric's thickness (mm) under the increased load was displayed and recorded.
9	The black ring was returned to neutral setting and the sample removed.

3.2.3.2 FAST-2 BENDING LENGTH

R and V were tested for bending length (mm) on the FAST-2 Bending Meter to determine fabric bending length and calculate formability. Samples were guided with an aluminium platen towards an electronic reader which recorded bending length at 41.5°. As stiffness was mentioned as a limitation to recycled fabrics in the literature, this test was performed to determine if this was true for rPET from plastic bottles. Samples were cut to 50mm width and 130mm length, with 5 across

warp and 5 across weft in each fabric. The resulting bending length was also combined with fabric weight (g/m²) to calculate bending rigidity.

Table 3-3 FAST-2 Bending Meter Procedure

1	The bending meter was auto-calibrated during a 10-minute warm-up period after the power switch was turned to 'on'.
2	The sample was positioned along guidelines, fabric right side upwards, underneath the aluminium platen, with 10mm along the fabric length remained exposed, towards the drop gauge.
3	The 'START' button was pressed
4	The sample was guided manually to the right by the operator's sliding of the platen along the meter.
5	Upon lighting of the green LED arrow, the fabric was moved further right, into the gauge where the light sensor is located.
6	Once the sample was within reach of the light sensor, the red LED arrow illuminated. Using the operator's hand to guide the sample at low pressure and maintaining a grasp on the platen, the sample was guided left-to-right several times, alternating between red and green lights.
7	A beeping noise was heard after a measurement period and the bending length (mm) displayed on the meter screen. This result was then recorded manually.
8	The 'RESET' button was pressed.
9	Steps 2-8 were repeated with the underside of the fabric facing upwards .

3.2.3.3 FAST-3 EXTENSION UNDER LOADS

R and V were tested on the Fast-3 Extension Meter to determine the extension rate (%) of the fabric at set loads: 5gf/cm, 20 gf/cm and 100 gf/cm, as created by combinations of the weights provided with the FAST-3 machine. 5 samples across warp and 5 across weft were cut from each fabric. Samples measured 130mm by 50mm to test at a gauge length of 100mm. The results from this test were also combined with bending rigidity (see: FAST-2) to determine fabric formability.

Table 3-4 FAST-3 Extension Meter Procedure

1	The extension meter was given a 60-minute warm-up period. Checking meter calibration involved placing all 3 weights in place on the balance arm, turning the locking knob fully anticlockwise, freeing the balance beam and ensuring that the display screen read “00.0”.
2	The locking knob was turned clockwise back to neutral position and the smallest weight removed from the balance arm (two weights remaining).
3	The sample was mounted by dropping through the top set of clamps and turning first the upper clamp and then lower clamp mechanisms anticlockwise to lock the sample in place, so that the sample was exposed above and below each clamp.
4	Once the sample was locked in position, the locking knob was turned anticlockwise to extend the fabric at a 5gf/cm load. Following the meter’s beeping sound, a stable result was displayed and recorded manually.

5	The locking knob was turned clockwise back to neutral position and the second largest weight removed (one weight remaining).
6	The locking knob was turned anticlockwise to extend the fabric at a 20gf/cm load. Following the beeping sound, a stable result was displayed and recorded manually.
7	The locking knob was turned clockwise back to neutral position and the final and largest weight removed (zero weights remaining).
8	The locking knob was turned anticlockwise to extend the fabric at a 100gf/cm load. Following the beeping sound, a stable result was displayed and recorded manually.
9	The locking knob was turned clockwise back to neutral position and the sample removed from the clamps by turning the jaw mechanisms clockwise.

3.3 SUBJECTIVE RESEARCH

Subjective research was carried out to explore the concept of introducing a commercial system of ocean waste collection to be sold as raw material in the UK, and the potential social impact of such a scheme. The research was industry-specific: collecting informed opinions from the local fishing industry or those in relevant organisations to gain a sense of the viability of such a project.

3.3.1 RESEARCH SURVEY

A research survey was conducted online via surveymonkey.com and an identical version drafted in paper format, distributed to a specific demographic: those

employed in the fishing industry, and commercial fishermen/women in particular. The survey is available in Appendix B. The objective of this research was to gather qualitative data on the factors which might motivate the industry towards or against a recycling business venture. Key motives were introduced with simple rating scales (for example – this factor “positive” or “negative”) in order to encourage full response on all topics; early discussions with fishery managers suggested that willingness to answer surveys was historically low amongst this demographic and it was decided that an ideal survey be kept to 10 multiple-choice questions. Issues raised in Chapter 2 were prompted. Further specific issues were introduced after a review of fishing internet forums, with Brexit and long-term job stability commonly discussed. The survey was designed to gradually introduce the concept of fishing for waste commercially, to gauge true views on this. Another objective was to measure how many of the respondents were already aware of such schemes, or even involved in them. Comment boxes were available for those questions most relevant to the further discussion, to invite respondents to give examples of existing programmes or explain views towards a recycling scheme.

The survey was trialled with multiple persons outside of the fishing industry to ensure that questions were clear, unbiased and quick-to-complete. With the average test time recorded as 7 minutes and all test subjects reporting clarity of questions and ease in answering, the survey was taken forward and distributed via industry-specific online forums, facebook groups, to willing managers of fisheries to share with their employees and to friend/family contacts who were employed in the sector.

A final question gave respondents the opportunity to provide contact details, should they be willing to participate in further detailed discussion via an interview or focus group. Screening questions at the survey's beginning asked for confirmation of respondents' employment in the fishing sector.

3.3.2 KIMO UK CASE STUDY

3.3.2.1 KIMO BACKGROUND

KIMO UK is a non-profit organisation which organises a Fishing for Litter scheme across Scotland and England. KIMO-owned skips are provided for waste collection, and the fishermen collect litter at sea during ordinary working hours. KIMO represents the interests of fisheries, harbours and local councils with regard to marine pollution.

3.3.2.2 OBSERVATION

The author worked closely with Faron McLellan, UK coordinator for the KIMO project. Initial correspondence via email established KIMO's background and direct relevance to the research, and it was arranged that the author shadow McLellan during a working visit to Eyemouth harbour.

3.3.2.3 INTERVIEW

Formal, face-to-face interviews were conducted with KIMO's UK Coordinator and Eyemouth's Harbour Master. This research was intended to find qualitative issues and benefits to coordinating KIMO's Fishing for Litter scheme, the impact on the local fishing industry and an informed view on the viability of a commercial ocean waste recycling venture – discussing details such as quantity of waste, collection and recycling infrastructure. As details of the scheme's daily workings and possible future developments were also discussed, a semi-structured style

of interview was used, to allow for expansion on topics introduced by the respondents. Open-ended questions were used to allow full exploration of the themes and to benefit from the on-the-ground knowledge of the fishing sector. Closing questions followed an introduction-and-discussion format, whereby ideas or examples were detailed by the author, and then the respondent invited to express an opinion on, or challenge, the idea.

3.3.3 *ETHICAL CONSIDERATIONS*

All social research was conducted with ethical practice. Respondents' information was stored in accordance with the Data Protection Act and all research survey answers were recorded anonymously. Names were given only of respondents for whom job title was necessary to explain and support of the data collected, and with the respondents' oral consent prior to interview. Plain Language statements were distributed (see Appendix C) prior to interview to fully explain the interview's purpose and data storage. Informed Consent forms were then signed (see Appendix D) and dated to record respondents' willingness to participate and right to withdraw information, with contact details provided to enable respondents to do so.

4 Chapter 4. Results and Analysis

4.1 OBJECTIVE RESULTS

4.1.1 MAXIMUM FORCE

Fig.4-1 shows continuous maximum force test results for rPET and vPET, recorded as x (force, N) per elongation/time (these parameters were controlled at 100mm per 60s) and presented following weight normalisation (see Appendix E), to produce xCN/g.m². rPET outperforms vPET by a significant margin. The 'X' marked values represent maximum load at break.

The following results represent maximum force in the warp direction only.

Figure 4-1 Weight Normalised Max Force in CN/g.m² - Mean

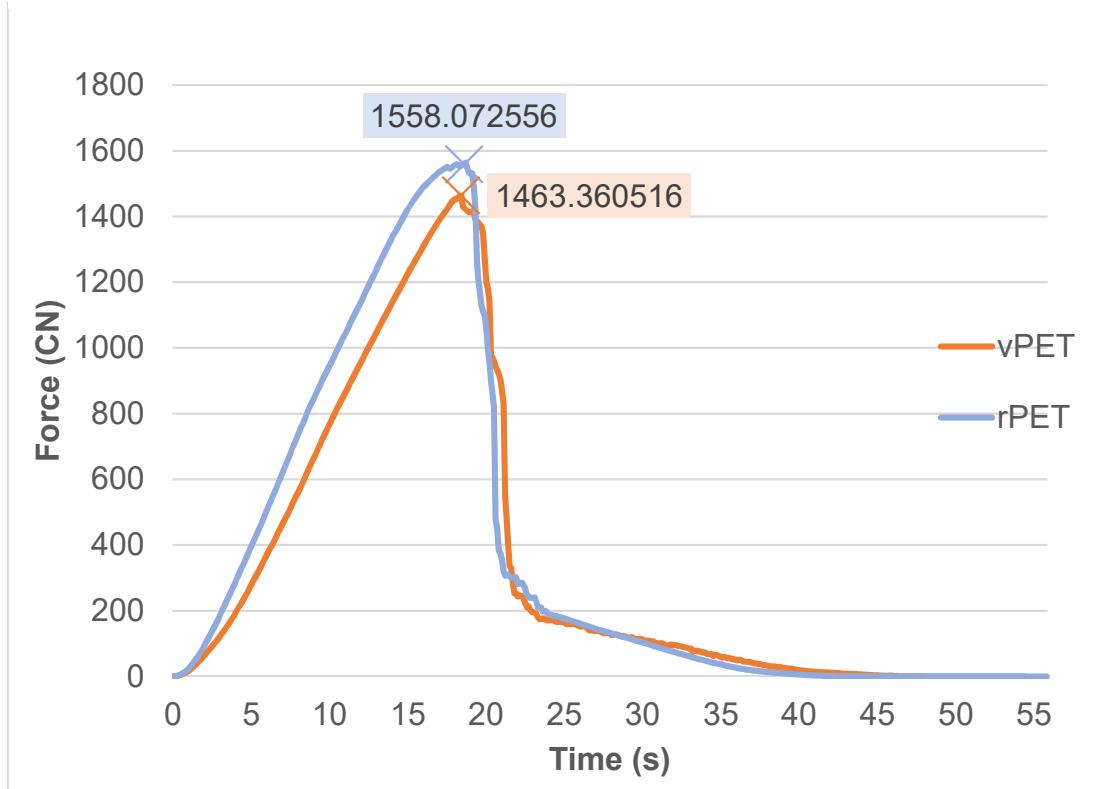
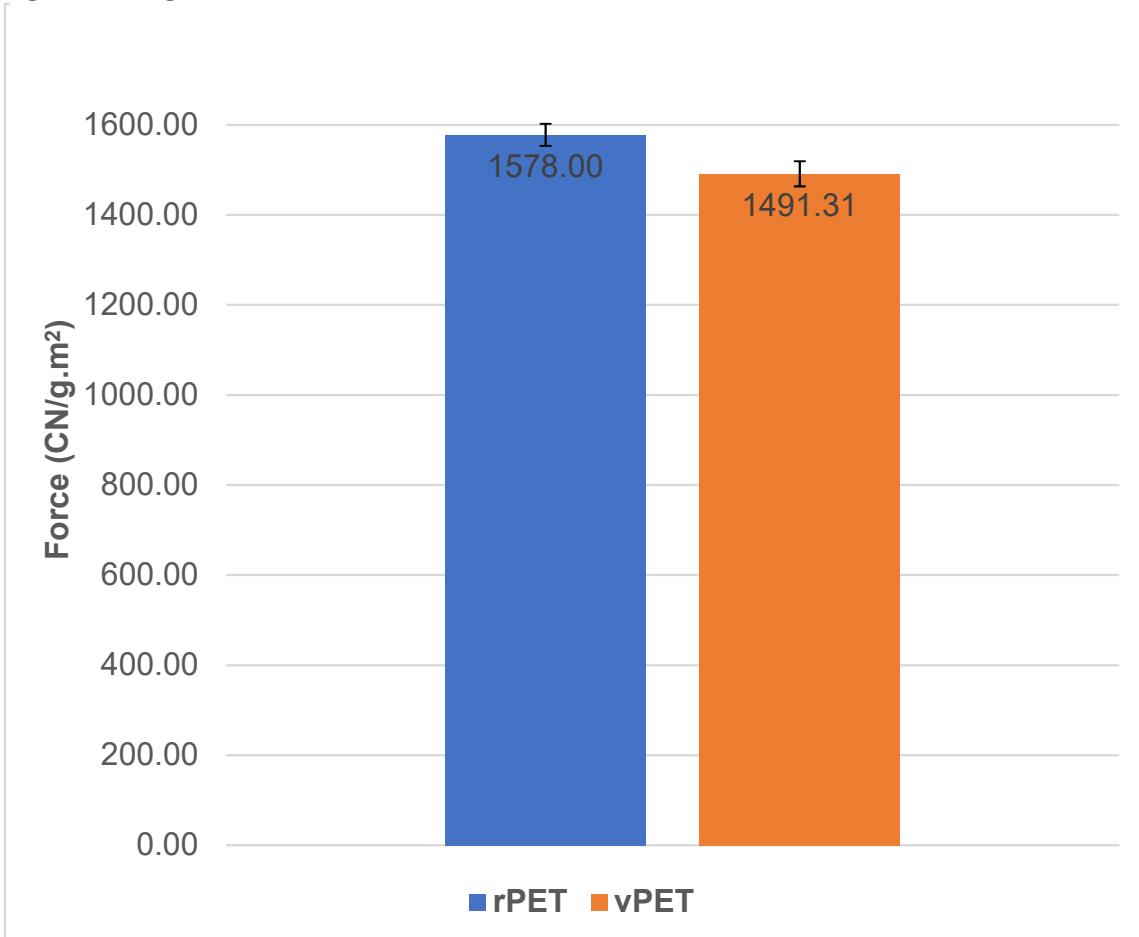


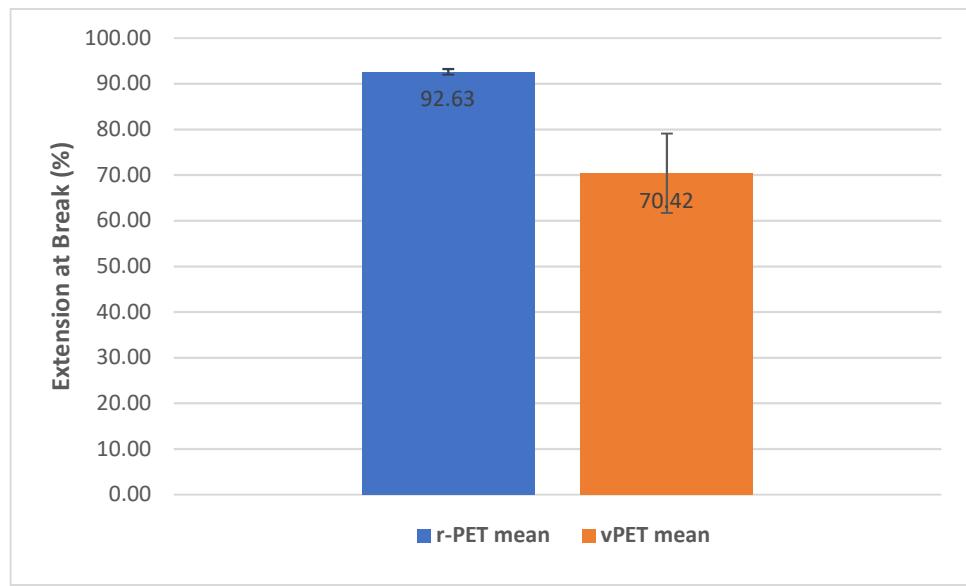
Figure 4-2 displays the mean force at breaking point, included to demonstrate the low margin of standard error, suggesting high reliability.

Figure 4-2 Weight Normalised Maximum Force at Break - Mean



rPET also outperformed vPET in extension (%) at break.

Figure 4-3 Mean Extension at Break - RawData



One limitation came from a technical difficulty which resulted in the voiding of all weft results for both fabrics. R and V performed similarly in that samples broke at the jaws of the Instron machine before an accurate result could be taken. Void results can be found in Appendix E

Figure 4-4: Photograph of weft sample breaking at machine jaws



4.1.2 MARTINDALE – APPEARANCE

Table 4-1 documents appearance change in fabric surface at significant intervals during the Martindale test. rPET showed earlier signs of pilling than vPET but, as noted by the author at 50,000 intervals, the surface degradation began to slow down and level between the test and control fabrics. All samples passed the pre-determined limit of 70,000 rubs without yarn breakage. Details from all intervals tested are available in Appendix E.

Table 4-1 Martindale Abrasion Test, Appearance and Yarn Breakage

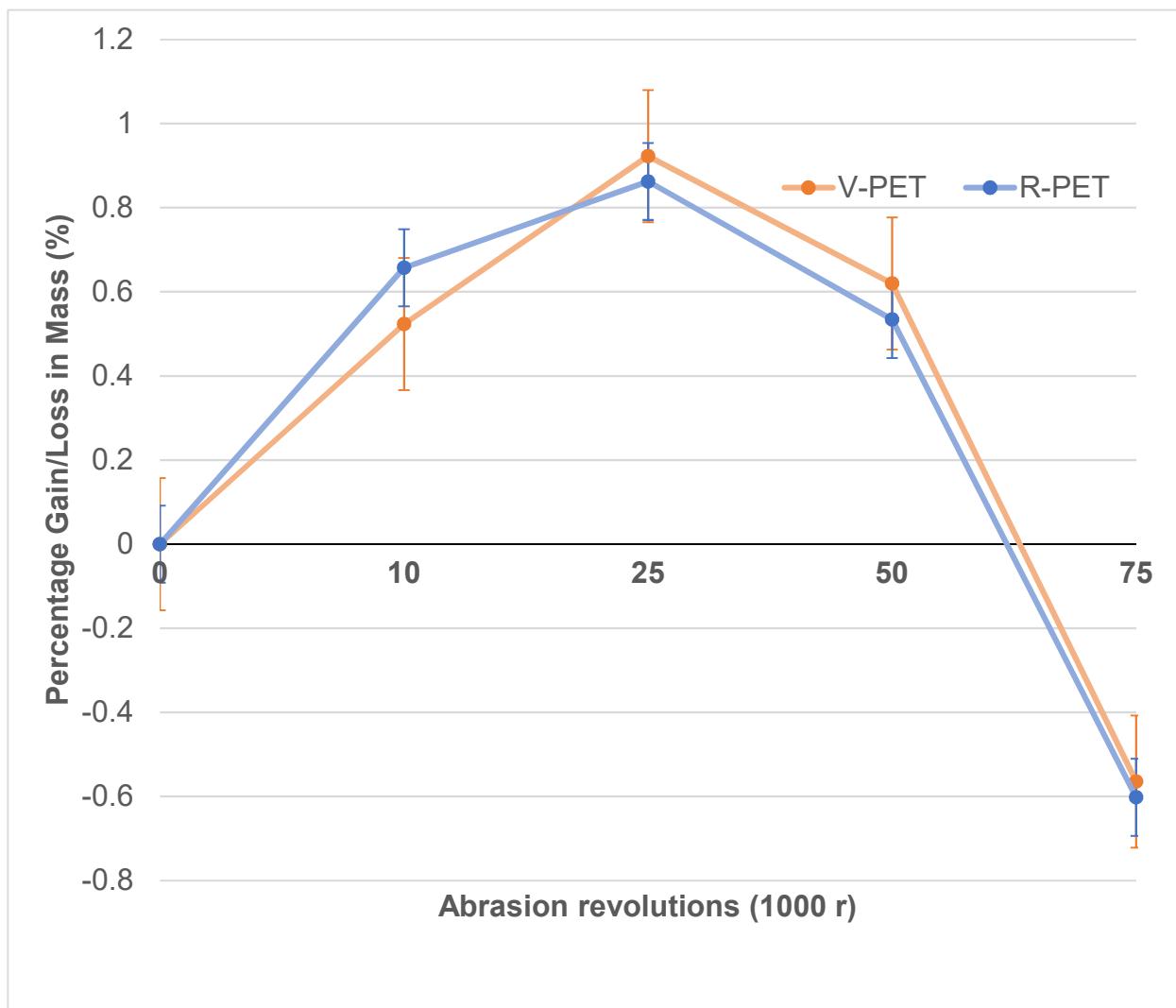
MARTINDALE 1 - ABRASION, APPEARANCE AND YARN BREAKAGE													
INTERVAL [RUBS]	1. V-M1			2. V-M2			3. R-M1			4. R-M2			OTHER PHOTOS/NOTES
	Breakage?	Appearance	Notes	Breakage?	Appearance	Notes	Breakage?	Appearance	Notes	Breakage?	Appearance	Notes	
4000	N		SOME PILLING	N		SOME PILLING - QUITE BAD BUT DOESN'T SHOW UP WELL IN PHOTOS	N		FLUFFINESS, PILLING - SLIGHTLY WORSE THAN vPET	N		FLUFFINESS, PILLING - SLIGHTLY WORSE THAN vPET	
10000	N			N		vPET STARTING TO CATCH UP R.E. PILLING	N			N		RPET PILLING VISIBLY MORE	
20000	N		PILLING BADLY AT W/ST, NO ONE THREAD OF YARN PARTICULARLY UNDER STRAIN THOUGH	N		PILLING BADLY AT W/ST, NO ONE THREAD OF YARN PARTICULARLY UNDER STRAIN THOUGH	N		PILLING VERY BAD AT THIS POINT, ONE OR TWO WEFT YARNS THREATENING TO BREAK IN BOTH R-PET SAMPLES BUT WARP YARNS UNBUDGED	N		PILLING VERY BAD AT THIS POINT, ONE OR TWO WEFT YARNS THREATENING TO BREAK IN BOTH R-PET SAMPLES BUT WARP YARNS UNBUDGED	
30000	N		PILLING REALLY CATCHING UP WITH vPET	N		PILLING REALLY CATCHING UP WITH vPET	N			N			
40000	N			N			N		SLIGHT DISCOLORATION	N		SLIGHT DISCOLORATION	
50000	N		VISIBLE LOSS OF COLOUR, DULLNESS	N		VISIBLE LOSS OF COLOUR, DULLNESS	N			N			OVERALL PILLING AND DEGRADATION OF ALL SAMPLES HAS HAPPENING AT A SLOWER RATE, THERE WAS MUCH MORE VISIBLE DAMAGE BETWEEN INITIAL INTERVALS, E.G. UP TO 30000
70000	N			N			N			N		1 WARP YARN BROKEN	
FINAL RESULT	PASSED			PASSED			PASSED			PASSED			

**Breakage? results: Y = Yes, N = No

4.1.3 MARTINDALE – MASS LOSS

The graph below charts the culminative mass loss/gain in each fabric (%), as an average of 2 additional samples tested for each R and V on the Martindale. Results are displayed according to intervals as specified in the standard. All samples were tested to 75,000 rubs and passed without yarn breakage. Raw Data is included in Appendix E. Notably, both samples gained mass until the 25,000 interval before losing mass, suggesting that the standard abradant fabric initially experienced more abrasion at the hand of the test samples, and the tests accumulated off-cast fibres from the abradant. The abradant was changed, as is standard after 50,000 revolutions, and only after this point did the test samples appear sustain an overall loss in mass. The standard error is slightly higher in the V sample than in the R sample, but given the very small range of increments, both fabrics performed on a closely comparable level, with V maintaining a minutely higher resistance to the abrasion overall, with a more balanced curve and better retention of original mass.

Figure 4-5 Martindale Abrasion Test: Percentage Mass Loss/Gain

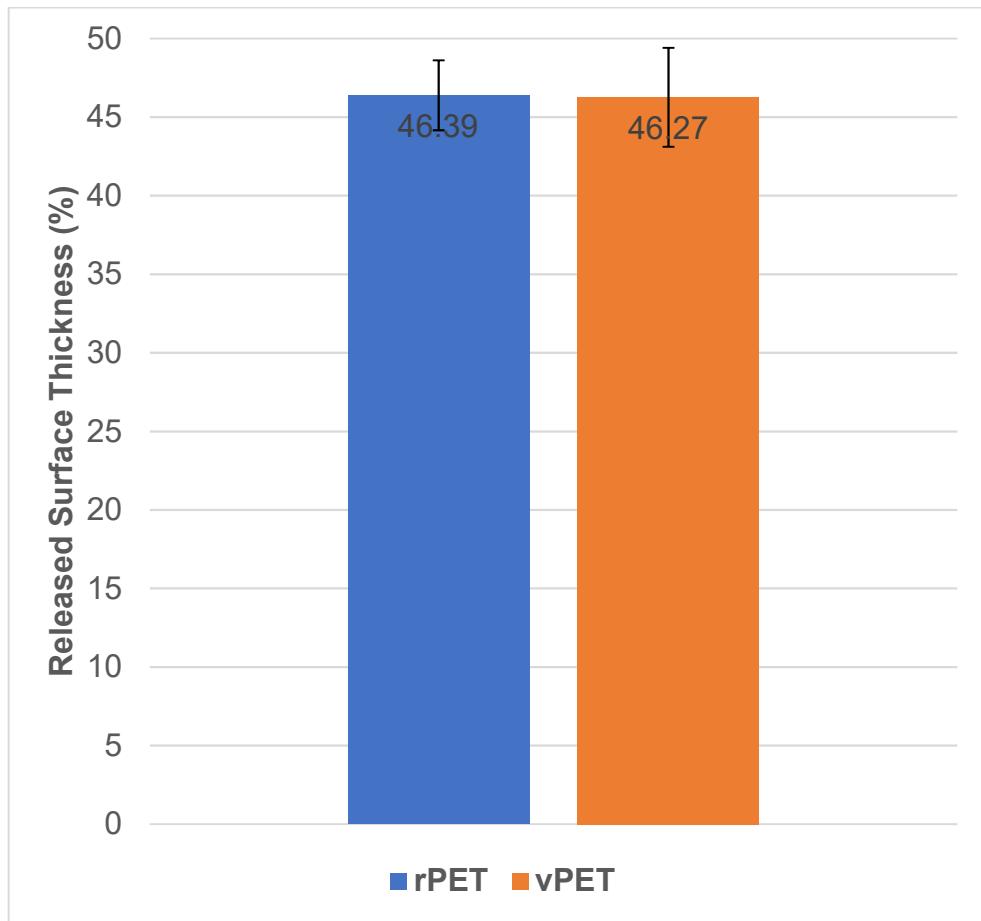


4.1.4 FAST-1

4.1.4.1 RELEASED FABRIC THICKNESS

The surface thickness of each fabric was calculated at 2gf/cm² and 100gf/cm² loads. The difference between loads was expressed as percentage loss to demonstrate released surface thickness. rPET incurred a higher result, suggesting a higher level of compression to vPET, and that vPET better retained its structural integrity – but only marginally (0.12%). The error bar does prompt some consideration, as the vPET upper error margin exceeds that of rPET. However, the vPET average was taken as mean of only 4 samples: with 2 extreme results emitted, whilst only 1 sample was emitted due to skewing rPET results.

Figure 4-6 Released Surface Thickness (%)

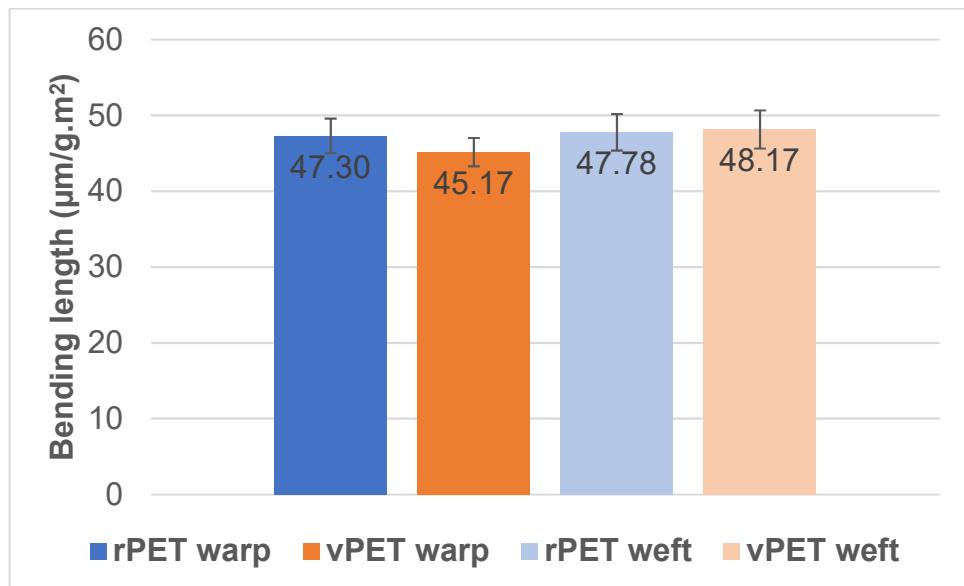


4.1.5 FAST-2

4.1.5.1 BENDING LENGTH

The bending length was calculated in warp and weft directions for rPET and vPET. The results ($x[\text{mm}]$) were normalised as per Fig. 4-7 to eliminate weight bias (see Appendix E) and converted to the below, expressed as mean values of ($x[\mu\text{m/g.m}^2]$). Both fabrics followed a similar trend in decreased bending length in the warp direction as compared to weft. Results are within a minute range in the context of the parameters and error margins prove reliable.

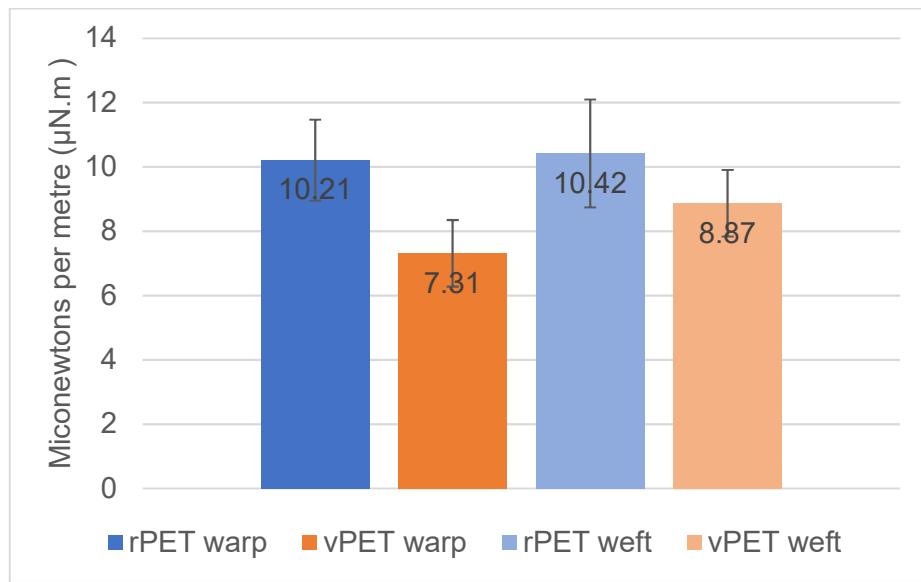
Figure 4-7 Bending Length - Weight Normalised



4.1.5.2 BENDING RIGIDITY

Bending rigidity was calculated from raw bending length results and individual fabric weight (See Appendix E). rPET showed a strong trend towards higher bending rigidity than vPET, suggesting more stiffness.

Figure 4-8 Bending Rigidity

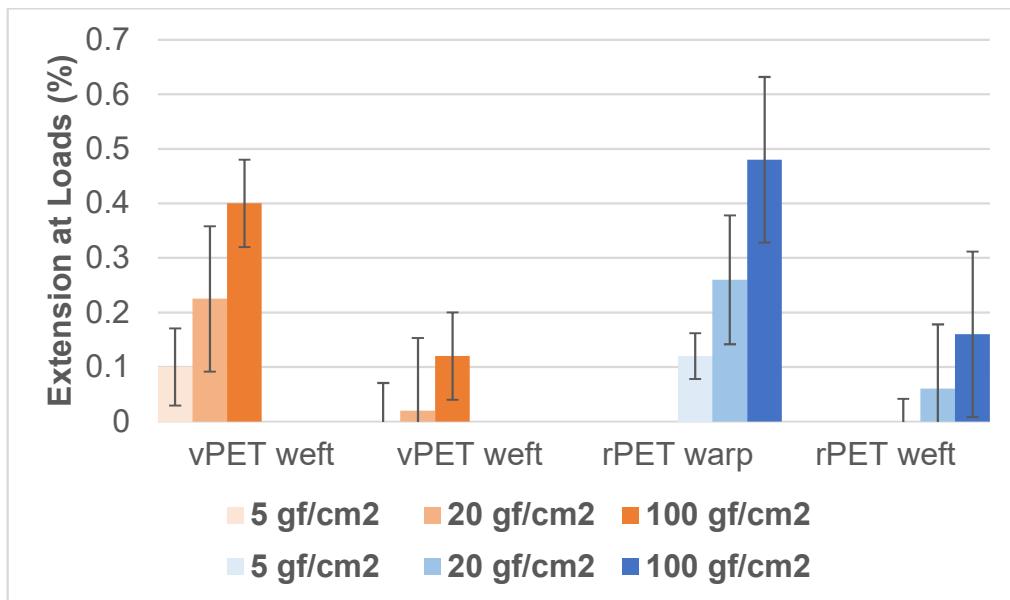


4.1.6 FAST-3

4.1.6.1 EXTENSION UNDER LOADS

Fabric extension under loads (%) was recorded. rPET displayed higher extension rates as a general trend. However, error bars are considerable and the parameters are notably within a low range, concluding that fabrics performed at comparable levels. One extreme vPET result was considered inaccurate and so both fabrics were retested with 4 additional samples before obtaining the average (mean).

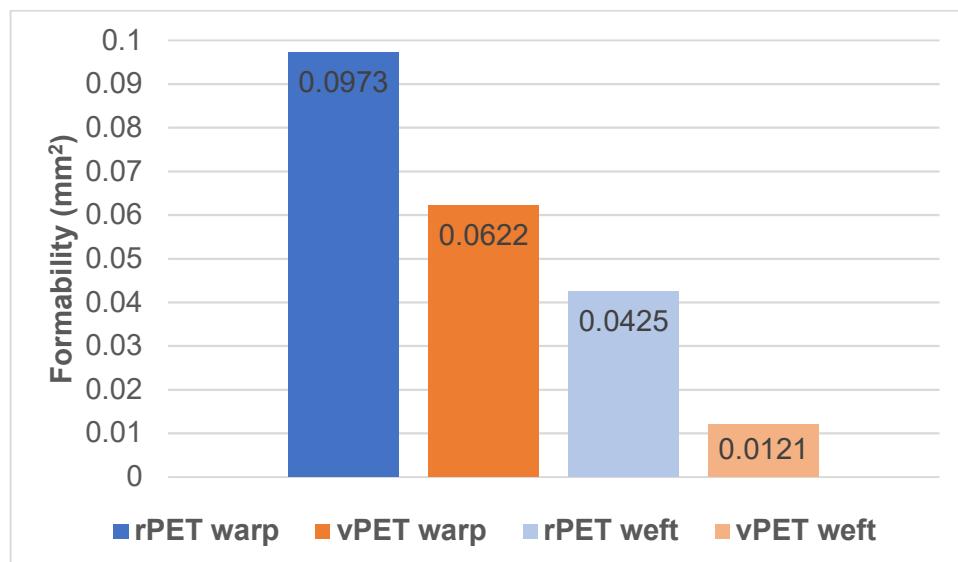
Figure 4-9 Extension (%) at Set Loads, Warp and Weft (Mean)



4.1.6.2 FORMABILITY

Formability was calculated using Bending Rigidity and Extension results (see Appendix E). As with the former, weight bias was intrinsically eliminated through the equation. rPET displayed markedly higher results in both directions, suggesting an increased ease of use during garment construction.

Figure 4-10 Fabric Formability



4.1.7 LIMITATIONS

One minor limitation is that the virgin polyester sample could only be sourced yarn dyed, which may have affected the yarn strength very slightly. The resulting difference in quality (rPET 5% heavier than vPET) was off-set with weight normalisation to successfully eliminate weight bias for relevant results.

The Maximum Force test was only conducted across warp for both fabrics. This was due to an issue with yarn breakage at the machine jaws during weft testing, which resulted in 3 void results for each R and V (Appendix E). Due to difficulty in sourcing and splitting rPET yarn, production of samples was delayed significantly, resulting in a limited resource of test yardage and lab time. Therefore, the Maximum Force test was repeated 3 times in each sample, when the author had ideally planned for a minimum of 5 repeats. Due to an unsolved technical issue, only 4 samples could be placed on the Martindale machine per test without risking an offset in calibration.

There is also an inherent subjectivity in CSIRO FAST tests, due to the influence of operator handling, particularly with FAST-2.

4.2 SUBJECTIVE RESULTS

4.2.1 RESEARCH SURVEY

4.2.1.1 DEMOGRAPHICS

The survey received a total of 20 respondents. Demographic proportions are presented in the following charts. Age and gender of respondents reflects a typical cross-section of the fishing industry, with 95% respondents being male and 40% respondents aged 36-45.

Figure 4-11 Representation of Age Groups (%)

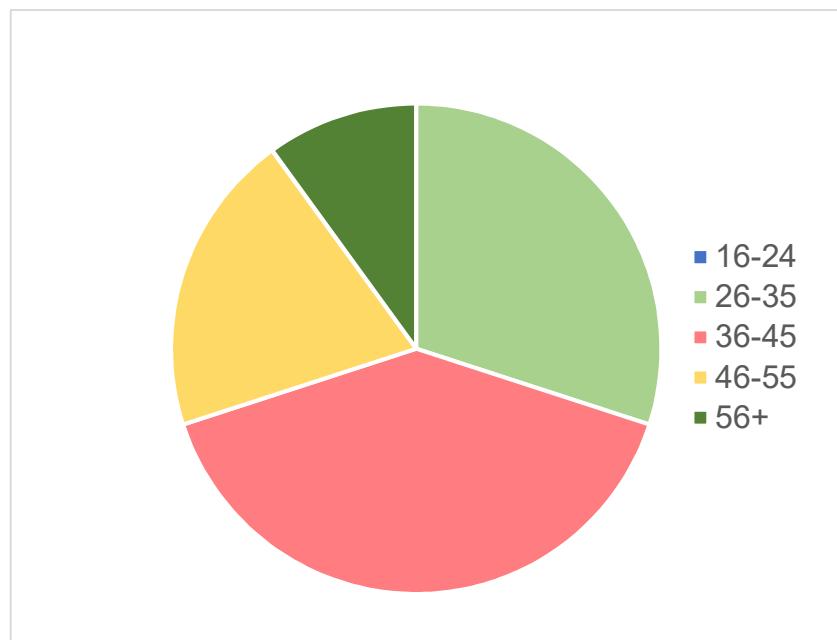
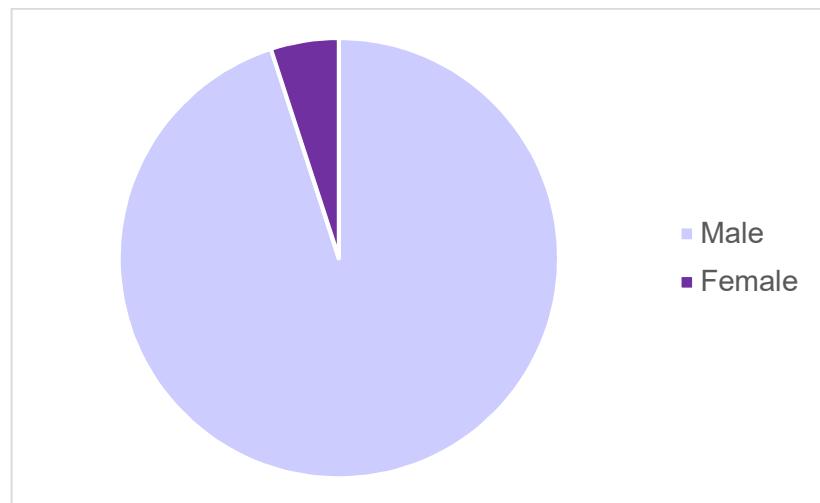


Figure 4-12 Representation of Gender (%)



The largest group of respondents did not specify a region, stating “UK” or, in the case of 2 respondents, leaving this option unanswered. Celtic regions Northern Ireland and Scotland were majority-represented with 25% and 30% of respondents respectively.

Figure 4-13 Regional Representation (%)

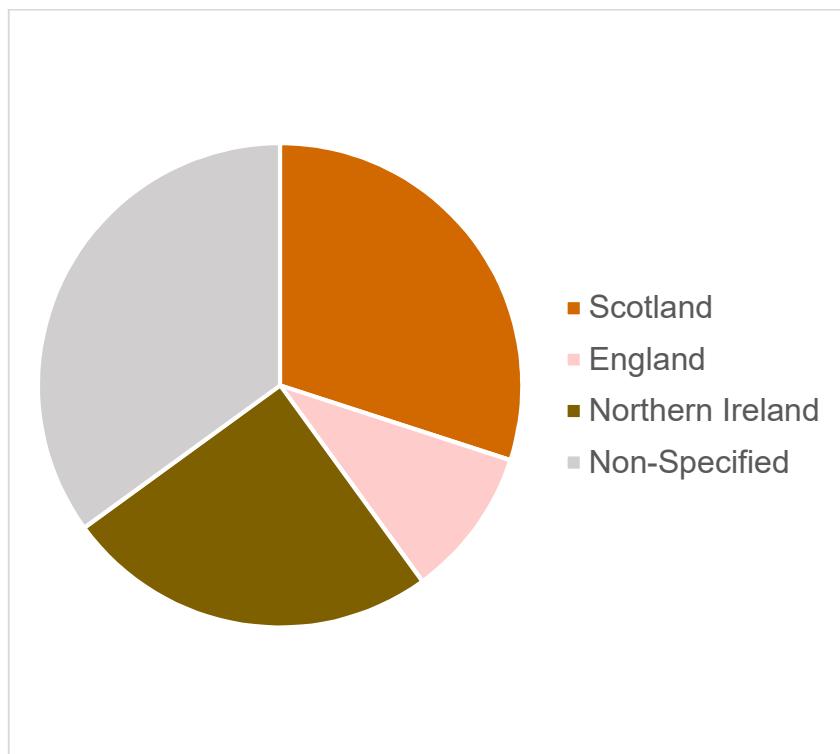
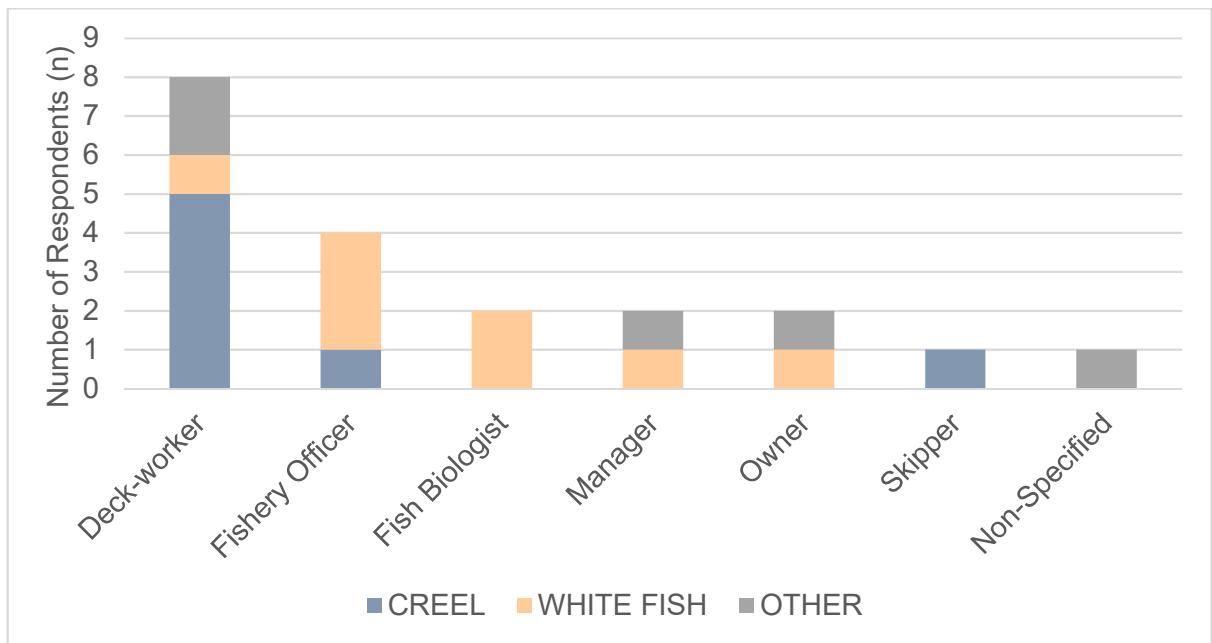


Fig 4-14 displays response per job title, stacked per key species (e.g. 1 respondent was a deck-worker working with white fish). The white fish industry is represented across a balanced range of sectors and positions. Creel workers, and overall responses, came mainly from those in onboard positions (deckhand, deck boss, skipper). See Appendix-7 for detail on marine hierarchy and job descriptors.

Figure 4-14 Representation of Workers Per Job Position and Species (Stacked)



4.2.1.2 RESPONSES

4.2.1.2.1 Question-4

Respondents were asked to rank a range of factors on their current impact on the fishing industry. Responses were given a weighted score as shown in Table 4-2. The sum of all weighted scores per factor was calculated to determine an overall positive or negative score.

Table 4-2 Question-4 Score Rating

Q4. Do you feel that any of the following are having a current positive or negative effect on your work in the fishing industry? Please select one option for each on a scale of "strong positive" to "strong negative" effect.						
	Strong positive effect	Some positive effect	No effect	Some negative effect	Strong negative effect	Not sure
Value	10	5	0	-5	-10	0
E.G. response	2	8	1	3	5	1
E.G. Weighted Score	=2x10	=8x5	=1x0	=3x-5	=5x-10	=1x0
	20	40	0	-15	-50	0
			Total Score		=20+40+0-15-50+0	
					-5	

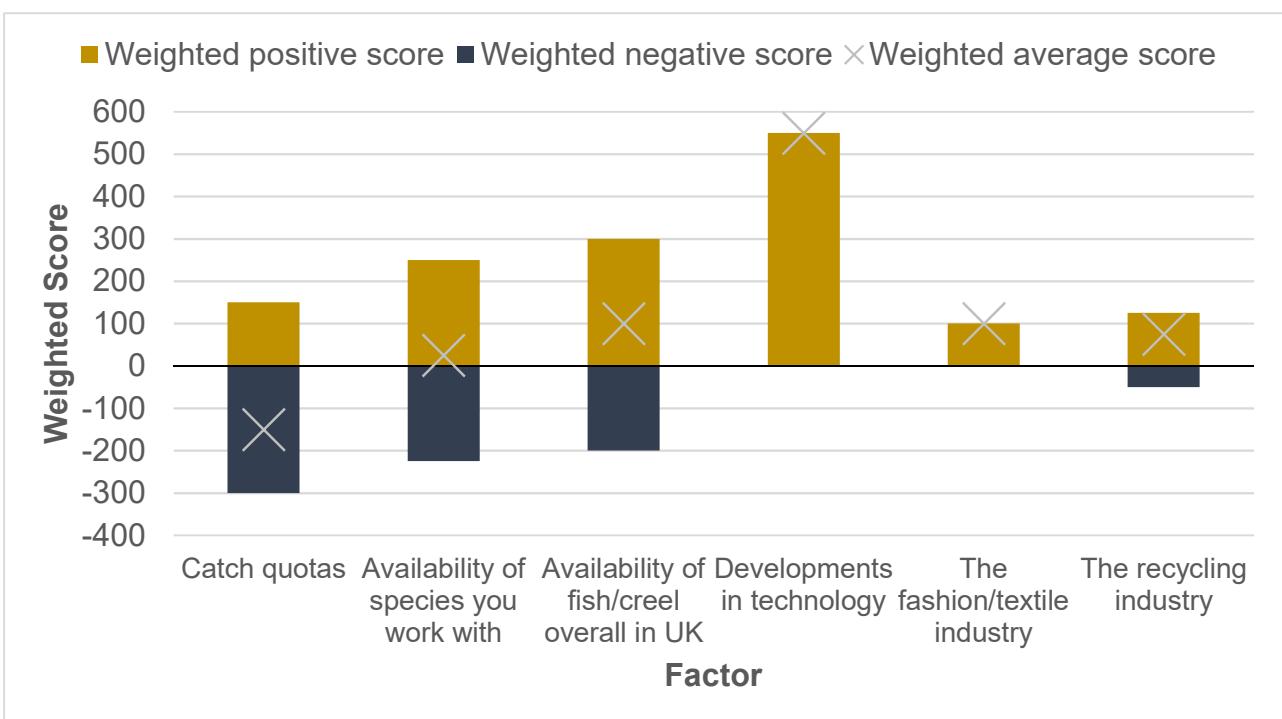
Scores were then normalised as per the equation below to eliminate group number bias, to facilitate comparison between unequally populated categories.

Equation 1 – Normalisation of category size

		$y/n \times 100$
y	Score	
n	Number of Respondents (per category)	

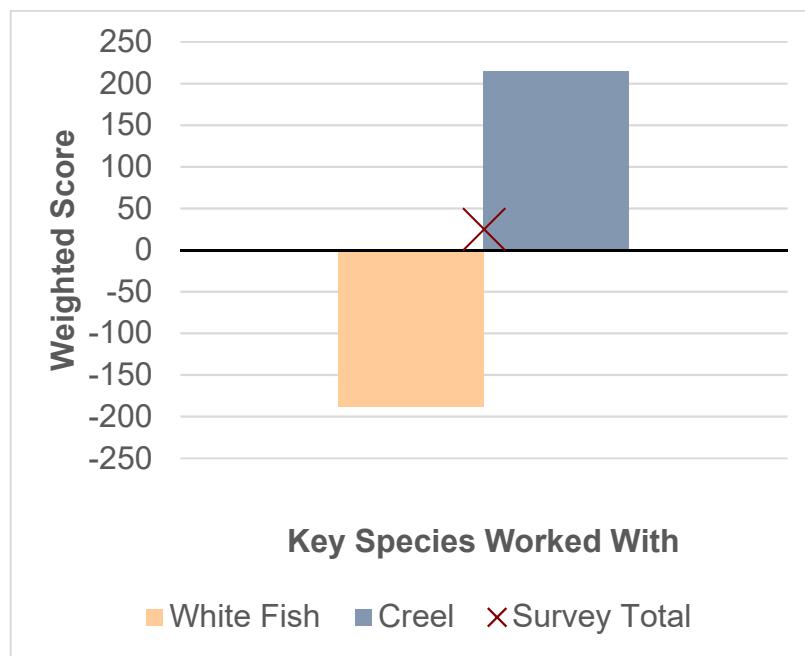
Fig. 4-15 shows a total survey comparison between surveyed factors. Catch quotas were the only category which scored an average negative, with 100% of respondents aged 46-55 considering catch quotas to have a negative impact. Some conflict between age groups was present. Overall 60% of respondents thought the textile industry had no impact on their work, while 37% of 36-45's surveyed saw a positive effect.

Figure 4-15 Positive/Negative Effect on The Fishing Industry



'Availability of species you work with' averaged close to zero, demonstrating strong conflict. Figure 4-16 graphs differing scores for this factor amongst two work-species groups. Both groups' results deviated towards the survey total mean (300) in the factor "Availability of fish/creel overall in UK" which suggests the demographics are aware of the other's issues/security, and that white fish workers' stock is more under threat than creel.

Figure 4-16 Positive/Negative Effect:"Availability of Species You Work With"



4.2.1.2.2 Question-5

Respondents ranked given factors as potential future opportunities or threats, with weighted scores produced under the following headings, following the same calculations and normalisation as Q4 (above). Positive scores reflect "opportunity" score and negative scores reflect "threat" score.

Table 4-3 Question-5 and Ranking

Q5. Do you feel that any of the following pose a potential future threat/risk, OR a positive opportunity for the fishing industry, thinking about your own line of work in particular?

	Strong opportunity	Some opportunity	No effect	Some threat	Strong threat
Weighting value	10	5	0	-5	-10

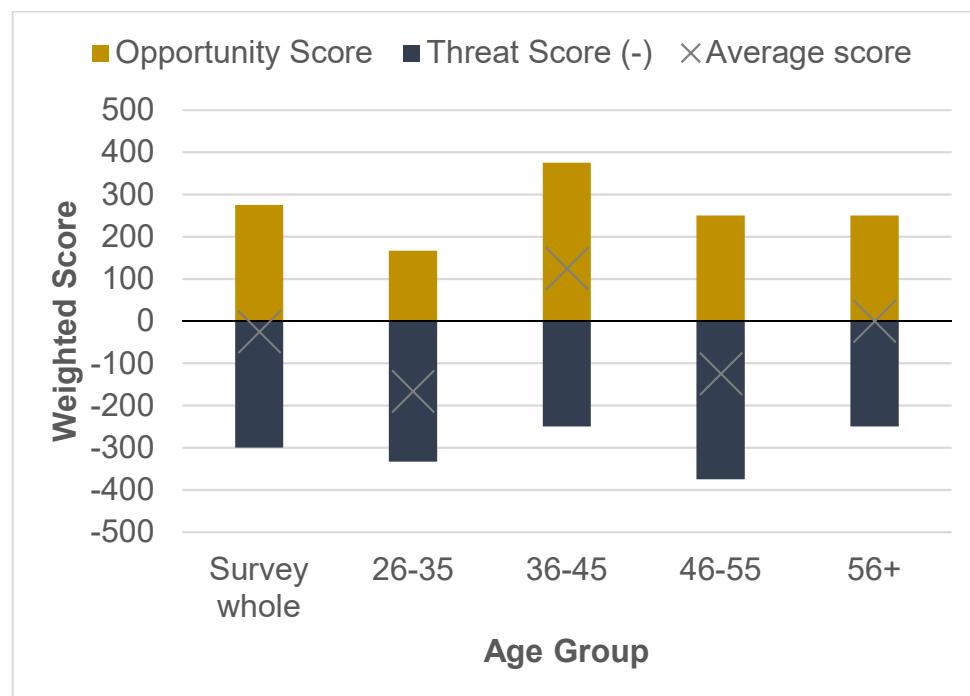
Notably, survey total results show that, despite viewing the recycling industry as having “no effect” on their industry at present, an overall strong positive average was attained regarding future opportunity in this category.

Figure 4-17 Potential Opportunity/Threat of Factors to the Fishing Industry



The ‘Brexit’ category incurred strong conflict, with an average score at near zero. Figure 4-18 shows a break-down amongst age groups, with the 36-45 category scoring highly in favour of Brexit -at odds with the 26-35 category particularly, who saw a strong “threat” in Brexit.

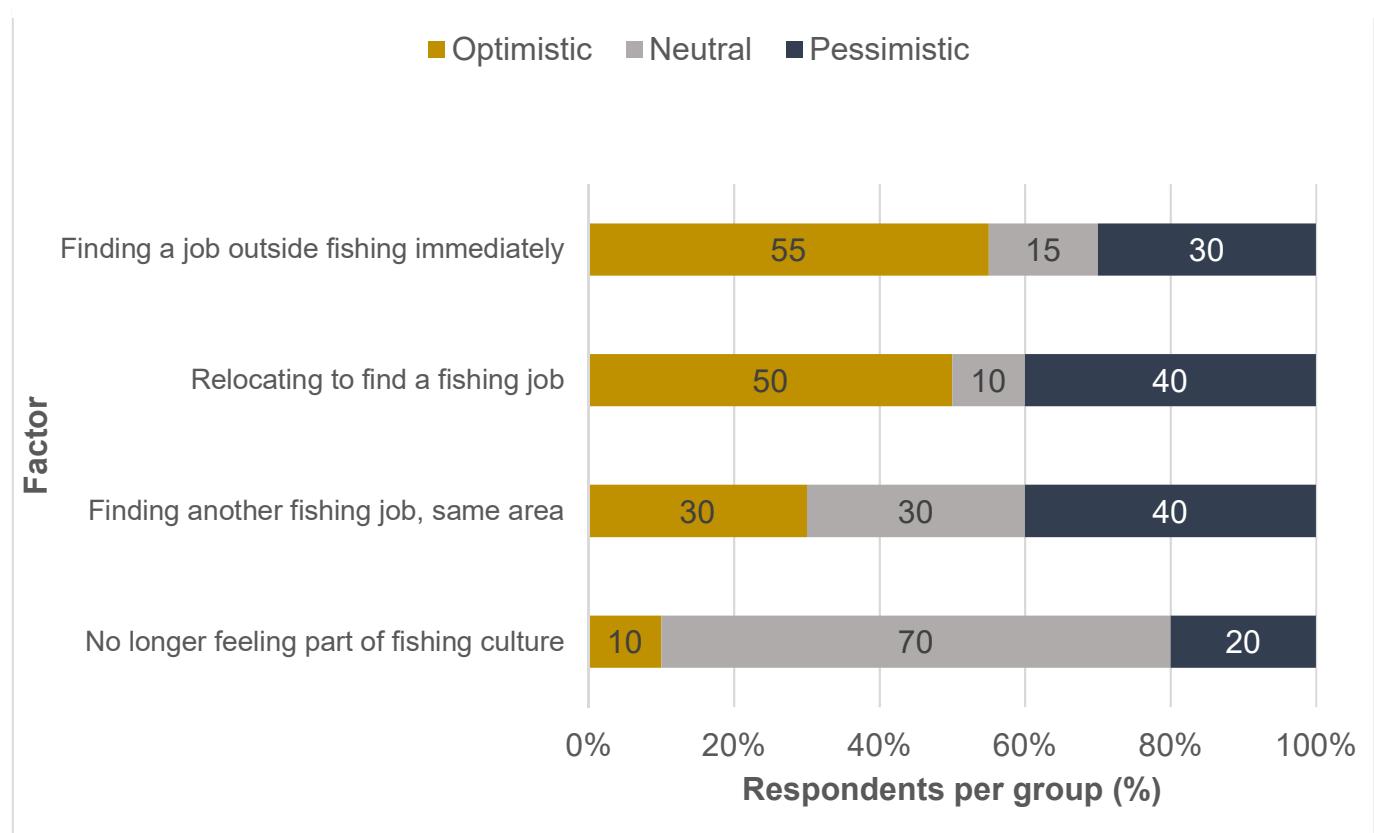
Figure 4-18 Brexit - Potential Opportunity or Threat? Comparison of Age Groups



4.2.1.2.3 Question-6

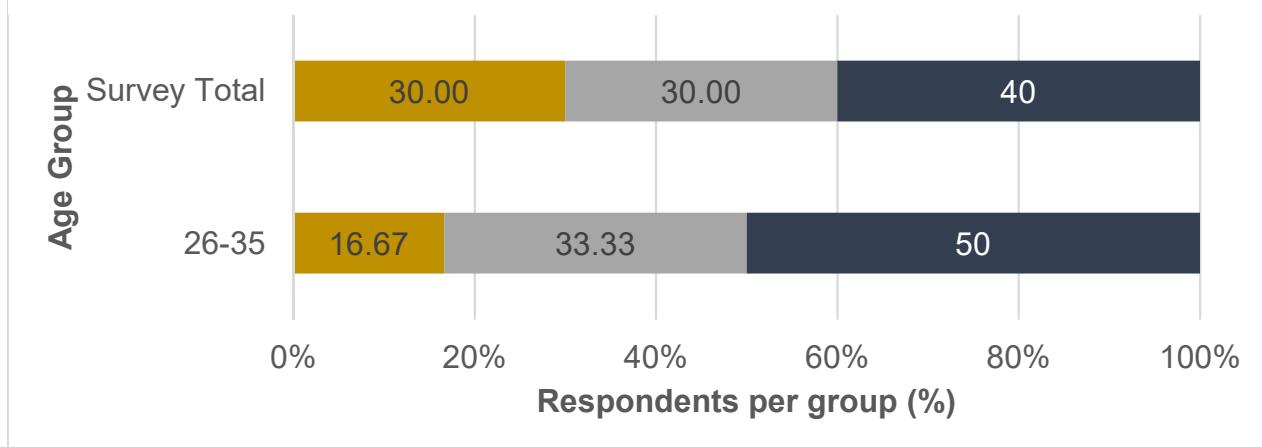
Respondents recorded their views towards future professional prospects as 'optimistic', 'neutral' or 'pessimistic' in the event of unemployment. Figure 4-18 shows percentage response towards each prospect, highlighting moderate optimism towards relocation or re-training. With a strong majority (70%) feeling neutral towards a loss of fishing culture, this factor seems to be a low priority amongst the demographic.

Figure 4-19 Optimism/Pessimism Towards Future Prospects



'Finding another fishing job in the same area' scored the most pessimistic average result. Respondents in the 26-35 age category felt most pessimistic about this.

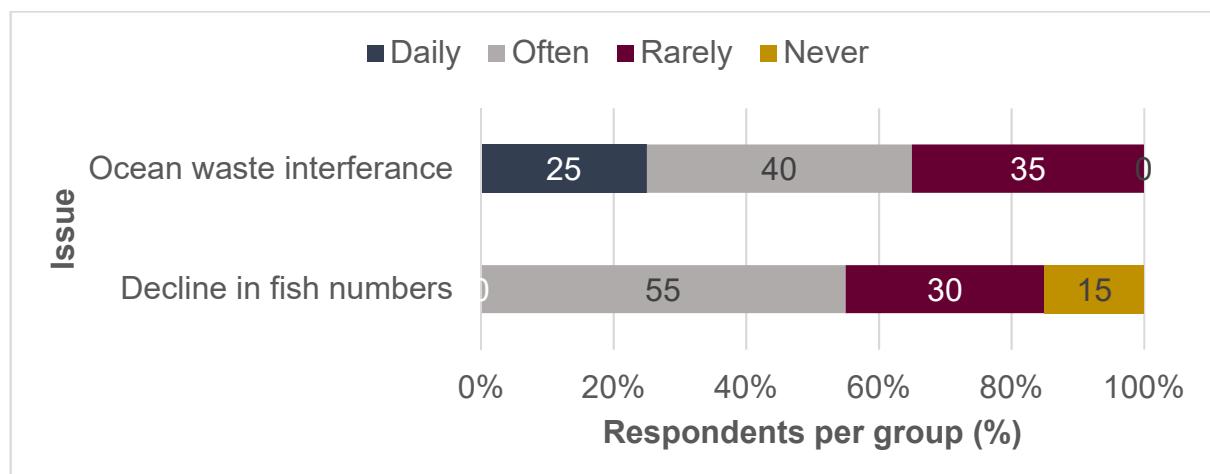
Figure 4-20 Pessimism Trend re. "Finding another job in the same area, in the fishing industry" amongst 26-35 age group



4.2.1.2.4 Question-7

100% of respondents reported having experienced 'ocean waste interference' in work. 'A sense that the number of fish/creel is in decline' was reported as less frequent, but had been experienced at some point by an 85% majority.

Figure 4-21 Reported Frequency of Issues in Fishing



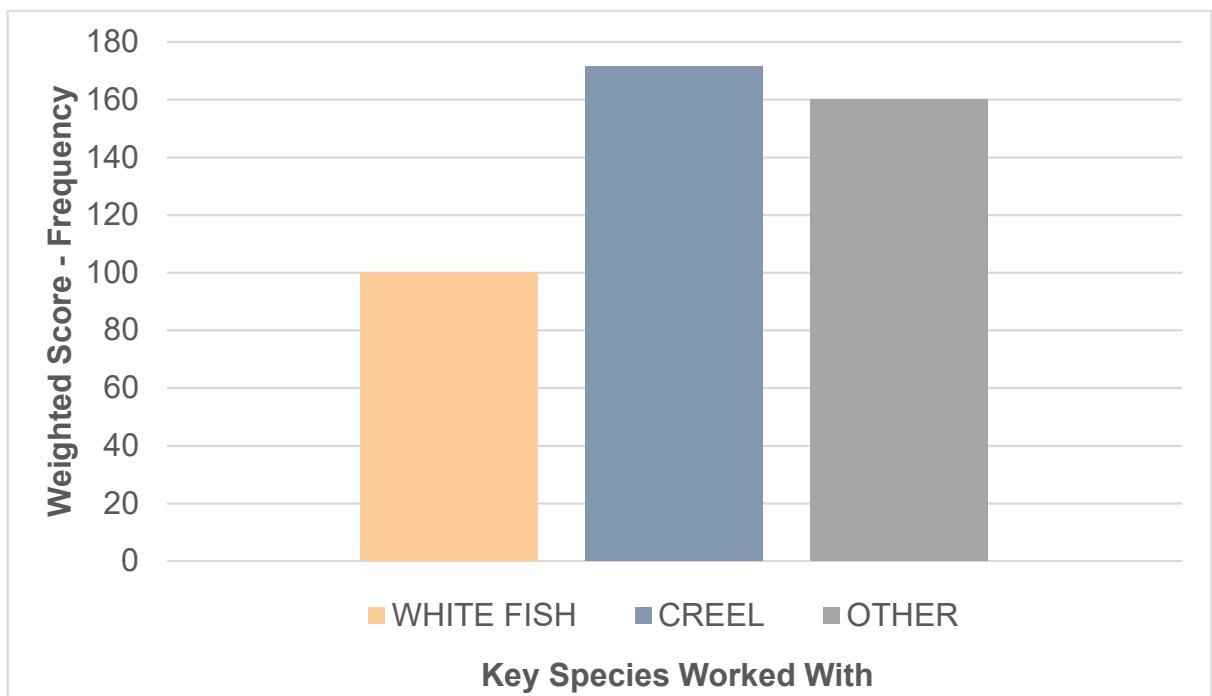
A weighted and normalised score was created, as per Question-4, according to the below values, to analyse trends between age/species categories.

Table 4-4 Question-7

How much do you experience the following in your work?				
	Daily	Often	Rarely	Never
Weighting Value	3	2	1	0

Creel workers reported a sense of declining numbers as more frequent than any other group, in contrast to previous optimism.

Figure 4-22 Sense that number of fish/creel is in decline



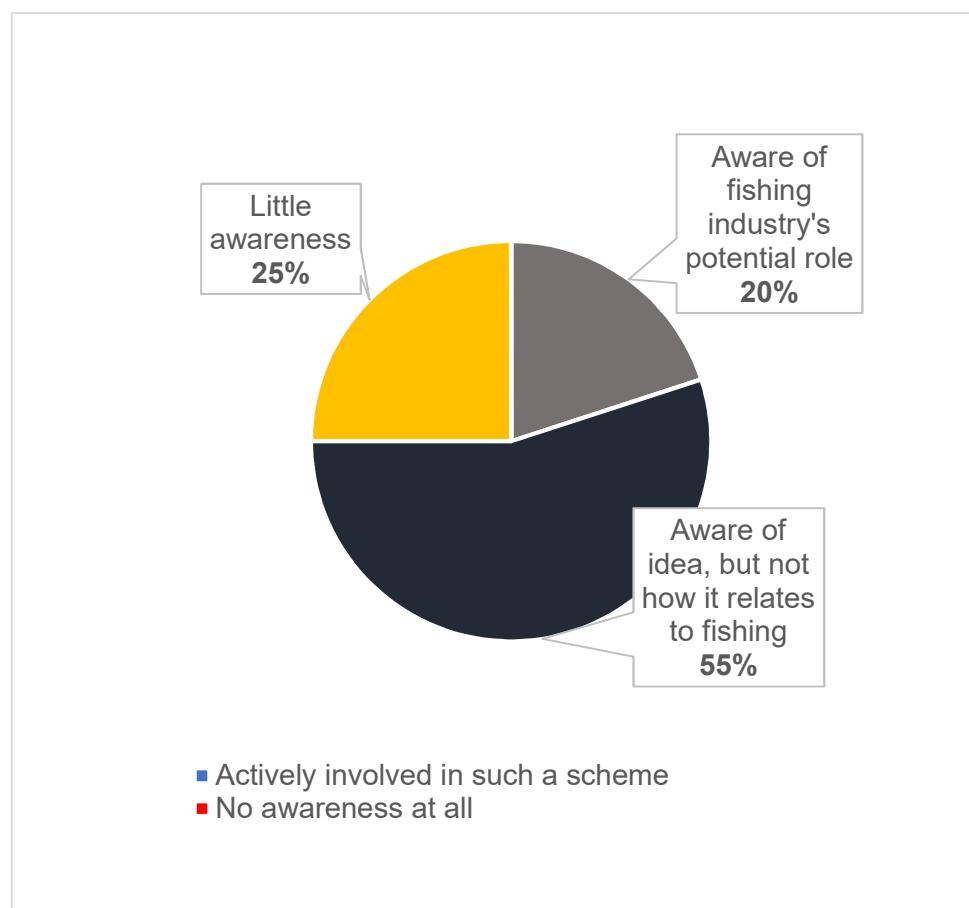
4.2.1.2.5 Question-8

Respondents were surveyed on their awareness of the below. 0 respondents reported an existing involvement in such a scheme, although 100% respondents reported some level of awareness. One respondent also commented with an example brand.

Table 4-5 Question-8

Q8. Are you aware of companies using recycled plastic waste to create textile products, such as fabric for clothing/bags? Tick one option.					
Comment	Age Group	Work Species	Location	Job Title	Q-8 Answer
"fourth element have just released a new range 'ocean positive' clothing that uses recycled plastics and ghost nets https://life.fourthelement.com/product-category/oceanpositive/ "	36-45	Other: "King scallop, Queen scallop, razors, lobster"	Scotland	Owner: "owner / diver"	I am aware of this and how the fishing industry can get involved

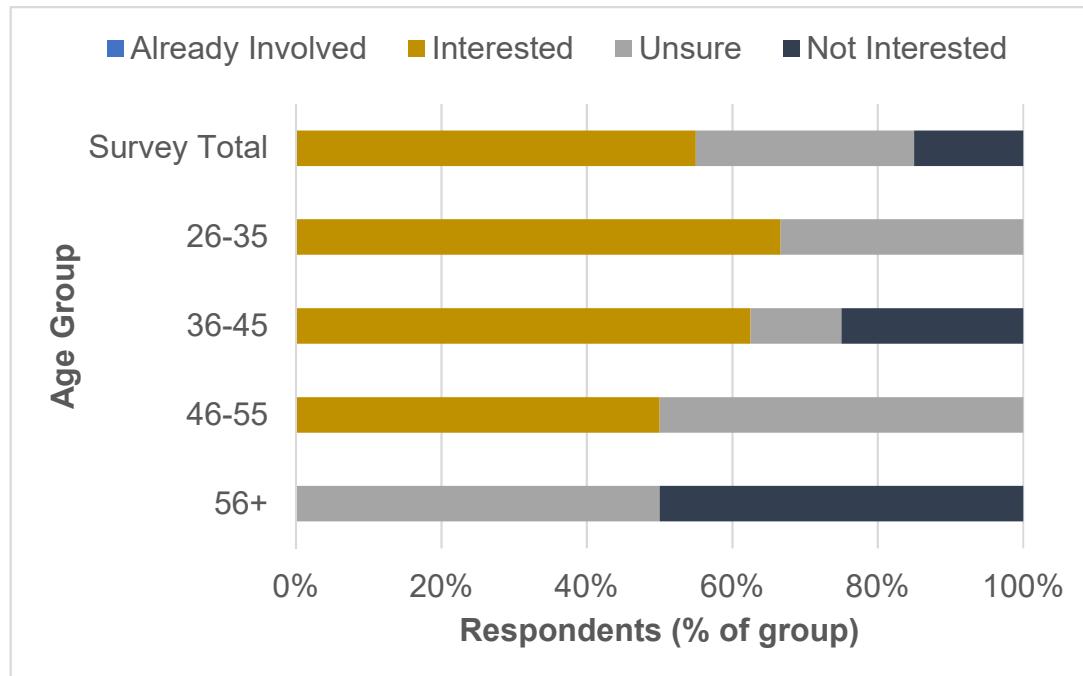
Figure 4-23 Awareness of Firms Recycling Plastics into Textiles (% respondents)



4.2.1.2.6 Question-9

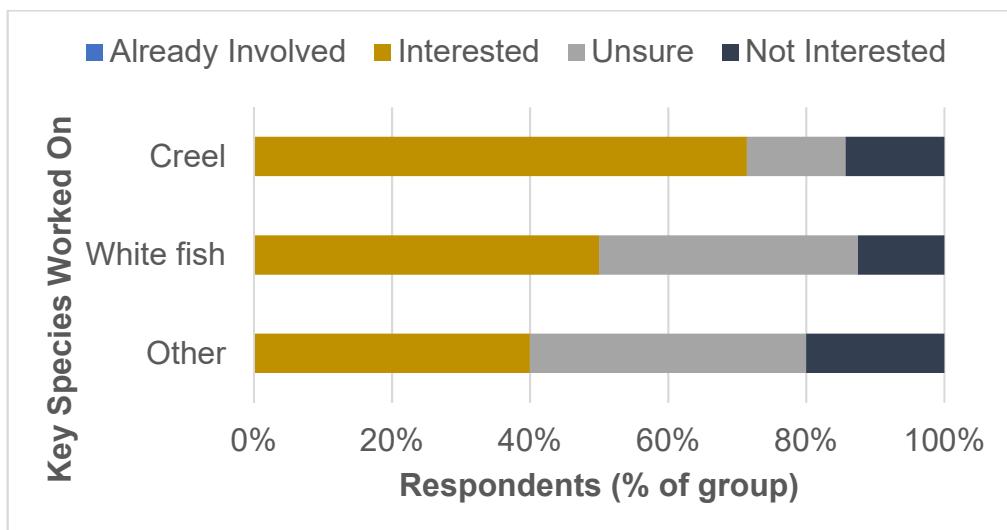
Respondents were surveyed on their interest in a profitable fishing for litter scheme. As before, 0 respondents reported current involvement, but 55% selected the 'yes, interested' option, with a negative correlation between age and interest, as displayed in Figure 4-24.

Figure 4-24 Interest in Participation by Age



Creel workers were the most interested demographic by categorisation of work-species.

Figure 4-25 Interest in Participation by Key Species



Five respondents used the comment box to further detail their views on the subject (Table 4-6). Two managerial-level respondents mentioned financial concerns and one respondent mentioned KIMO; commenter 5 also expressed frustration, hinting at poor public perception of fishermen.

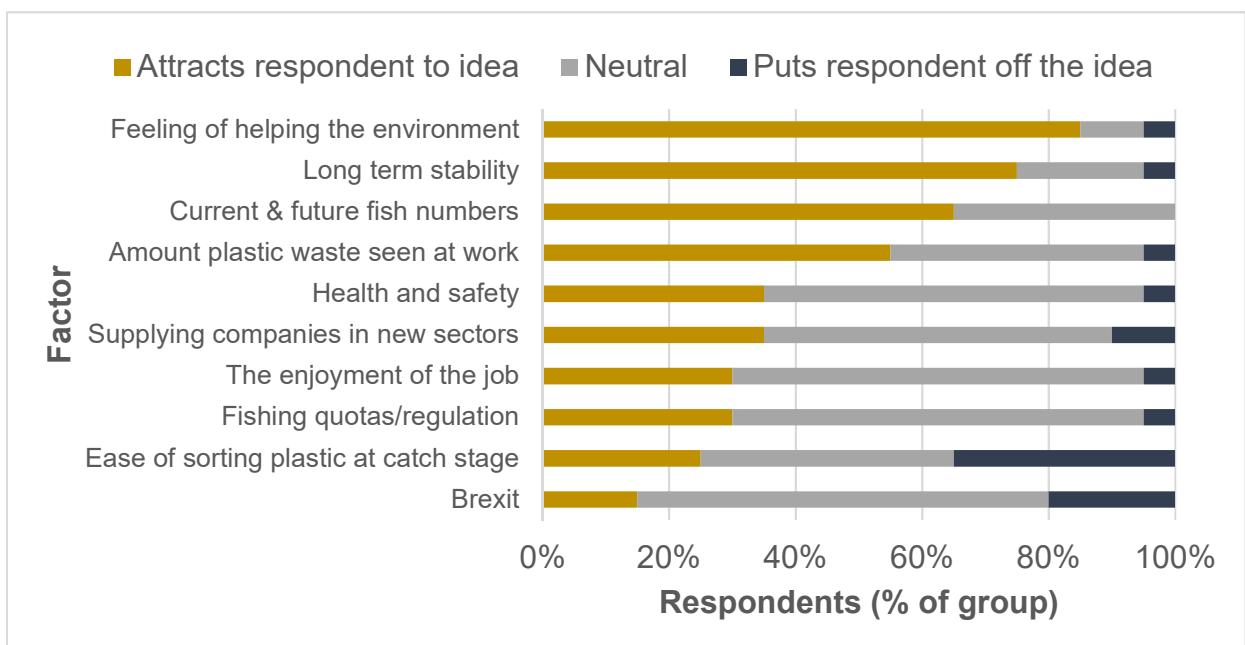
Table 4-6 Question-9

Q.9 Would you be interested in the idea of fishing for plastic waste, to be sold to private companies for creating textiles and other products? Tick one option.					
Comment	Age Group	Work Species	Location	Job Title	Q-9 Answer
1. "Not sure the monetary benefit to fishermen would be worth the effort"	26-35	Creel	"UK"	Fishery Office r	Unsure
2. "The plastic could still be reused thus having to use less common resources globally in an already dwindling stock"	26-35	White fish	"Peter head"	Fishery Office r	Yes, interested
3. "Unsure how my work can help in this field"	36-45	Other: "Whelks/ crab/ lobster/ scallops"	"Irish Sea"	Deck hand	Not interested
4. "If alongside fishing - yes. In replacement of fishing - unsure of how profitable it would be for fisheries."	26-35	White fish	"North ern Ireland "	Fish Biologist	Unsure
5. "Kimo already do a fishing for waste scheme, with bins readily available on the dockside. environmental NGO's do not give enough recognition to 'fishermen' regarding this!"	36-45	Other: "King scallops, Queen scallops, razors, lobsters"	"Scotla nd"	Owner: "owner/ diver"	Unsure

4.2.1.2.7 Question-10

Respondents were surveyed on whether given factors would attract them to the idea of involvement in profitable fishing for litter. Figure 4-26 charts the survey total trends, with ‘feeling of helping the environment’ and ‘long term stability’ ranking as the strongest pull factors. ‘Ease of sorting plastic catch at stage’ remained the strongest off-putting concern by a large margin, with 35% overall viewing it as such.

Figure 4-26 Motivating Factors for/against fishing for plastic waste to be sold to private firms



2 respondents used the comment section for Question-10 to provide contact details (to remain confidential). This was insufficient to create a focus group, and the respondents were not within a reasonable location range.

4.2.1.3 LIMITATIONS

The immediate limitation for the research survey results lies in the small sample size. Despite reaching a significant target audience through several channels,

only 20 qualifying people in total responded to the survey. A small sample size increased the likelihood of extreme results, by reducing the natural effect of deviation to the mean and because the probability that those with strong views were more likely to be willing to participate in a survey. All results should therefore be considered a weak suggestion of trends in this demographic, with the author recommending extensive repeat surveying to accurately represent the fishing industry.

4.2.2 KIMO UK CASE STUDY

4.2.2.1 OBSERVATION

The author shadowed KIMO's UK Coordinator (McLellan) over a one-day period. General conference calls with local Scottish council members raised issues in coordination of the Fishing for Litter project, such as difficulty in gaining support from in-land councils, especially in Scotland's Central Belt [Edinburgh, Fife, Glasgow regions] as council members here felt a lack in responsibility for ocean waste and a distance from the problem. Other council members in Highland and Island regions were enthusiastic to get involved with the project but lacked established relationships with harbourmasters and KIMO proved necessary as an intermediary between the two.

The author observed key challenges in KIMO's role in coordinating ocean waste management; aiming to source waste collection locally proved a time-consuming logistical challenge. Recruiting new harbours usually required active volunteering from individual fishermen; the author and coordinator discussed a need for future education projects to raise awareness of the Fishing for Litter scheme and the benefits it could provide.

Once established, a need for further education remained as issues were raised around achieving full participation of all fishermen and fleets at each harbour. This was known to be lacking in some harbours involved.

A harbour tour was led by Eyemouth harbourmaster (Lawton). The group discussed potential sites for a floating sea bin: a motor device used to filter plastic waste from harbours without harming marine life, yet to be introduced in the UK. Existing skips and collection schedules were reviewed; the site is strategically

placed near existing waste bins, to minimise effort and encourage participation, which has been effective in Eyemouth.

Net repair was also observed, and a comparative case study introduced; profitable net recycling is at a similar stage of development to the rPET market but is attracting much more attention in the UK. Issues with net legislation and repair were introduced, and ideas raised around taking strengths from the nylon net recycling campaign to increase the awareness of an rPET-from-waste model to a similar level.

4.2.2.2 INTERVIEWS

Following the shadowing period, a semi-structured, open-ended interview was conducted each with McLellan and Lawton (Appendix-10 and -13). Key prepared topics were discussed, such as KIMO's organisation, funding and lobbying activity; difficulties in recruiting harbours and fishermen; challenges in waste management; social impact on those involved- and new topics were raised based on the observation.

The following infographics were generated with dialogue from each interview. Filler words were removed for editing and relevance. The font size of each word is relative to its weighting in the interview to emphasise mood and key themes. The infographics facilitate quick visual comparison between the key points of both interviewees.

Figure 4-27 Infographic, Interview with KIMO Coordinator. Author's own



Figure 4-28 Infographic, Interview with Eyemouth Harbourmaster. Author's own



Table 4-7 charts the key themes discussed and compares points made by each respondent.

Table 4-7 Interview Comparison

Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster
KIMO background, details		
General	9 member states; each with a national coordinator as one employee; over 70 member authorities mainly consisting of local councils; 18 signed-up harbours in Scotland, 12 in SW England; McLellan involved since January 2018.	Involved as harbourmaster in a KIMO-participating harbour for 4.5 years prior to interview (2013)
Concept	KIMO provide litter skips for fishermen to deposit waste collected at sea - "it's a passive act [for the fishermen]"	"I think there's a realisation something needs to be done about the problem of plastic litter in particular going into the sea and there's a general movement to try and do something about it."
Funding	KIMO Scotland: EMFF (European Maritime and Fisheries Fund, EU body) as main source (around 80%), local council members on KIMO board, Aberdeenshire council, Scottish Fishermen's Trust (branch off Scottish Fishermen's Federation), Harbour Trust, Peterhead Port Authority. KIMO England: MMO (Marine Management Organisation, English branch off EMFF)	N/A
Coordination	KIMO aim to "use the waste companies that the harbours already use. That just makes more economic sense". Aim to support local economies and also maintain logistical sense: "I'm not going to have someone up in Inverness drive down to Edinburgh to pick up a skip". This is later identified as an organisation issue which is time-	N/A

	consuming in recruiting new harbours.	
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster

Motivating Factors -Fishing for Litter		
Pressure Fishermen	on	McLellan acknowledges poor image of fishermen in press and perpetuated by social media - for instance, complaints re. fishing-specific glove packaging on beaches. Explains that fishermen come to KIMO feeling frustrated, a "fear of public perception" and looking for a way to help. "They get a lot of negative press. I get a lot of volunteers, members of the public email me randomly to say they love the concept: why isn't everyone doing it?" Also mentions pressure from local councils, which may have negative impact as they tend to approach in a punitive way, rather than a solution-focused way.
Documentaries Increasing Awareness		"[I've seen a] massive increase [in involvement], especially in the last few months since I've joined: it seems to be that since the Sky Ocean project - the documentary, and also since Blue Planet 2"
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster

Quotas	Mentioned in passing as a motivation for fishermen; general daily discussion for this demographic.	"They always complain about quotas, the fishermen – they always have done. There's the feeling that, with Brexit, maybe it'll be a means of getting away from quotas – I mean, dodging them and coming up with a new system perhaps."
Threat to Job Stability	Identifies financial barriers through landfill tax and pressure from the public as major threats to fishing industry job stability.	"...if there's a public reaction against the fishing industry because of the perceived problems of the plastic pollution, then in the end it's going to be detrimental to them [fishermen], to the industry as a whole and in the long term they'll lose jobs. Anything that can be done to ensure that the measures are being taken is going to be beneficial."
Regulation	McLellan sites the Landfill Tax (tax on landing ocean waste) as the biggest "financial blockage" in preventing fishermen from collecting litter willingly - and so KIMO provide skips and pay collection charge to encourage more litter collection. This results in a strong surge in ocean litter collected at each new harbour.	N/A
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster

Plastic Waste	<p>McLellan makes regular mention to a common complaint amongst fishermen: "throwing the same bottle back into the sea over and over". With FFL, "there's less frustration [in their daily work] and it's more time-effective."</p>	"We're making some attempt to tackle the problem, and it's evidence that we are doing something when we're approached by the public and the people round the town saying, " <i>What are you doing about this?</i> ". It's useful to be able to say, "yes, we're doing this, this and this."
Environmental Motivation	<p>"it helps them feel like they're really making a difference ... No-one wants litter in their work environment and for them, their work environment is the sea." Cites her personal motivation as preserving ecosystems.</p>	"I think there's a certain amount of job satisfaction from our point of view... You know, we're attempting to make some difference. As far as the fishermen are concerned, yes, the ones that have subscribed to the scheme are very happy"
Depleting Fish Stock	N/A	<p>"The fish stocks you can see are under pressure; we can see from the prawn fishing industry that they're under pressure, because they'll come and flesh out a certain area and it'll then not recover for a couple of years" He cites recovery times as one of the key threats for the industry, and refers to "peripatetic" nature of the industry - moving from place to place for each fleet. "As far as the lobster and the crab fishing industry - the static gear - is concerned, we can also see that this is under heavy pressure as well. There's an awful lot of gear being put out there</p>

		and we're all wondering how long it will last, how long those fish stocks will support the industry."
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster
Litter Collection - Coordination Issues		
Sea – boat	Sees as a passive process. Cites fishermen as relieved in not having to throw same litter over again (more detail above).	N/A
Harbour Level	"Foreign vessels won't necessarily hang around to talk". Harbours may have several fleets landing but only effectively communicate with a few.	Points out tension, competition and lack of communication with foreign fleets- especially for fleets who have moved into the area when the seabed there is already under threat.
National Level	Identifies issues in coordinating with SW England harbours, has appointed an officer for KIMO down there. Visiting harbours in-person is a big part of the job and promotes good management.	"If there was one in Britain that could take all [the regional waste], that was proved to work, then that would be great. On a more localised scale, I don't think it would ever work as we don't have the continuity of material to work with."
Plastic Ocean Waste - Cause and Quantity		
Causes: Industry	Gloves packaging cited as industry-specific anecdotal issue. Attracts complaints from public. Issue identified in that the manufacturer includes single-use packaging for UK products but not in likes of USA. Goal - lobby	Sees fishing industry as biggest producer of ocean waste:"I don't think so much that it interferes with it, it's more the fact that what we do here is a cause; it's a source, a partial source of the problem ... we have the industry

	manufacturer to remove unnecessary packaging.	material: the nets and the ropes and so on. "
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster
Causes: Consumer	Sees consumer plastic as biggest issue: "I hate the idea of single-use plastic; I just don't see the point in it. I think the issue is we need to change how people use plastic especially but the problem is unless it's forced it doesn't happen"	Mentions in passing.
Quantity	KIMO UK has collected an estimated 1402 tonnes of waste since its inception in 2005. McLellan points out that this notable sum excludes figures from harbours who do not have the resources to monitor mass. KIMO internal surveys carried out suggest 38%+ of that waste to be plastic bottles alone. "88% is miscellaneous plastic".	"I think there should be enough for the country as a whole to support at least one recycling centre and the feeds into it need to be established, so that the regular feed into it from the whole country then [could] sustain it."
Hinderances in Fishing for Litter		
Problems recruiting harbours	McLellan refers to the industry as "very set in their ways." See also above: coordination of waste collection. "The industry need a drive ... I think it's a combination of both [lack of education and legislative barriers]".	N/A
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster

Local government backing	Difficulty in convincing local councils that "KIMO is worth their while, worth the financial investment as well". Particular problem with in-land councils; "Arguably, it <i>is</i> their issue. All of them will have some water source that will end up in the sea .. it's a worldwide problem and we can do something".	N/A
Lack of awareness	McLellan makes example of foreign fleets landing in SW England whose home states have FFL schemes but who are not aware of UK scheme - identified need for more communication between KIMO countries. Responds "lack of awareness and lack of communication" when asked on biggest issue. Discussed plans to increase PR events, collaborating with volunteering fishermen groups, and talks at harbours.	N/A
UK Recycling Infrastructure - Lack of, Issues		
UK Recycling Infrastructure - Lack of, Issues	Sees lack of UK recycling infrastructure as one of the difficulties in organising a FFL recycling scheme - due to KIMO's aim to make use of local services in collection/sorting of waste. "It's local; it's got to be local .. Then eventually we'll move away from exporting [waste] and just make it UK-based, which is really the ultimate goal."	" ...especially now as we're losing some of the [business,] such as the Chinese refusing to accept any more [waste for recycling] so some of the traditional outlets for this sort of stuff has been closed off to us now, so if it could be re-directed [domestically]."

Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster
KIMO future goals		
Expansion	Net recycling: "I can send you more but it's still very much in its infancy but ... it just doesn't happen [in the UK] yet". Expansion also to other harbours	N/A
Lobbying	Identified as one of KIMO's main aims. The PRF Directive is discussed as a future development - in removing the Landfill Tax on fisheries.	N/A
Recycling	At present, KIMO only organises waste collection to landfill. McLellan "very keen to add a recycling element". Also, r.e. PRF Directive: "Or, if I can manage to secure tax relief from the landfill tax then maybe that money can go towards recycling"	N/A
Micro-Plastics		
Micro-Plastics	"The media are in an absolute frenzy about plastics – microplastics being the hot topic"	"...if they're [the fishermen are] not careful, if that is carried forward into microplastics in fish, in flesh then the consumer will react against it and you might find that if there's a problem that the product isn't as popular as it used to be" - identifies microplastics as linked to job stability and devaluation of the fish as a product
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster

Net Recycling		
Net Recycling	"The net recycling ... litter is the perfect example of [profitable recycling] and how [waste] could easily be used for raw material." "Net recycling is driven by profit .. I have a lot of people wanting to be involved purely because they have money in their eyes." Discussed issue of seeing types of waste as valuable/invaluable material and how education is needed to convince venture capitalists to invest in plastic recycling. Also lists lobbying for change to shrinkage policy in nets: "legislation is the reason that nets have to be replaced so often, they are going to landfill or at sea most commonly"	N/A
Floating Bins		
Floating Bins	"Aberdeenshire council were installing a sea bin which is the first in Scotland and that's driven by them and they feel very proud of that ". "My goal then is to have one in every harbour that wants it" "you can install a sponge [sic] in it too where it will remove surface oils and diesel and things"	N/A
Theme	McLellan - KIMO UK Coordinator	Lawton - Eyemouth Harbourmaster
Future Project - Collection Bags rPET from this work		

Future Project - Collection Bags rPET from this work	McLellan suggested a future project utilising the strong performance qualities of the rPET used in the objective studies in this work to create new litter collection bags for the Fishing for Litter scheme. "They have to be a very hard-wearing bag."	N/A
Fishing for Litter for Profit - Viable?		
Fishing for Litter for Profit - Viable?	"I completely think it could be - absolutely." McLellan refers to level of waste collected in KIMO-participating harbours, which represents only a small portion of the possible resource which could be tapped into for plastic recycling.	"Because of the quantities you've got, we're talking something more in terms of regional centres for recycling and such."

4.2.2.3 LIMITATIONS

The case study was intended to cover 2 harbours, but the second visit was cancelled by all parties due to weather restrictions and unable to be rescheduled within the time allocated. Overall, the two interviewees covered great detail and represent two well-informed but different standings in the Fishing for Litter effort: McLellan as an intermediary between fishermen and government, Lawton as a representative of local fishermen.

5 Chapter 5: Discussion

This chapter will evaluate results from Chapter 4 in further detail, in the context of the overall research aims.

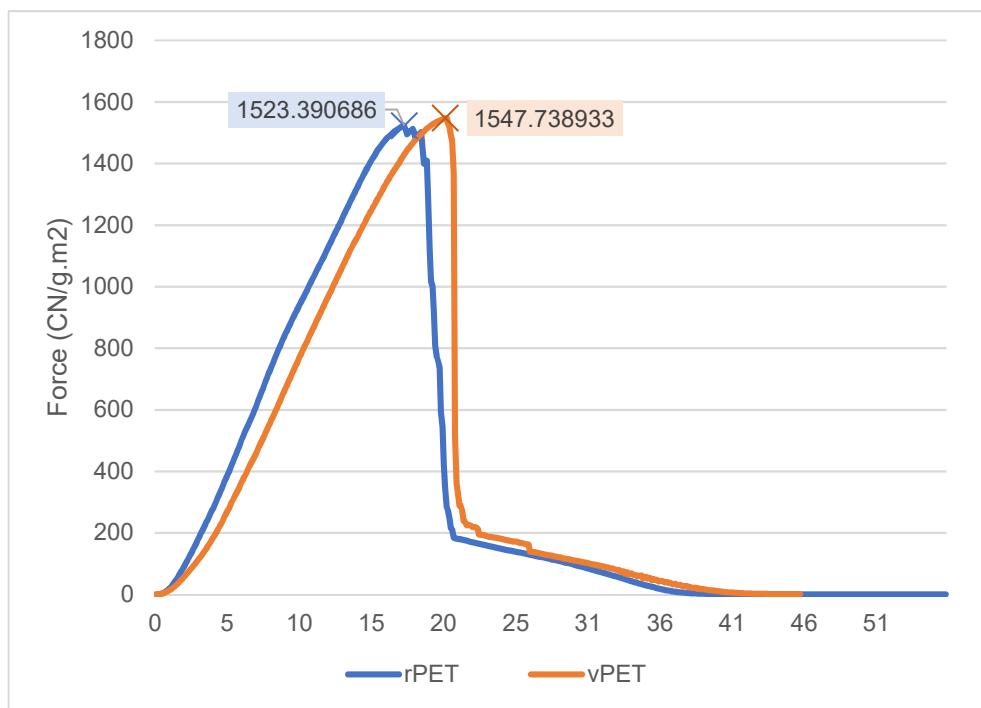
5.1 LAB TESTS

This section details the results from lab tests, and the findings that can be drawn from them with regard to rPET performance: stand-alone, and relatively to vPET.

5.1.1 MAXIMUM FORCE

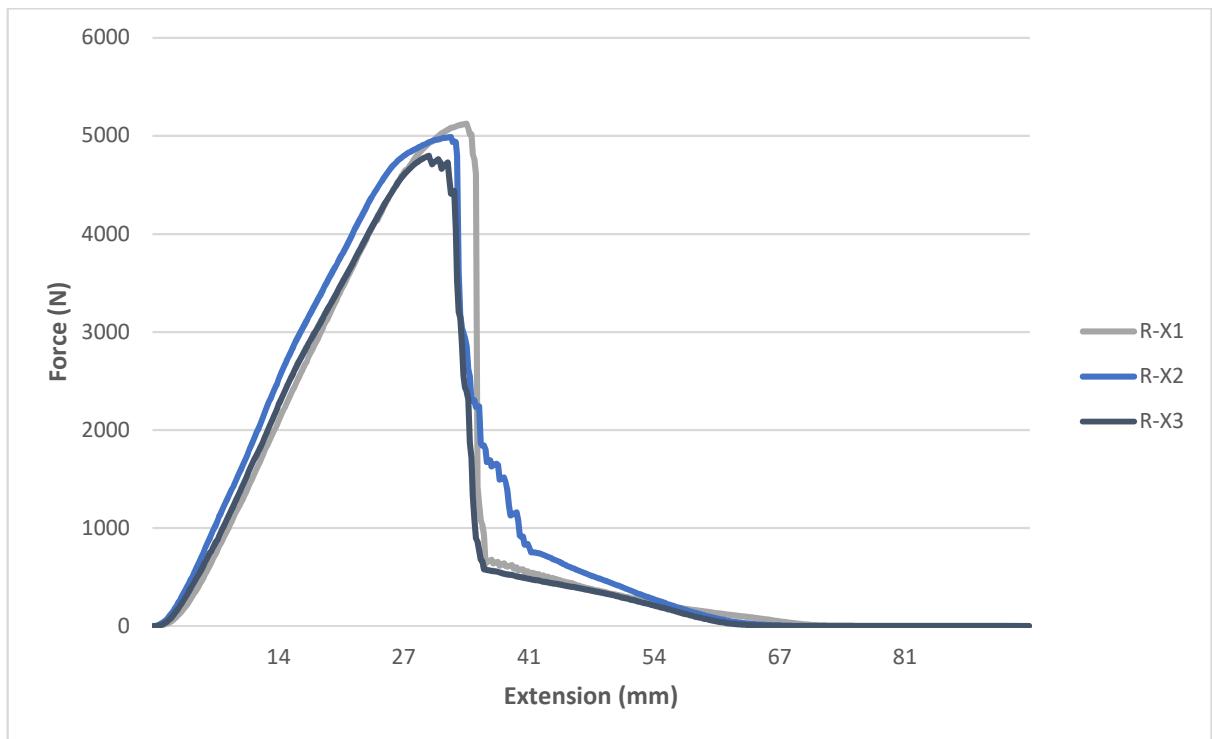
The graph below shows a notable result, in that the highest value obtained for vPET on the Maximum Force test is comparable with rPET's lowest. After weight normalisation, vPET's upper limit was a mere 1.6% greater than rPET's lower limit. It was expected that vPET out-perform rPET in this area by a significant margin, due to degradation of the fibre before and during recycling.

Figure 5-1 Maximum Force, Highest vPET and Lowest rPET - Weight Normalised (CN/g.m²)



The raw figures produced for rPET Maximum Force (Figure 5-2) also merit stand-alone consideration, displaying a suitable strength for heavy-duty applications, with a mean of 4970N. This represents successful development of a durable recycled fabric.

Figure 5-2 rPET Maximum Force – Raw Data



The possibility of using the high performing fabric in a waste collection bag such as those used by KIMO was raised. Taking raw data, the average (mean) maximum force at break for rPET was used to calculate the maximum mass (kg) that could be held by a bag made from this fabric using Newton's Second Law of Motion.

Equation 2 Bag Holding Weight Estimation

M = f / a				
Wherein				
M	=	kg	Unknown Mass (Holding mass)	
F	=	N	(Maximum Force, rPET [mean])	
A	=	m/s/s	Acceleration rate (gravity)*	
M = 4970.7 / 9.80665				
M = 506.870338				
M = 506.87				
* gravitational rate of acceleration used, as specified rate of acceleration needed to lift bag is unknown.				
This equation simply calculates maximum mass at holding point.				

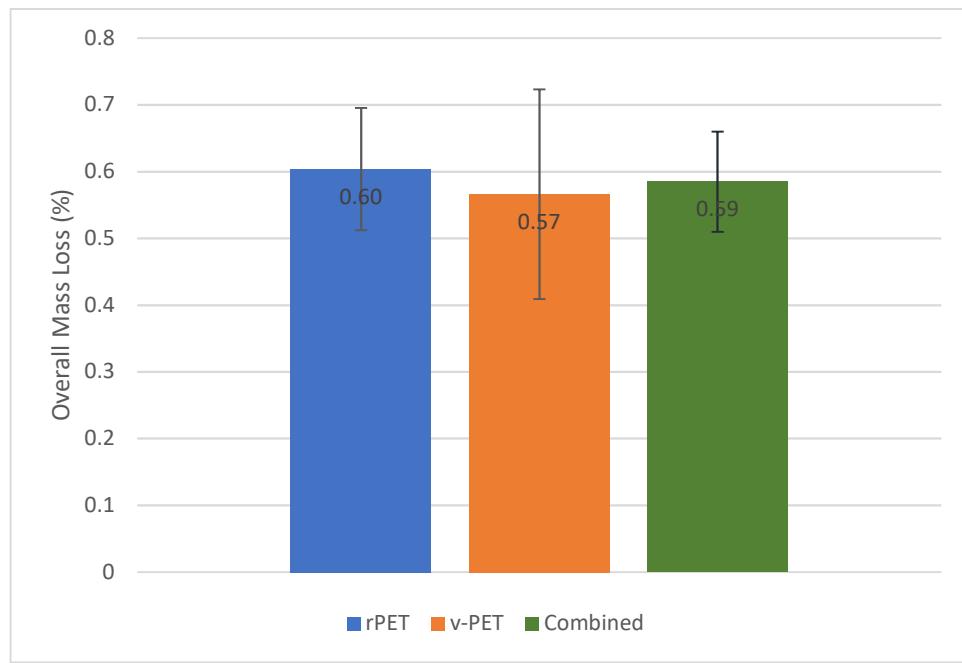
Theoretically, rPET bags could hold around 500kg of waste. KIMO's current bag suppliers specify an average of 1000kg holding weight per bag, but these are developed with the construction sector in mind (ie. holding sand as end-use) and it is likely that plastic waste would impose a much lower mass-to-area ratio than a high-density material such as sand. This only considers holding weight and not other necessary characteristics for this purpose.

5.1.2 MARTINDALE TESTS

vPET outperformed rPET objectively (through lower overall mass loss) in Martindale-abrasion tests. However, Martindale-appearance results have an inherent subjectivity and were impacted by the difference in colour; pilling was more visible on the blue-tinted rPET than the white vPET. The end results were also very comparable, with both fabrics successfully surviving the pre-defined revolutions limit (70,000) without yarn breakage (as is the industry standard for heavy-use purposes such as public-institutional upholstery) and so serve as further evidence to support rPET's suitability in industrial applications.

The third bar in Figure 5-3 displays the mean of combined rPET and vPET mass loss results, to demonstrate that an acceptable standard error results as though both fabrics were from the same sample.

Figure 5-3 Mass Loss (mean) – with rPET and vPET Combined to Show Standard Error



5.1.3 FAST TESTS

FAST tests are intended to give a view of suitability for apparel fabrics. They were used to reflect any minute issues at heavy quality – but this is only a loose predictor and so the results cannot speak for fabric behaviour if reproduced in apparel quality. rPET does again perform comparatively in all aspects (compression, bending length, extension at loads), which is encouraging considering both fabrics returned tiny increment results. These tests would ideally be repeated with an apparel weight fabric, if this could be sourced.

5.1.3.1 COMPRESSION

Released surface thickness results (see FAST-1) indicate better structural integrity in vPET. This may be beneficial for many textile applications [eg]. However, this contrasts to Bendell *et al* (2017)'s result, in measuring compression modulus of rPET in automotive foams; rPET expressed more resistance to compression and was deemed less useful in determining comfort for the

consumer. If the FAST-1 results were repeated and a higher released thickness confirmed, rPET fabric could in fact provide comfort benefit in, for instance, automotive upholstery covering.

The Bending Rigidity value calculated using FAST-2 and -3 tests does however show one weak trend regarding rPET performance limitation, which could reproduce more strongly through repeat tests and in lower quality equivalent fabrics; the higher bending rigidity value does confirm an issue with stiff handle which was mentioned as a draw-back in the literature review.

Limitations resulted also from sourcing yarn from different manufacturers, and although construction of fabric was controlled as much as possible, there will be inevitable differences in quality.

5.2 SOCIAL SURVEYING

This section discusses results from the research survey and interviews: how they contrast and support each-other, and their overall contribution to the research question.

5.2.1 SOCIAL BENEFIT

One recurring theme was that of job satisfaction and happiness as possible benefit of ocean waste collection – seemingly associated with assisting in positive impact. When questioned on Fishing for Litter's impact on worker well-being, both interviewees reported a feeling of helping the environment as positively affecting participants' morale. This was reinforced by the same factor being ranked by the survey sample as most attractive aspect of the concept to fish for plastic waste.

Although respondents' feeling on current fish/creel stocks differed between work-species categories, a fear of future decline was a strong trend in the results.

Lawton provided additional background to this, highlighting recovery times in creel fishing as an immediate source of tension and risk to job stability.

5.2.2 FACTORS MOTIVATING INVOLVEMENT

The results contradicted the author's original predictions surrounding fishing industry workers' perceived threats, with less priority on quotas and catch numbers than anticipated. Amongst other factors, public perception and the impact of negative media attention featured strongly in the interviews as threatening the industry and driving change. Notably, both interviewees cited recent film documentaries as inspiring a surge in awareness of ocean waste issues – with particular public concern regarding the potential impact on human health (through consumption of contaminated fish). This has prompted close evaluation of the fishing industry: not only by the public, but also internally, with Lawton's suggestion that colleagues and peers expressed new environmental awareness in the period since the documentaries' release. Reluctance to partake in surveys itself may have limited the accuracy of statistics obtained through low sample size, but this also arguably further demonstrates the demographic's fear of negative perception, and its effect on their long-term professional prospects - with one targeted Facebook group refusing to answer surveys until the author had answered a list of in-depth questions on storage and availability of the collected data.

Financial factors also proved significant in determining fishing professionals' willingness to participate in fishing for litter. This element was introduced at interview stage after survey respondents voluntarily raised concerns over whether the scheme could provide sufficient "monetary benefit to fishermen". KIMO's Fishing For Litter scheme's continued existence and success

demonstrates a financial motivation at a managerial level in fisheries and harbours; the scheme's core aim is to provide a means of ocean clean-up to harbours without restriction from the Landfill Tax on landed litter. However, that challenges remain in engaging new harbours despite KIMO providing a means of removing this "financial blockage" (McLellan, 2018) strongly suggests that other factors persist in the decision not to collect ocean waste. The author acknowledges too that this decision may not be an active one; with several references made by fishing industry individuals during the observation period to the sector remaining "stuck in its ways", complacency could potentially represent a barrier more than any competing push/pull factor.

The rate of engagement with such schemes is considerably low (this remains consistent with KIMO's listed goal of expanding to reach more fleets, and survey respondents' 0% engagement rate) despite McLellan's reports of enquiry from fishery workers or citizens and given that 0 survey respondents reported having "no awareness at all" of a Fishing for Litter type scheme. This resulting conflict could be explained by a gap in education; this suggests a need less so to inform a wider audience on the possibility of like-projects, but to better educate the existing audience on the benefits and importance of their implementation.

Lack of mention to culture in the interviews and an overall 'neutral' score assigned to the loss of fishing culture in the survey suggested a disproving of the author's preliminary idea that continued involvement in fishing culture may be a principal factor in respondents' desire to preserve the industry and their work environment.

– but quotas not so much as I thought, more so from increasing plastic pollution, especially in light of recent media campaigns, Lawton even suggested that these

made those already in the industry more aware of the issues - as discussed in literature review – this is not true for those surveyed in the fishing industry

5.2.3 *REPRESENTATION*

As stated in Chapter 4, a sample size of 20 respondents limits the validity of survey results. Additionally, UK regions are not proportionally represented. The over-representation of Scottish and Northern Irish workers was due in-part to ease of access to the demographic and potentially also to an increased awareness/participation in this demographic of Fishing for Litter; coordination and expansion in England were problems highlighted in McLellan's interview.

Trends appeared as expected regarding age demographics (for instance: younger demographics viewed Brexit as a stronger threat to the industry than their older counterparts); however, sample sizes severely limits the accuracy of these trends.

Despite small sample size, a balanced range of roles within the industry was represented in the research, with on-board workers successfully targeted as the majority demographic -possessing the most informed first-hand knowledge of ocean conditions. All levels of the fishery professional hierarchy were surveyed and those in in-direct supporting positions (such as fish biologist) contributed to a balanced range of job titles within the industry.

After consideration of results and unexpected themes, certain demographics gone un-targeted may have provided useful contributions to the overall assessment on the viability of a UK ocean-waste-as-recycled-textile business such as: waste management professionals, environmental lobbyists outside fishing, local councillors. A lack of knowledge on the logistics of the UK recycling

industry was shared between author and respondents and this limited much of the commercial assessment to rough estimation. Anecdotal information on interviewees' interaction with this industry suggested an incapable infrastructure.

5.3 ENVIRONMENTAL ASSESSMENT

Topics discussed in the social surveying led to discussions of environmental issues. Surveying fishermen presented a reliable means of gauging the first-hand situation, and its impact on those immersed within marine life. With 100% of respondents experiencing some level of plastic waste interference in their work and access to KIMO's historical data, one firm result drawn -and confirming the findings in the literature review- is that an unquantified, extremely large resource of ocean waste plastic is available, with plastic posing the most significant problem – and PET likely to be a considerable fraction of that overall mass (with PET bottles 38% of the waste collected in KIMO's survey).

In the context of the lab test results, that rPET may have high durability suggests not only a potential profitable resource, but also a positive effect on eco-systems in the event that ocean waste generates demand as a raw material. Whilst assessment of processing impact has been drawn exclusively from existing literature, depends on recycling method (mechanical, semi-mechanical or chemical) and remains largely inconclusive, the immediate risks to marine eco-systems from plastic pollution can only be effectively reduced through waste removal; this much is straight-forward. Whilst chemical recycling showed the strongest "green" ranking in the literature, the UK's unestablished position in the recycling industry and historic reliance on exports suggests a limitation in acquiring the skill-base of most recent and capital-heavy methods, such as those used in Japan. (Teijin, 2017)

Theoretically, assuming commercial success, increased profits from rPET sold in a waste-collection-to-textile model could be used, in-part, by fisheries to fund the floating bins discussed and further reduce pollution, targeting micro-plastics. There is insufficient data to estimate how significant a profit margin could be generated from this work, and interviewees tentatively predicted a risk of initial back-log in material, with a gradual decrease as the local area was cleaned-up.

Micro-plastics were mentioned several times in interviews, presenting a significant and current issue, with risks to marine life, human health - and resulting risks to the fishing industry, as discussed; this was not given enough consideration in the preliminary secondary research. The profile of this issue has increased during the research period and McLellan cited it as one of the driving factors behind an increase in KIMO receiving participation queries during the period January 2018 – March 2018.

Building a rounded environmental assessment would have benefited from access to industry-knowledge, for instance confidential data on chemicals used in production of yarn samples. The environmental assessment is limited in being largely based on secondary data.

6 Chapter 6 Conclusions

6.1 VIABILITY OF MATERIAL

With the key drawback to rPET in apparel use -rigidity - in these results consistent with the literature, there may be much room for improvement rPET in fashion textiles. However, aesthetic-focused tests were conducted, and the results cannot accurately speak for fashion applications, unless repeated using a lower density yarn.

Furthermore, performance value is not limited merely to apparel; rigidity, for instance, although unattractive here, may be a specified characteristic in other end-uses. As discussed in Chapter 5, the rPET developed in this work could potentially hold around 500kg of plastic waste and serve as material for ocean waste collection bags, aided by a rigid structure in withstanding extreme [adj for wind] and [adj for water, hydro-] conditions. This concept is in its infancy, as the calculation used factors only acceleration of gravity (does not determine force applied in lifting the material) and marine-situational characteristics were not tested.

rPET may at present be considered as effective, if not more effective, than vPET in heavy-duty applications, especially in the context of the material outperforming vPET in strength tests post-normalisation. Another potential use for rPET, assuming the improved elongation at break trend was reproduced in a twill weave structure and other specification requirements were met, could lie in a car safety-belt.

The author tentatively proposes a positive result in favour of rPET, pending repeat experiments – but is encouraged by rPET's surprising results: with mention to Maximum Breaking Force, where it was expected to underperform. Small sample size may have generated extremely favourable results. The strongest conclusion that can be drawn from these results in terms of performance is that rPET has the potential to perform on a comparative level to vPET.

6.2 VIABILITY OF BUSINESS STRUCTURE

6.2.1 SOCIALLY

Collected data is inconclusive on whether a profitable ocean-waste-to-textile business structure could provide lasting job stability or financial benefit for those in the fishing industry, and the research is insufficient to form an accurate estimation of its future impact. This is due to the passive nature of litter collection, unlikely to require additional labour or working hours and placing excess profits under individual fisheries' discretion. This uncertainty is further increased when considering that plastic waste is also a non-renewable resource.

However, the research does suggest a likelihood of increased job satisfaction and well-being for those involved in environmentally beneficial schemes, with the effects felt most strongly by those in onboard positions, for whom the working environment would see a significant improvement.

One uncertain, but potential benefit, of the scheme is an improvement in public perception of the fishing industry, which could improve long-term stability for the industry as a whole. A response to issues such as contamination of fish and water systems could quell public and internal fears.

6.2.2 ENVIRONMENTALLY

In addition to benefitting eco-systems through removal of waste, the recycling process theoretically diverts plastic from landfill or incineration. Further primary assessment of the impact of recycling on human health and the environment is needed, but at present it presents an optimistic and profitable solution to the ocean plastic problem.

This business model ranks favourably in environmental impact when compared with vPET production but faces competition from organic fibre methods, and more in-depth and periodic research is required into the effects of the rPET production cycle. There is also no guarantee that rPET will achieve enough commercial success to compete with vPET demand, and therefore may not decrease PET production rate.

Evidence is insufficient to support a conclusion on whether a closed-loop production system is achievable, but trends point positively in favour of this suggestion, and if rPET is re-assessed and proven to have further functioning lives (post first recycling phase) at performance levels equivalent to that discussed in Chapters 4 and 5, a solid case can be built.

6.2.3 *COMMERCIALLY*

With findings establishing that micro-plastics are a “hot topic” (McLellan, 2018) and a strong media campaign surrounding ocean waste currently in place, the fishing industry is arguably presented with opportune timing to capitalise on the proposed business venture. This work has generated local press attention, a fortunate achievement at undergraduate level, and the author confidently suggests that this idea could benefit from a higher national – perhaps even international – level of press attention if it were operated commercially. Optimistic predictions also include the interest of investors and sponsors.

Logistically, the project would be limited by a lack of existing UK recycling infrastructure.

Establishing the ocean-waste-to-textile production model in the UK would also benefit from current sentiments, with Brexit seeing a drive towards “Made in

Britain”, as discussed in Chapter 2. One significant limitation is an established lack of established recycling infrastructure; however, this industry also faces demands for change as exports to China are being restricted.

6.2.4 OVERALL

The results obtained in this work alone are insufficient to confidently propose a business model or build necessary logistics to construct a strategy. Further investigation and repetition of method is necessary, but there does remain a very tentative -but positive- confirmation that if successfully put in place, deploying the UK fishing industry to source and collect PET waste for recycling by private firms into textiles does pose future possibilities and may have the potential to achieve mutual benefit for consumers, fishing industry employees and local ecosystems alike.

7 Chapter 7 Recommendations

As discussed in Chapter 6, this work is insufficient to reach a full conclusion and study all parameters affecting the viability of an rPET-from-ocean-waste business in the UK but, when strengthened with further research, may potentially inform a successful proposal.

Given the small sample size in both survey and lab tests, the author encourages the repeating and extending of these methods to achieve further reach and accuracy in results, suggesting a body with considerable resources and time for research.

There is much room for building on the preliminary environmental assessment attempted in this work. A comparative study between rPET and vPET would benefit from collaboration with willing manufacturing partners, controlling and

investigating the production processes in each to accurately rank the two. Such work would also enable a cost-analysis of the proposed business venture in this work.

There is also a lack of existing insight into the impact of rPET during the post-purchase phase, which results in an incomplete life cycle assessment. In addition to investigating 1st stage rPET (PET recycled once) and its end-of-life (surveying how much rPET is re-purposed further versus disposed of), there is a need to review rPET performance during 2nd recycling phase and further, to determine if the product retains its usefulness. Whether through consumer behaviour or loss of functionality, rPET is hindered in its viability as a sustainable fibre if recycling leads merely to a delay in the original material's journey to landfill, without any impact on overall landfilling.

Consumer perceptions of recycled products could be charted over a future period to determine whether this “green label” increases or decreases perceived product value.

Regarding the fishing industry, the situation may require re-evaluation post-Brexit as, although findings are inconclusive on whether positive or negative, a certainty is that Brexit will have a substantial impact on this industry.

The author also welcomes collaboration on a potential future project investigating whether an equivalent rPET material to that tested in this work could be re-purposed as a waste collection bag for KIMO UK. Research would follow similar themes of investigating potential local production, existing infrastructure (this time, of the textile industry) and would also necessitate further lab testing to

evaluate rPET characteristic relevant to salt-water applications, including basic factors such as moisture permeability.

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School of Textiles and Design
Research Ethical Guidelines

In keeping with directives from the European Union and from the UK Government, universities are required to put in place ethics procedures and guidelines for research. In addition, research councils ask for formal ethics approval of proposals in some of their funded programmes.

Heriot-Watt University has established a University Ethics Committee to guide schools, monitor procedures and ensure appropriate ethical issues are being considered. The committee has asked schools to submit ethical approval procedures relevant to their research activities. At the School of Textiles and Design, Ethical Approval must be sought using this form. The Director of Research approves most requests on presentation of the form (with supporting documents where applicable). In a limited number of cases granting of approval may have to be referred to the School Research Committee (or part thereof). Where there are more serious concerns applications will be referred to the University's Ethics Committee.

This note outlines the context and provides a standard protocol for ethics approval for research proposals.

General Ethical Principles

- No field of human activity can be considered exempt from ethical concerns. Increased accountability has led to systems of research governance to ensure that research methods and information are open to public scrutiny and can be seen to be subject to the highest ethical standards.
- Research should conform to generally accepted moral and scientific principles. There are:
 - a) Obligations to society:- for example, conforming with responsible, moral and legal practice; maintenance of high scientific standards and impartial assessment and dissemination of findings.
 - b) Obligations to funders and employers:- the relationship between researchers, funders, and employer should be clear and balanced without compromise to morality, the law or professional integrity.
 - c) Obligations to colleagues:- the maintenance of standards and appropriate professional behaviour with methods, procedures and findings open to review.
- Breaches of these principles include areas of research misconduct such as fabrication, falsification and plagiarism.
- The well-being of all involved in research is of central concern in ethical considerations. All staff are therefore obliged to comply with health and safety

Appendix A: Ethics Forms

guidelines and to carry out a risk assessment of the research whatever its nature (for example, laboratory work, field work, testing of participants).

Ethical principles for research involving human participants

One major obligation on the part of researchers which is not included in the above list is to the participants who are involved in research. Social researchers must strive to protect participants from undue harm arising as a consequence of their participation in research. This requires that their participation should be voluntary, and as fully informed as possible. At the same time, no group should be disadvantaged by routinely being excluded from consideration. Participants should also be aware of their entitlement to refuse to participate at any stage for whatever reason, and to withdraw data just supplied. Special considerations should be given to studies requiring informed consent from vulnerable participants. Such groups include children, those with an intellectual disability and those in a dependent relationship to the researcher or commissioning body (for example, students in the University or patients in a hospital).

a) For interviews / focus groups:

- All participants must be fully informed of the nature of the research and give informed consent prior to interview.
- Participants must be given a plain language statement of the nature and purpose of the research.
- It is generally preferable not to identify individual participants but, if the identification of participants is necessary, participants must be informed of this, and of safeguards to ensure that this information is restricted to the researcher or a specific research group.
- No interview should be recorded without the permission of the participant.
- Interviews by telephone must meet the same conditions as face-to-face interviews.
- Written parental consent is required for interviews with participants under age 18 (16 in Scotland), unless such interviews take place in the presence of a parent or guardian or in an institutional setting where the institutional consent has been given.

b) Questionnaires: All written questionnaires must have an opening statement informing the participant of the nature and purpose of the research. If a questionnaire contains any questions likely to cause offence to the respondent, this should be clearly indicated on the front cover, so that the participant may decide not to read on. Completion of the forms shall indicate evidence of informed consent. Please provide a copy of your proposed questionnaire.

c) Observational methods: Where behaviour patterns are observed without the participants' knowledge, researchers should take care not to infringe the privacy of an individual or group. Where practical, an attempt should be made to obtain consent *post hoc*. Cultural variations in what constitutes public and private space should be acknowledged.

Appendix A: Ethics Forms

d) Photography: Photographing human participants in publicly accessible spaces is a legitimate research tool. However; if prejudicial to the participants' interests or reputation, identifying features of the participant must be obscured.

e) Experimental or field testing of participants: Ethical requirements for this situation are the same as for those applying to participant interviews.

f) Withholding information from participants: If it is essential to the design of an experiment, questionnaire or interview that some information about its purpose is withheld from participants (e.g. because this knowledge would influence their behaviour), then full information must be provided when participants are debriefed and they must be given the opportunity to withdraw their data. Experiments of this kind should not be conducted if it is likely that participants will react to debriefing with discomfort, anger or objections.

More detailed reference documents are available which provide useful further guidance on these issues, notably, the Social Research Association's *Ethical Guidelines*, <http://the-sra.org.uk/wp-content/uploads/ethics03.pdf> and the British Psychological Society ethical code at

http://www.bps.org.uk/system/files/documents/code_of_ethics_and_conduct.pdf

Appendix A: Ethics Forms
School of Textiles and Design
Protocol for Ethics Approval

1. Title of research:

Investigative study into the viability of recycled PET fibres as a sustainable alternative to current industry standards

2. Purpose of study:

To compare the performance standards of recycled PET-based fabrics with market-dominating fibres, eg. cotton, and to investigate potential socio-economic benefits of commercialising this market on fishing communities hit by unemployment/fishing quotas.

3. Is ethical approval required by another body linked to the research?

No

If YES please attach copies of the approval given to the other body, and confirmation that no changes have been made to the protocol since approval was granted

4. Is permission required from another body to use data or research materials?

No

If YES please attach copies

5. Does the research involve the use of human subjects:

Yes

If YES what is the nature of the research e.g. focus group, questionnaire, etc

Focus group selected from fishing communities, telephone interviews with suppliers, email exchange with suppliers, etc. May involve consumer questionnaires to determine commercial credibility.

Will also involve written/online (identical) surveys of fishermen who are unavailable for a focus group as yet. Also: live interview with harbour masters and coordinator of Fishing for Litter programme (NGO), as well as observation and shadowing of their work for one day.

If NO please go to Q.13

Appendix A: Ethics Forms

N.B. The researcher should have considered the use of secondary data sources and should be clear that the aims of research cannot be met without new primary research involving people.

6. Is written consent to be obtained?

Yes, for focus groups/interviews

If YES please attach a copy of the consent and information form or indicate when it will be supplied.

If NO please justify.

7. How long will a subject have to decide whether to take part in the study.

Time in days: 7

If less than 1 day, please comment.

(Note that it is common in the case of face to face interviews not to give significant advanced notice. This is acceptable in view of maximising the response rates and reliability of some survey based research.)

8. Will any of the subjects be from one of the following vulnerable groups?:

- Children under 18 (16 in Scotland)
- People with learning difficulties
- Patients in hospital
- Other vulnerable groups (e.g. mental illness, dementia)

No

9. If any 'yes' box in question 8 is ticked, what special arrangements have been made to deal with issues of consent for the subjects (e.g. consent from parents, professional carer, relevant institution, etc).

10. Are there any potential physical, psychological or disclosure dangers that can be anticipated from involvement in the research?

If yes, please give details.

applicable. Data stored according to the Data Protection Act and anonymity given by full omission of names unless participants have volunteered to have names shared.

12. Does the study design involve actively deceiving participants?

No

If yes, briefly describe the nature of the deception and explain why it is necessary

13. Does the research project comply with the requirements of current Data Protection legislation (for example, data storage and security.), including in relation to the use and (non) disclosure of secondary data sets?

Yes

14. Is your risk assessment of the health and safety implications for staff of the research High/Medium/Low or negligible:

Low/negligible

If medium or high please ensure that the health and safety officer in the School is informed.

Please sign the following:

I as a Principal Investigator have checked the above for accuracy and am satisfied the information provided is a true reflection of the intended study.

Name (please print) HAYLEY McCULLOUGH

Signature Hayley McCullough

Date 01.02.2018

My Supervisor is:

Name (please print) DANMEI SUN

Signature Danmei Sun

Date 01.02.2018

I am satisfied that the researcher has properly considered the ethical implications of the intended study and has taken appropriate action.

S. Thomas (Ethics Officer)
Date 08.02.2018

Appendix B: Fishing Survey Paper Format

My name is Hayley McCullough. I'm doing some research towards my final year project, as a student at Heriot Watt university. I'd really appreciate your response to the following questionnaire, as someone employed in the fishing industry. The questionnaire should take no longer than 10 minutes, and will be useful in my end research. Questions are either multiple choice (e.g., q1) or ask for you to select a response on a scale (e.g. "positive effect", negative effect", like in q4) for multiple options.

All information will be anonymous and stored according to the Data Protection Act. You are under no obligation to answer all questions. By starting this survey you are agreeing to take part in this research and have your answers used.

1. Please tick your **age group/sex** for surveying purposes.

16-25	Male
26-35	Female
36-45	Other
46-55	
56+	

2. Do you **work in the fishing industry (or are retired)**? If yes, please state job title and area of the UK/Ireland that you work in (or worked in) in the boxes below.

Yes	Job Title:	
No	Area in UK/Ireland:	

3. Please select the **main species** you deal with in your work.

Creel	
White fish	
Other (please state)	

4. Do you feel that any of the following are having a current positive or negative **effect on your work in the fishing industry**? Please select one option for each on a scale of "strong positive" to "strong negative" effect.

	Strong positive effect	Some positive effect	No effect	Some negative effect	Strong negative effect	Not sure
Catch quotas						
Availability of species you work with						
Availability of fish/creel overall in UK						
Developments in technology						
The fashion/textile industry						
The recycling industry						

5. Do you feel that any of the following pose a **potential future threat/risk to, or positive opportunity** for, the fishing industry, thinking about your own line of work in particular?

	Strong opportunity	Some opportunity	No effect	Some threat	Strong threat	Not sure
Brexit						
Change in number of fish						
Increase in vegan lifestyles						
The fashion/textile industry						
The recycling industry						

Appendix B: Fishing Survey Paper Format

6. If you were to find yourself **out of work due to declining fish/creel numbers**, how would you feel about the following prospects?

	Optimistic	Neutral	Pessimistic
Finding another job in the same area, in the fishing industry			
Re-locating to find another job in the fishing industry			
Re-training in another area outside of fishing			
Finding another job immediately outside of fishing			
No longer feeling part of fishing culture			

7. How much do you experience the following in your work?

	Daily	Often	Rarely	Never
Ocean waste interference, e.g. plastic in nets				
A sense that the number of fish/creel is in decline				

8. Are you aware of **companies using recycled plastic waste to create textile products**, such as fabrics for clothing/bags? Tick one option.

Yes, I am aware and actively involved in supplying this type of programme	
I am aware of this and how the fishing industry can get involved	
I am aware of the recycling technology but not how it relates to my work	
I have a little awareness of this	
I am not aware of this	

9. Would you be interested in the idea of **fishing for plastic waste, to be sold to private companies** for creating textiles and other products? Tick one option.

I am already involved in this kind of project.	
Yes, I would be interested in this.	
I'm unsure.	
I would not be interested in this.	

10. And finally, would each of the following attract you to, or put you off the **idea of fishing for plastic waste to be recycled?**

	Attracts me	Neutral	Puts me off
The feeling of helping the environment			
Current and future fish numbers			
Amount of plastic waste that you see in your daily work			
Ease of sorting the (plastic) material at catch stage			
Supplying companies in new sectors (e.g. textiles)			
Fishing quotas/regulation			
Brexit			
Health and safety			
The enjoyment of the job			
Long term job stability			

Thank you so much for taking the time to respond!

If you'd consider taking part in a **focus group** at a later date (i.e., an hour-long directed discussion over a pint with myself and other fishing industry workers in your area) to help with my research in more detail, please leave your name and contact details below.

Name:	
Phone number:	
Email address:	

Appendix B: Fishing Survey (Online Format)

Figure 1 Opening Screen with Disclaimer

The screenshot shows a web browser window for a secure survey at <https://www.surveymonkey.co.uk/r/XCBXK5Z>. The title bar reads "Fishing Questionnaire 2018". The main content area starts with a "Welcome to My Survey" message. Below it is a text block about the researcher's name, Hayley McCullough, and her research project at Heriot Watt University. It states that the questionnaire will take no longer than 10 minutes and will be useful for end research. Questions are either multiple choice or ask for a response on a scale. A disclaimer follows, stating that all information will be anonymous and stored according to the Data Protection Act. It also mentions that by starting the survey, the participant agrees to take part in the research and have their answers used. A note indicates there are 10 questions in total and encourages leaving contact details in the last question if interested in a focus group. An "OK" button is present at the bottom left, and a progress bar at the bottom center shows 0 of 10 answered.

Figure 2- Informed Consent Statement and Agreement

The screenshot shows the continuation of the survey. The title bar remains "Fishing Questionnaire 2018". A text block reiterates the informed consent statement: "All information will be anonymous and stored according to the Data Protection Act. By starting this survey you are agreeing to take part in this research and have your answers used." Below this is a question numbered 1: "Please tick one circle which matches your age group and sex for surveying purposes." It includes three radio button options: "Male" (16-25), "Female", and "Other". An "OK" button is located at the top left of the question area, and a progress bar at the bottom center shows 0 of 10 answered.

Fishing Questionnaire 2018

All information will be anonymous and stored according to the Data Protection Act. By starting this survey you are agreeing to take part in this research and have your answers used.

- 1 Please tick one circle which matches your age group and sex for surveying purposes.

	Male	Female	Other
16-25	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26-35	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
36-45	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
46-55	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
56+	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- 2 Do you work in the fishing industry (or are retired)? If yes, please state your **job title and area of the UK/Ireland** that you work in (or worked in), in the boxes below.

Yes/no:

Job Title:

Area of the
UK/Ireland:

- 3 Please select the main species that you deal with in your work.

- Creel
- White fish
- Other (please state):

(4) Do you feel that any of the following are having a current positive or negative **effect on your work in the fishing industry?** Please select one option for each on a scale of "strong positive" to "strong negative" effect.

	Strong positive effect	Some positive effect	No effect	Some negative effect	Strong negative effect	Not sure
Catch quotas	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Availability of species you work with	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Availability of fish/creel overall in UK	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Developments in technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The fashion/textile industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The recycling industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(5) Do you feel that any of the following pose a **potential future threat/risk, OR a positive opportunity for the fishing industry**, thinking about your own line of work in particular?

	Strong (positive) opportunity	Some opportunity	No effect	Some threat	Strong (negative) threat
Brexit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Change in number of fish available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increase in vegan lifestyles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The fashion/textile industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The recycling industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

(6) If you were to find yourself **out of work due to declining fish/creel numbers**, how would you feel about the following prospects?

	Optimistic	Neutral	Pessimistic
Finding another job in the same area, in the	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Optimistic	Neutral	Pessimistic
Re-locating to find another job in the fishing industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Finding another job immediately outside of fishing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
No longer feeling part of fishing culture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7) How much do you experience the following in your work?

	Daily	Often	Rarely	Never
Ocean waste interference, e.g. plastic in nets	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A sense that the number of fish/creel is in decline	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8) Are you aware of **companies using recycled plastic waste to create textile products**, such as fabric for clothing/bags? Tick one option.

- Yes, I am aware and actively involved in supporting this type of programme
- I have a little awareness of this
- I am not aware of this
- I am aware of this and how the fishing industry can get involved
- I am aware of the recycling technology but not how it relates to my work

Feel free to give more detail below.

9) Would you be interested in the idea of **fishing for plastic waste, to be sold to private companies** for creating textiles and other products?

Tick one option

- I am already involved in this kind of project.
- Yes, I would be interested in this.
- I'm unsure
- I would not be interested in this

If interested/uninterested, please explain your reasoning below.

- 10** And finally, would each of the following attract you to, or put you off the idea of **fishing for plastic waste to be recycled?**

	Attracts me	Neutral	Puts me off
The feeling of helping the environment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Current and future fish numbers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Amount of plastic waste that you see in your daily work	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ease of sorting the (plastic) material at catch stage	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Supplying companies in new sectors (e.g. textiles)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fishing quotas/regulation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Brexit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Health and safety	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The enjoyment of the job	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Long term stability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Thank you so much for your time. If you'd consider taking part in a focus group at a later date (basically, a group discussion - maybe over a pint - with myself and other fishing industry workers in your area) to help with my research in more detail, please leave your name and phone number and/or email address in the box below.



Plain Language Statement - Interview

I am Hayley McCullough, a BSc Fashion Technology student of Heriot Watt University in the School of Textiles and Design, in Scotland.

I am doing research with regard to the viability of using recycled PET fibres as an alternative mass market for the fabrics used in the garment industry.

I would like to invite you to take part in this research work by **participating in an interview regarding your organisation's role in plastic waste management and the possible future developments of this market**. The research will be conducted in person for approximately 20 minutes.

The interviews will be digitally recorded, and I may take notes. This research has received ethics approval from the School Ethics Officer.

Participants' information is confidential and I will anonymise all of your answers, unless you wish to be recognised and it is appropriate. All answers collected will be shared only with the project supervisor and marker. You have the right to withdraw your name or withdraw completely without giving reason and at any time prior to the publication of the research in April of 2018.

Contact for further information:

Researcher: Hayley McCullough, hcm1@hw.ac.uk / +44 (0)7922921660

Signature:

Date: 14/03/18

Supervisor: Dr Danmei Sun, d.sun@hw.ac.uk / +44 (0)1896892138

Signature:

Date: 14/03/18

Informed Consent Form – Interview

You are invited to participate in a research project.

This work is being carried out as part of the Honours year dissertation research of Hayley McCullough from the School of Textiles and Design at Heriot Watt University, Scotland. I am exploring the viability of alternative fibre types for fabrics which can be sourced from the ocean – in particular, recycled PET.

The **interview** will be on **your organisation's role in plastic waste management and the possible future developments of this market**. I will take notes and record the interview digitally. This research has received ethics approval.

The length of the **interview** will be approximately **20 minutes**. You will be under no obligation to answer any of the questions.

Your information is confidential and your answers will be anonymous, unless you wish to be recognised. All data will be collected and stored in accordance with the UK Data Protection Act, 1998. You have the right to withdraw without giving a reason and prior to the publication of the research before April 2018.

Participant

I have been fully informed as to what this research will entail, and am aware of my right to withdraw at any time. I hereby fully and freely consent to participation in the interview, which has been fully explained to me.

Participant signed _____

Contact details _____

Postcode _____

Date _____

Contact for further information:

Researcher: Hayley McCullough, hcm1@hw.ac.uk / +44 (0)7922921660

Supervisor: Dr Danmei Sun, d.sun@hw.ac.uk / +44 (0)1896892138

FAST-1 Test Results					
SAMPLE	FABRIC THICKNESS AT		DIFFERENCE	% DECREASE	
	2gf/cm2	100gf/cm2			
V-F1	1.305	0.599	0.706	54.0996169	
V-F2	0.941	0.567	0.374	39.7449522	
V-F4*	0.837	0.583	0.254	30.3464755	
V-F5*	0.879	0.593	0.286	32.5369738	
V-F3	1.148	0.594	0.554	48.2578397	
V-F6	1.073	0.612	0.461	42.9636533	
average	1.11675	0.593	V-PET AVG	0.593	46.2665155 46.27 %
STEDV	0.151895523	0.01892089	STEDV	0.018920888	6.29186077
ST ERROR	0.075947762	0.00946044	ST ERROR	0.009460444	3.14593039
			DIFFERENCE	% DECREASE	
R-F1	1.122	0.621		0.501	44.6524064
R-F2	1.314	0.589		0.725	55.1750381
R-F4*	0.783	0.583		0.2	25.5427842
R-F3	1.063	0.582		0.481	45.2492944
R-F5	1.082	0.616		0.466	43.0683919
R-F6	1.066	0.599		0.467	43.8086304
average	1.1294	0.6014	R-PET AVG	0.528	46.3907522 46.39 %
STEDV	0.105838556	0.01683152	STEDV	0.111031527	4.97980625
ST ERROR	0.047332441	0.00752728	ST ERROR	0.049654808	2.22703706

* = Extreme, possibly inaccurate: discounted

V-PET		FAST-2 Bending Meter Results -Weight Normalised			
SAMPLE	BENDING LENGTH (MM)	Weight 300 SAMPLE WARP	R-PET	BENDING LENGTH (MM)	Weight 315
V-A1	13	43.3333 R-A1		17	53.968
UNDERSIDE	11	36.6667 UNDERSIDE		16	50.794
V-A2	13.5	45.0000 R-A2		16	50.794
UNDERSIDE	17.5	58.3333 UNDERSIDE		17	53.968
V-A3	14.5	48.3333 R-A3		14	44.444
UNDERSIDE	12.5	41.6667 UNDERSIDE		15.5	49.206
V-A7	13	43.3333 R-A7		14	44.444
UNDERSIDE	12	40.0000 UNDERSIDE		9.5	30.159
V-A8	14	46.6667 R-A8		16.5	52.381
UNDERSIDE	14.5	48.3333 UNDERSIDE		13.5	42.857
V-PET WARP AVG	13.55	45.1667 R-PET WARP AVG		14.9	Avg 47.302
ST DEV	5.9030				ST DEV 7.2469
ST ERROR	1.8667				ST ERROR 2.2917
WEFT					
V-A4	17	56.666667 R-A4		16	50.794
UNDERSIDE	14	46.666667 UNDERSIDE		14.5	46.032
V-A5	18.5	61.666667 R-A5		19.5	61.905
UNDERSIDE	16	53.333333 UNDERSIDE		14	44.444
V-A6	15	50.000000 R-A6		20 REPEAT	17.5 55.556
UNDERSIDE	14.5	48.333333 UNDERSIDE		11.5 REPEAT	14.5 46.032
V-A9	14.5	48.333333 R-A9		15.5	49.206
UNDERSIDE	12	40.000000 UNDERSIDE		15	47.619
V-A10	12.5	41.666667 R-A10		13.5	42.857
UNDERSIDE	10.5	35.000000 UNDERSIDE		10.5	33.333
V-PET WEFT AVG	14.45	48.166667 R-PET WEFT AVG		15	Avg 47.778
ST DEV	7.952405				ST DEV 7.6106
ST ERROR	2.514771				ST ERROR 2.4067

FAST-3 Extension Meter Results			
SAMPLE	EXTENSION % at		
	5 gf/cm2	20 gf/cm2	100 gf/cm2
v-PET WARP			
V-S1	0.0	0.1	0.3
V-S2*	0.0	1.9	2.6
V-S3	0.0	0.0	0.3
V-S7	0.1	0.3	0.5
V-S8	0.3	0.5	0.5
V-PET WARP AVG	0.1	0.2	0.4
ST DEV	0.1	0.2	0.1
ST ERROR	0.1	0.1	0.1
v-PET WEFT			
V-S4	0.0	0.0	0.1
V-S5	0.0	0.0	0.1
V-S6	0.0	0.0	0.1
V-S9	0.0	0.1	0.2
V-S10	0.0	0.0	0.1
V-PET WEFT AVG	0.0	0.0	0.12
ST DEV	0.0	0.0	0.0
ST ERROR	0.0	0.0	0.0
r-PET WARP			
R-S1	0.1	0.4	0.5
R-S2	0.2	0.5	0.9
R-S3	0.0	0.1	0.4
R-S7	0.2	0.2	0.3
R-S8	0.1	0.1	0.3
R-PET WARP AVG	0.1	0.3	0.5
ST DEV	0.1	0.2	0.2
ST ERROR	0.0	0.1	0.1
r-PET WEFT			
R-S4	0.0	0.0	0.1
R-S5	0.0	0.1	0.2
R-S6	0.0	0.1	0.2
R-S9	0.0	0.1	0.2
R-S10	0.0	0.0	0.1
R-PET WEFT AVG	0.0	0.1	0.2
ST DEV	0.0	0.1	0.1
ST ERROR	0.0	0.0	0.0
* =	Extreme, possibly inaccurate: discounted		

BENDING RIGIDITY									
Sample	Mass	Avg bending length cubed	Bending length cubed X MASS	9.8	0.000001	Result			micro newton s per metre
rPET weft	315	15	3375	1063125	10418625	10.418625	10.42	μN.m	
vPET warp	300	13.55	2487.813875	746344.1625	7314172.79	7.3141728	7.31	μN.m	
vPET weft	300	14.45	3017.196125	905158.8375	8870556.61	8.8705566	8.87	μN.m	
R-A1	315	17	4913	1547595	15166431	15.166431	15.17	μN.m	
UNDERSIDE	315	16	4096	1290240	12644352	12.644352	12.64	μN.m	
R-A2	315	16	4096	1290240	12644352	12.644352	12.64	μN.m	
UNDERSIDE	315	17	4913	1547595	15166431	15.166431	15.17	μN.m	
R-A3	315	14	2744	864360	8470728	8.470728	8.47	μN.m	
UNDERSIDE	315	15.5	3723.875	1173020.625	11495602.1	11.495602	11.50	μN.m	
R-A7	315	14	2744	864360	8470728	8.470728	8.47	μN.m	
UNDERSIDE	315	9.5	857.375	270073.125	2646716.63	2.6467166	2.65	μN.m	
R-A8	315	16.5	4492.125	1415019.375	13867189.9	13.86719	13.87	μN.m	
UNDERSIDE	315	13.5	2460.375	775018.125	7595177.63	7.5951776	7.60	μN.m	
rPET Warp AVG	315	14.9	3307.949	1042003.935	10211638.6	10.211639	10.21	μN.m	
						ST DEV			
						ST ERROR			
R-A4	315	16	4096	1290240	12644352	12.644352	12.64	μN.m	
UNDERSIDE	315	14.5	3048.625	960316.875	9411105.38	9.4111054	9.41	μN.m	
R-A5	315	19.5	7414.875	2335685.625	22889719.1	22.889719	22.89	μN.m	
UNDERSIDE	315	14	2744	864360	8470728	8.470728	8.47	μN.m	
R-A6	315	17.5	5359.375	1688203.125	16544390.6	16.544391	16.54	μN.m	
UNDERSIDE	315	14.5	3048.625	960316.875	9411105.38	9.4111054	9.41	μN.m	
R-A9	315	15.5	3723.875	1173020.625	11495602.1	11.495602	11.50	μN.m	
UNDERSIDE	315	15	3375	1063125	10418625	10.418625	10.42	μN.m	
R-A10	315	13.5	2460.375	775018.125	7595177.63	7.5951776	7.60	μN.m	
UNDERSIDE	315	10.5	1157.625	364651.875	3573588.38	3.5735884	3.57	μN.m	
R-PET WEFT AVG	315	15.05	3408.862625	1073791.727	10523158.9	10.523159	10.52	μN.m	
V-A1	300	13	2197	659100	6459180	6.45918	6.46	μN.m	
UNDERSIDE	300	11	1331	399300	3913140	3.91314	3.91	μN.m	
V-A2	300	13.5	2460.375	738112.5	7233502.5	7.2335025	7.23	μN.m	
UNDERSIDE	300	17.5	5359.375	1607812.5	15756562.5	15.756563	15.76	μN.m	
V-A3	300	14.5	3048.625	914587.5	8962957.5	8.9629575	8.96	μN.m	
UNDERSIDE	300	12.5	1953.125	585937.5	5742187.5	5.7421875	5.74	μN.m	
V-A7	300	13	2197	659100	6459180	6.45918	6.46	μN.m	
UNDERSIDE	300	12	1728	518400	5080320	5.08032	5.08	μN.m	
V-A8	300	14	2744	823200	8067360	8.06736	8.07	μN.m	
UNDERSIDE	300	14.5	3048.625	914587.5	8962957.5	8.9629575	8.96	μN.m	
V-PET WARP AVG	300	13.55	2487.813875	746344.1625	7314172.79	7.3141728	7.31	μN.m	
V-A1	300	13	2197	659100	6459180	6.45918	6.46	μN.m	
UNDERSIDE	300	11	1331	399300	3913140	3.91314	3.91	μN.m	
V-A2	300	13.5	2460.375	738112.5	7233502.5	7.2335025	7.23	μN.m	
UNDERSIDE	300	17.5	5359.375	1607812.5	15756562.5	15.756563	15.76	μN.m	
V-A3	300	14.5	3048.625	914587.5	8962957.5	8.9629575	8.96	μN.m	
UNDERSIDE	300	12.5	1953.125	585937.5	5742187.5	5.7421875	5.74	μN.m	
V-A7	300	13	2197	659100	6459180	6.45918	6.46	μN.m	
UNDERSIDE	300	12	1728	518400	5080320	5.08032	5.08	μN.m	
V-A8	300	14	2744	823200	8067360	8.06736	8.07	μN.m	
UNDERSIDE	300	14.5	3048.625	914587.5	8962957.5	8.9629575	8.96	μN.m	
V-PET WARP AVG	300	13.55	2487.813875	746344.1625	7314172.79	7.3141728	7.31	μN.m	

Fabric Formability						
EXTENSION AT (%)			Difference	X BENDING RIGIDITY EQUALS	Divide By	RESULT FORMABILITY
	5 gf/cm2	20 gf/cm2				
V-PET WARP AVG		0.1	0.2	0.1 7.314172793	0.9142716	14.7 0.0622 mm2
V-PET WEFT AVG		0.0	0.0	0.0 8.870556608	0.17741113	14.7 0.0121 mm3
R-PET WARP AVG		0.1	0.3	0.1 10.21163856	1.4296294	14.7 0.0973 mm4
R-PET WEFT AVG		0.0	0.1	0.1 10.418625	0.6251175	14.7 0.0425 mm5

INTERVAL [RUBS]	MARTINDALE 1 - ABRASION, APPEARANCE AND YARN BREAKAGE												OTHER PHOTOS/NOTES		
	1. V-M1			2. V-M2			3. R-M1			4. R-M2					
	Breakage?	Appearance	Notes		Breakage?	Appearance	Notes		Breakage?	Appearance	Notes		Breakage?	Appearance	Notes
1000	N			N				N				N			
2000	N			N				N				N			
3000	N			N			SOME PILLING - QUITE BAD BUT DOESN'T SHOW UP WELL IN PHOTOS	N			FLUFFINESS, PILLING - SLIGHTLY WORSE THAN VPET	N		FLUFFINESS, PILLING - SLIGHTLY WORSE THAN VPET	
4000	N		SOME PILLING	N				N				N			
5000	N			N				N				N			
6000	N			N				N				N			
SWITCH FROM 1,000 REV INTERVALS TO 2,000 REV INTERVALS															
8000	N			N				N				N			
10000	N			N			VPET STARTING TO CATCH UP R.E. PILLING	N				N		R-PET PILLING VISIBLY MORE	
12000	N			N				N				N		ONE OF WARP YARNS CLOSE TO BREAKING, LOTS OF PILLING	
14000	N			N				N			PILLING V BAD - SOME YARNS LOOK READY TO BREAK	N		PILLING V BAD - SOME YARNS LOOK READY TO BREAK	
16000	N			N				N				N			
18000	N			N				N				N			
20000	N		PILLING BADLY AT WEFT, NO ONE THREAD OF YARN PARTICULARLY UNDER STRAIN THOUGH	N			PILLING BADLY AT WEFT, NO ONE THREAD OF YARN PARTICULARLY UNDER STRAIN THOUGH	N			PILLING VERY BAD AT THIS POINT, ONE OR TWO WEFT YARNS THREATENING TO BREAK IN BOTH R-PET SAMPLES BUT WARP YARNS UNBUDGED	N		PILLING VERY BAD AT THIS POINT, ONE OR TWO WEFT YARNS THREATENING TO BREAK IN BOTH R-PET SAMPLES BUT WARP YARNS UNBUDGED	
SWITCH FROM 2,000 REV INTERVALS TO 5,000 REV INTERVALS															
25000	N			N				N			1 WARP YARN CLOSE TO BREAKING	N		2 WARP YARNS UNDER THREAT	

30000	N	PILLING REALLY CATCHING UP WITH V-PET	N	PILLING REALLY CATCHING UP WITH V-PET	N		N	
35000	N		N		N		N	
40000	N	ON PAR WITH R-PET IN TERMS OF DEGRADATION	N	ON PAR WITH R-PET IN TERMS OF DEGRADATION	N	SLIGHT DISCOLORATION	N	SLIGHT DISCOLORATION
45000	N		N		N		N	
50000	N	VISIBLE LOSS OF COLOUR, DULLNESS	N	VISIBLE LOSS OF COLOUR, DULLNESS	N		N	
SWITCH FROM 5,000 REV INTERVALS TO 10,000 REV INTERVALS								
60000	N	1 YARN THREATENING TO BREAK	N	1 YARN THREATENING TO BREAK	N		N	1 WARP YARN THREATENING TO BREAK
70000	N		N		N		N	1 WARP YARN BROKEN
FINAL RESULT	PASSED		PASSED		PASSED			1 WARP YARN BROKEN, BUT PASSED
								

Q1. Please tick one circle which matches your age group and sex for surveying purposes.			
Age Group	Male	Female	Total
16-24	0	0	0
26-35	6	0	6
36-45	8	0	8
46-55	4	0	4
56+	1	1	2
		Total	20

Q2. Do you work in the fishing industry (or are retired)? If yes, please state your job title and area of the UK/Ireland that you work in (or worked in), in the boxes			
	Yes/No	Job Title	Area in the UK/Ireland
	Yes	Deck Hand	Peterhead
	Yes	Deckhand	Northern Ireland
	Yes	Fishery Officer	UK
	Yes	Fishery Officer	Aberdeenshire
	Yes	Fishery Officer	Peterhead
	Yes	Deeckhand	Irish Sea
	Yes	General Manager	N.W Scotland
	Yes	Deckhand	Northern Ireland
	Yes	Fish biologist	UK
	Yes	Deck hand, engineer	Cornwall
	Yes	deckhand	northern ireland
	Yes	Skipper	Northern Ireland
	Yes	fishery officer	UK
	Yes	Fish biologist	Uk
	Yes	Fisherman	Shetland
	Yes	Manager	Scotland
	Yes	Skipper/ owner	Grimsby
	Yes	owner/diver	
	Yes	Deckboss	
	Yes		
Total	20	19	17

Q3. Please select the main species that you deal with in your work.		
		Comments
Answer	Responde-nts	
Creel	7	Whelks/crab/lobster/scallops shelfish ,lobster, crabs ,whelks
White Fish	8	Mackerel
Other (please state)	5	Scallops/Prawns
Total	20	King scallops, Queen scallops, razors, lobsters

Q4. Do you feel that any of the following are having a current positive or negative effect on your work in the fishing industry? Please select one option for each on a scale of "strong positive" to "strong negative" effect.							
	Strong positive effect	Some positive effect	No effect	Some negative	Strong negative effect	Not sure	Total
Factor							
Catch quotas	1	4	5	8	2	0	20
Availability of species you work with	3	4	2	9	0	2	20
Availability of fish/creel overall in UK	4	4	2	6	1	3	20
Developments in technology	5	12	3	0	0	0	20
The fashion/textile industry	1	2	15	0	0	2	20
The recycling industry	1	3	12	2	0	2	20

Q5. Do you feel that any of the following pose a potential future threat/risk, OR a positive opportunity for the

	Strong opportunity	Some opportunity	No effect	Some threat	Strong threat		Total
Factor							
Brexit	3	5	1	10	1		20
Change in number of fish	4	6	2	6	2		20
Increase in vegan lifestyles	0	2	15	3	0		20
The fashion/textile industry	0	1	19	0	0		20
The recycling industry	1	8	10	1	0		20

Q6. If you were to find yourself out of work due to declining fish/creel numbers, how would you feel about the

	Optimistic	Neutral	Pessimistic	Total
Prospect				
Finding another job in the same area, in the fishing industry	6	6	8	20
Re-locating to find another job in the fishing industry	10	2	8	20
Finding another job immediately outside of fishing	11	3	6	20
No longer feeling part of fishing culture	2	14	4	20

Q7. How much do you experience the following in your work?

	Daily	Often	Rarely	Never	Total
Answer					
Ocean waste interference, e.g. plastic in nets	5	8	7	0	20
A sense that the number of fish/creel is in decline	0	11	6	3	20

Q8. Are you aware of companies using recycled plastic waste to create textile products, such as fabric for

	Answer	P/answer
Actively involved in such a scheme		0
Aware of fishing industry's potential role		4
Aware of idea, but not how it relates to fishing		11
Little awareness		5
No awareness at all		0
	Total	20
Comments		
"fourth element have just released a new range 'ocean positive' clothing that uses recycled plastics and ghost nets		

Q9. Would you be interested in the idea of fishing for plastic waste, to be sold to private companies for creating

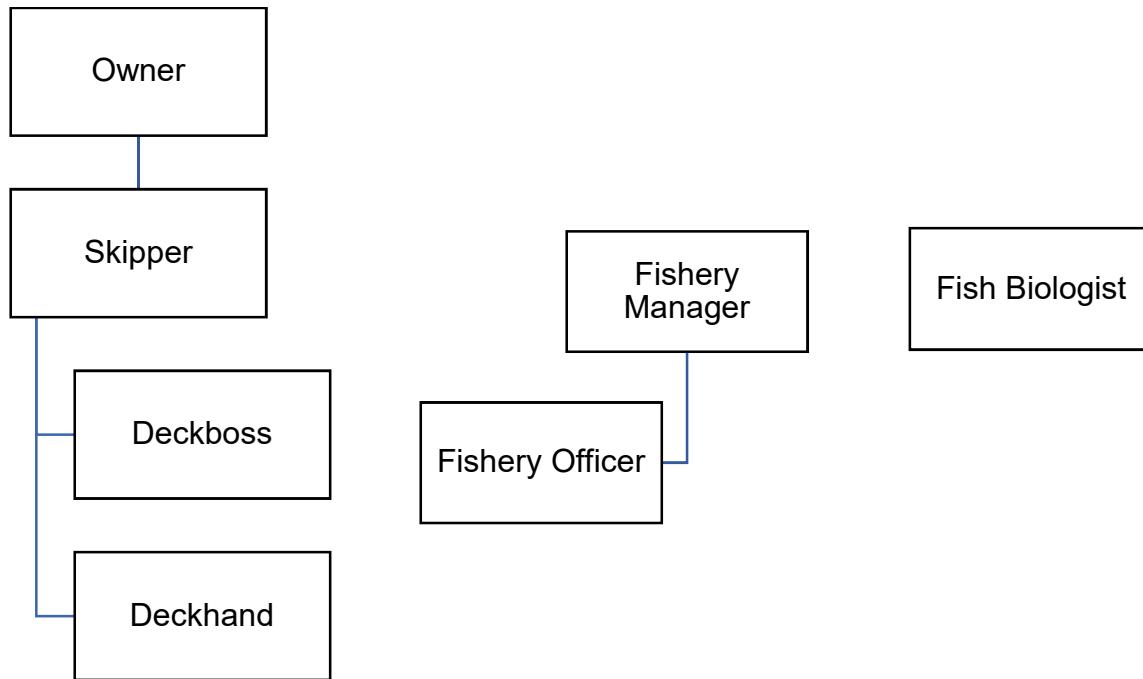
	Answer	P/answer
Already Involved		0
Interested		11
Unsure		6
Not Interested		3
	Total	20
Comments		

"Not sure the monetary benefit to fishermen would be worth the effort"
"The plastic could still be reused thus having to use less common resources globally in an already dwindling stock"
"Unsure how my work can help in this field"
"If alongside fishing - yes. In replacement of fishing - unsure of how profitable it would be for fisheries."
"Kimo already do a fishing for waste scheme, with bins readily available on the dockside. environmental NGO's do not give

Q10. And finally, would each of the following attract you to, or put you off the idea of fishing for plastic waste to				
	Attracts me	Neutral	Puts me off	Total
Factor				
Brexit	3	13	4	20
Ease of sorting plastic at catch stage	5	8	7	20
Fishing quotas/regulation	6	13	1	20
The enjoyment of the job	6	13	1	20
Supplying companies in new sectors	7	11	2	20
Health and safety	7	12	1	20
Amount plastic waste seen at work	11	8	1	20
Current & future fish numbers	13	7	0	20
Long term stability	15	4	1	20
Feeling of helping the environment	17	2	1	20

Appendix G: Hierarchy of Fishing Industry Jobs Mentioned and Job Descriptors

Figure G-1 Hierarchy of surveyed titles: onboard, in-harbour, research



Job Descriptors

Onboard	
Owner	Ship/vessel captain; owns boat and fishing permit.
Skipper	Head of command on ship, may also take owner's position. Charged with charting course, managing boundaries, ordering nets to be released/lifted.
Deckboss	Experienced deck member, deckhands report to Deckboss (usually only on larger fleets).
Deckhand	Largest group, 2 or more per fleet depending on fleet size. Responsible for labour along with deckboss: lowering nets/cages, pulling fish/creel, etc.
In-harbour	
Fishery Manager	Head of command in fishery landwork. Head of administration/finance in smaller fisheries, maintains relationship with harbourmaster.
Fishery Officer	Reports to fishery manager, administration and general running of fishery.
Research	
Fish Biologist	Independent category; researches fish behaviour, illness, etc.



Informed Consent Form – Interview

You are invited to participate in a research project.

This work is being carried out as part of the Honours year dissertation research of Hayley McCullough from the School of Textiles and Design at Heriot Watt University, Scotland. I am exploring the viability of alternative fibre types for fabrics which can be sourced from the ocean – in particular, recycled PET.

The interview will be on **your organisation's role in plastic waste management and the possible future developments of this market**. I will take notes and record the interview digitally. This research has received ethics approval.

The length of the **interview** will be approximately **20 minutes**. You will be under no obligation to answer any of the questions.

Your information is confidential and your answers will be anonymous, unless you wish to be recognised. All data will be collected and stored in accordance with the UK Data Protection Act, 1998. You have the right to withdraw without giving a reason and prior to the publication of the research before April 2018.

Participant

I have been fully informed as to what this research will entail, and am aware of my right to withdraw at any time. I hereby fully and freely consent to participation in the interview, which has been fully explained to me.

Participant signed

A handwritten signature in black ink, appearing to read "Faron Mullan".

Contact details

FARON MULLAN

KIMO UIC

WOODHILL HOUSE, FIBERDEEN

Postcode

AB16 5GB

Date

16/3/18

Contact for further information:

Researcher: Hayley McCullough, hcm1@hw.ac.uk / +44 (0)7922921660

Supervisor: Dr Danmei Sun, d.sun@hw.ac.uk / +44 (0)1896892138

Appendix I: McLellan Interview Notes 18 @ Exmouth Harbour

Interview Draft for Farron McLellan – KIMO UK

1. Please describe what KIMO UK does through its Fishing for Litter scheme.

- a. What are the bags made from?

is harbours in Scotland, 12 in SW(England)
 provide skips
 KIMO pay for disposal
 can mix NB + COTY
 mainly litter
 landfill tax

2. How long have you been involved with this project?

since Jan
 KIMO since 2005

3. How much waste is collected per year/has been so far?

- a. How much of this is plastic?

Since 2005 : 166.02 tonnes
 roughly! 200 Scotland 202 SW Eng
 (Scotland more established)

4. Have you seen an increase/decrease in involvement during your time at KIMO?

- a. What are the factors??

massive increase
 a-sky ocean documentary
 & Blue Planet NO
 EPP Microplastics

2 more nations
 (part of rise
 funding agreement)

5. What do the fisheries give as their key motivations for getting involved?

- a. Quotas
- b. # of fish
- c. Brexit
- d. Pull towards environmental causes
- e. Annoyance at waste

Landing
 charges
 → landfill tax

fish
 to consume
 penalties
 fear of laws
 public pressure

new legislation - may get charged
 PRF directive demands flat charge

Appendix I: McLellan Interview Notes

Interview Draft for Farron McLellan – KIMO UK

6. How do you initiate the process of getting a new fishery on board?

Indiv fisheries companies go thru harbormasters

7. On that note, do you face any difficulties in getting fisheries on board?

- e.g. unwillingness to participate
- difficulty in communication *worst of KIMO*
- something you mentioned on the phone about UK industry being "stuck in its ways"

councils, changing people's minds, education
another thing is work the way they are set in their ways
while / how to change them

Seasonal fleet

8. Who funds KIMO?

(Marine Fisheries Fund KIMO - 9 counties
Sea: EMFF (Marine Scotland Eng Min) 70% member authornies
Cornwall Council + Falmouth 36% in Scotland
+ Aberdeenshire Council 100% in England
+ Plymouth 50%

9. What does KIMO UK do with the waste collected?

- Collection
- Sorting?
- Sell? Or in-house?
 - If in-house, are volunteers needed? What ratio of volunteers to staff
- Recycle?

Landfill waste
Local companies for logistics & funding
councils

Eyemouth, Frank Flanagan's

10. There's quite a lot of work involved in ocean waste management, do you think there is potential here for a commercial model?

completely viable

plastics
one of
biggest (80%)
38% plastic bottles
11%

since April 17 127 tons net

not even all harbours
measures

Appendix I: McLellan Interview Notes

Interview Draft for Farron McLellan – KIMO UK

11. I imagine budgeting might be tight for this kind of project, do you think things would be different if we considered waste a valuable material?

Faron Denmark

3D printing

net recycling
by project

12. What are the biggest challenges involved in organising Fishing For Litter?

- Moving waste?
- Finding willing fisheries?

already
answered

13. What is the biggest challenge you personally face as project coordinator?

KIMO = Connection

Lack of awareness
+ communication
impartial person trying it in

14. You mentioned the landing charges by email as a key challenge for fishermen, are these from the UK GOV?

- Please explain these further – do you consider them a barrier to positive change?

yes + no

needs
more education

15. Do you agree that reform is needed in the UK waste management industry?

CFO

Folder D

Z up to
1st
recording (40 mins)

Appendix I: McLellan Interview Notes

Interview Draft for Farron McLellan – KIMO UK

<p>16. I notice that KIMO lists lobbying as one of its key aims, which current UK policies present the biggest barriers to change right now?</p> <p>WT L.T. financial blockade net - Sanneage & Resincons & legislation on sizing & spacing & materials</p>
<p>17. What, if any, social risks do you consider to be immediately threatening as a result of ocean waste?</p> <ul style="list-style-type: none">a. For fishermenb. For local communities <p>complaints about litter washing up, blamed on Flindunay, esp. gloves pathogens</p>
<p>18. Do you get positive feedback/stories from the fishermen, in terms of..</p> <ul style="list-style-type: none">a. Increased job satisfactionb. Happinessc. Any negative feedback? <p>for when making a difference fed up of all improving their work environment & aids public perception + good feedback from public</p>
<p>19. What do you consider the most immediate environmental challenges from ocean waste?</p> <p>eco system removal of cotton buds plastic bottles single use plastic how people use plastic need to be循環</p>
<p>20. Thinking more positively, what are the next exciting challenges/aims for KIMO in the future?</p> <p>WT recycling in marine many from consumer waste</p>

1. Please describe what KIMO UK does through its Fishing for Litter scheme in the UK.

a. What are the bags made from?

So, Fishing for Litter: we've currently got 18 harbours in Scotland signed up for the scheme. We have 12 down in the South West of England. They're both primarily funded by EU funding [and] by our government and the concept is for when fishermen are out at sea and they're hauling in their nets, they tend to get a lot of litter debris in their nets. That can include anything from big steel cans to small water bottles, so it's a real mix. Currently in the UK and across many countries, they get charged to land that litter, mainly due to the landfill tax. So what we've done at KIMO is we've got funding from many sources – as I've said, mainly the EU – to provide them [the fishermen] with skips where they can land the waste free of charge and then we pay for the disposal of that skip and the waste and it's just a way – for them it's beneficial because catching the same litter over and over again is quite heart-breaking. It also can ruin their nets; as you've seen net repair is a big deal and it's costly, more than anything, if they ruin their nets. Also, of course, they don't want their fish to be eating the plastic and being exposed to this type of pollution so we work with the harbours; we provide hard wearing bags as you've seen today so they're kept at the harbours that are signed up. All fishermen have to do is ask for a bag, that's it. Then they can go off for 7-10 days, however long they're off shore, and then hopefully fill that bag with everything they catch – that isn't fish - and then they can land it safely without charge and they call us to collect as and when. And that's it.

- a. I'm not sure actually, as we have 3 different suppliers - but I could look into that for you if you want. Obviously, that's very relevant to you. They have to be a very hard-wearing bag – I can look it up whilst I answer your questions.

One thing that's been clear in my research of the recycled material so far [regarding the rPET fabric] which could be a benefit here, but is actually a complaint with apparel, is that it's very stiff and quite durable? People don't like hard-wear feeling clothes, but ...

For things like these bags, it would be absolutely perfect!

2. How long have you been involved with this project?

Me personally, I've only been here since January. Fishing for Litter has been around since 2005.

3. How much waste is collected per year, or has been so far?

a. How much of this is plastic?

Since 2005, we've collected 1402 tonnes approximately. I've actually just had some emails saying we've had more. We've had some skips emptied, so that broken down is about 1200 in Scotland and then 200, 202 or something like that in South West England. But that number changes every-time I empty a skip.

Have you any plans for expansion in other areas of the UK, such as Northern Ireland, Wales?

I would like to; we do have associate Fishing for Litter [schemes] – so we don't own the concept as such. We do have associate companies who do fishing for litter; there is some going on in Ireland, Yorkshire as well. Expansion, yes! I almost have daily emails and phone-calls about people wanting to do it so the only issue is the funding process and allowing extra or additional harbours to be signed up and things like that. But currently in Scotland, I have two more harbours about to be signed up: Pittenweem [Kirkcaldy, North East Fife] and Mallaig [West Coast]. They're very keen to get signed up this year and it is part of our funding agreement that we do sign up additional harbours each year and that we do have additional waste each year, things like that. Expansion is extremely important.

4. That answers my next question then: have you seen an increase/decrease in involvement during your time at KIMO?**a. What are the factors??**

Massive increase, massive yeah, especially in the last few months since I've joined: it seems to be that since the Sky Ocean project - the documentary - and also since Blue Planet 2. The media are in an absolute frenzy about plastics – microplastics being the hot topic – and it seems like now is really the time that they're pushing, and everyone wants to do something and this is a very simple way for them to get involved.

So do you think on top of educating consumers, that this [media coverage] has pushed people within the industry -?

Absolutely, yes. It's made them more aware and then when people come across projects like ours they realise [that] they can do it in their day-to-day jobs, not just at home. I get emails from random fishermen, actually, which is great and they ask in the email, "*Where can I get a bag?*" – and my answer to that is, "well, where do you land your fish?" If that's a harbour that is signed up [to Fishing for Litter already] then you just collect a bag from the harbour master, simple as that.

5. It's interesting that you've heard from individual fishermen; what do the fisheries give as their key motivations for getting involved?**Whether it is ..**

- a. Quotas**
- b. Number of fish**
- c. Brexit**
- d. Pull towards environmental causes**
- e. Or an annoyance at waste?**

I think, probably a combination of the annoyance for the amount of waste they collect... I imagine having to throw it back overboard is really quite heart-breaking for most of them, which is I think what originally started Fishing for Litter, that was the main drive. But I think now there's probably a fear of public perception; there's a lot of public pressure now for them to be seen to be doing something. Whether they're environmentally focused or not, I think they want to be seen to be doing something, so that's probably their primary focus.

And that issue, with having to throw things overboard, comes as you've said from the landing charges?

Yes – primarily the landfill tax. Now this might get changed. There's no date as far as we're aware at the moment but there's gonna be a new bit of legislation coming out across ports and harbours in – the PRF directive, it's called - so after Brexit, we don't know if this PRF directive is gonna be applicable to the UK. So, the whole directive is based on removing that charge for landing litter, which is great and it's something I fully support - even though it almost makes Fishing for Litter redundant, there's still a need for enforcing the action to happen. Because even though they [the fishermen] might not get charged, they're not guaranteed to still do it [continue the fishing for litter]. So I see it, with my position at KIMO, even if that does happen – which I would love – I would still play a very active role in making sure it [the removal of ocean waste] is still taking place and that it's gonna be happening. But at this point it's still unsure whether it [the PRF directive] is gonna be coming to the UK because we're leaving the EU. It's all up in the air at the moment.

Is it [the PRF directive] an EU-directed scheme then?

I believe so, yes.

6. How do you initiate the process of getting a new fishery on board – what are the first steps?

In terms of individual fishermen, or a fisheries company, I approach the harbour masters because the harbour masters are aware of who they're dealing with and which people are interested. I've got one harbour who ... they currently only have one fleet who collect litter but they could have a whole lot more and I've spoken to him [the harbour master] about potentially, *how could I do this, how could I make this better?* It's a case of changing people's minds and educating them more than anything, so my plan is quite hands-on. I've even said to Richard [Lawton, Eyemouth Harbourmaster] that I'm really quite keen to come and give a talk and tell them [the fishermen] about Fishing for Litter and not push them but convince them that they should be doing it; it's a passive action, it causes them no extra work but they're benefitting themselves, they're benefitting the environment. Their perception from the public will be improved as well – they've got nothing to lose by doing it but I think it's just a case of changing ... they're very set in their ways as an industry and coming in from an environmental stand-point doesn't always work.

You've mentioned that fishing for litter is a passive act. One of the things which was a motivating factor for fishermen in the Spanish start-up I referred to earlier [during the observation period and interview with Richard Lawton] was the sense that more litter was being caught in the nets than fish; do you think the same applies here [in the UK]?

I think it's the same here, across the world. It probably feels quite good for them [the fishermen] to not have to throw it back over; they never have to catch that bottle again, it's going. There's less frustration and it's more time-effective.

7. You've mentioned reluctance and being viewed in a certain way, being from an environmental background. On that note, do you face any difficulties in getting new fisheries on board?

- a. e.g. unwillingness to participate
- b. difficulty in communication
- c. something you mentioned on the phone about UK industry being "stuck in its ways"

Possibly even just location, from where I am. Also, with this particular harbour that I'm thinking of, that I need to go speak to [about only having one participating fleet and potentially securing more], they have a lot of foreign vessels who won't necessarily hang around to talk. You can't educate them, so that is a big issue. Some fleets are seasonal, so they'll fish in one area for part of the year, then they'll go somewhere else – somewhere which may not be a fishing for litter harbour, for example. So that's also an issue; not every fleet is in one harbour all the time. In the south west of England actually, I've spoken to our coordinator down there; she's got foreign vessels down there that land at our fishing for litter harbours who don't land litter because they don't know about KIMO. But the thing is, often their home countries are actually members of KIMO, and for me, I feel that they should be getting this education at home. So that's something I'm keen to bring up at the next meeting with the other coordinators, "you've got fishermen coming from your country to ours who don't know about fishing or litter." And they could be part of it. Maybe they do Fishing for Litter in their home country and don't realise it's here, maybe it's just a communication thing?

How many countries participate overall in KIMO?

Very good question – I feel like it's about 6 or 7 maybe more. I can give you an exact figure in a second: so it's mainly north west Europe, that's where it started.
She consults laptop

We've got 9 [countries] at the moment and we've got more than 70 member authorities: mainly local councils in each member country. Then we'll have a national coordinator in each – like myself, representing the UK.

Is that another challenge, then: collating everything across all the different local councils? You mentioned a lot on the drive here about getting the local councils on board, how this can help the overall effort. What are the difficulties you face in recruiting another council onto the board?

I think trying to convince them that KIMO is worth their while, worth the financial investment as well [is the challenge]. We do have many councils who have Fishing for Litter harbours in their area but they aren't necessarily a member of KIMO. The two aren't exclusive; they can still be a part of Fishing for Litter without having to be a member of KIMO. However, the benefit of being a member of KIMO is that they [the participating councils] have a say in what happens and that's really been quite a big part of the membership, I feel. It's not just Fishing for Litter; they can have a say in all the other things they have concerns with, regarding the marine environment. It offers a lot more than I think they realise. Potentially, they may not be aware of us, I think there are some councils who have Fishing for Litter harbours [in their constituencies] but don't know who we are or realise what it is. There is only myself [as an employee of KIMO UK] so it's something I'll be

focusing on, is the promotion of what we do and maybe it's just a lack of awareness and actually they do want to sign up – they just didn't know that they wanted to. So at least that's what I hope!

There's also the issue then that some councils may be far more/less involved with their local marine environment, their fisheries? You mentioned that land-locked councils were the most difficult to get onboard.

Yes, they feel that they're not on a coast so they feel it's not their issue. Arguably, it *is* their issue. All of them will have some water source that will end up in the sea and it's all – we shouldn't view it as someone else's problem, even just as a UK problem. It's a worldwide problem and we can all do something. From what I was told from the last Scotland Excel meeting, there is interest from these land-locked places now that they've realised, *well yeah our waste does end up in the sea, whether we know it or not – it does*. There's no pretending that one river is completely litter-free, it doesn't happen anymore – it doesn't exist. I think that's something I'm gonna be focusing on a lot more in the next months: to get the word out to the [land-locked] councils. From getting through to the council, word will trickle down to the local populations. Even on the west coast of Scotland, Norman – the councillor I was speaking to there [in the car on the way to Eyemouth] – is very keen on what we do at KIMO, however there are no fishing for litter harbours in his area. I've actually had a 17-year-old student approach me who managed to get a letter published in *The Times* about it, and she really wants to push to get a Fishing for Litter harbour where she is, in North Uist. So I've managed to set up a meeting – once she's finished her exams – with Norman [MacDonald, local councillor, Uist], to actually get something in place. Even though Norman's really passionate about it, it's not actually up to him, it's up to the harbourmasters. It's also up to KIMO; we should really be targeting these places and enforcing it and I now I've got Norman's support which is fantastic and I know he'll make it happen but that's what I'm employed to do. That's something I'm really keen to do.

8. Who funds KIMO – is it exclusively EU funding?

Nope, we've got the EMFF fund. EMFF is the European Maritime and Fisheries Fund. It is European funding. So when I apply for that funding – unfortunately it's separate between UK government and Scottish government – when I'm doing the work in England, it's the MMO [Marine Management Organisation, English branch of EMFF] who provide the money. Even though it's still technically EMFF, it's coming out of their budget, and Marine Scotland is the Scottish version of that as well. So EMFF fund most of our Fishing for Litter in Scotland – a fair chunk, more than 80%. England, it's practically 100% funded by EMFF because it's a lot smaller scale. It's about a 10th of the size of what we do here in Scotland.

And why is that, in England – is the industry significantly smaller or has interest not been as great?

It's still quite new, and I think with the location of coordination – obviously I'm based in Scotland so it's a lot easier for me to visit harbours. We do have a coordinator down there; she doesn't work for KIMO, it's essentially a sub-contracted project which she officially spends 2 days a week on – though she spends more – going around the harbours because that's part of her other job. We employ her, her services at Seafood Cornwall training, the company is called.

She's already based at one of the biggest harbours so that's kind of why it's smaller scale. And it's currently just in the South West, it's in a little pocket. But I'm also quite keen to know why more isn't collected, for example. The SW is still very nice, it's still in its infancy so getting word out and things ... Scotland's been going on for a long time. In fact at the moment the SW has only just got its first EMFF fund so prior to that it's still very much in its infant stage so it's difficult to have a direct comparison at the moment.

Other funders for Scotland include the Scottish Fishermen's Trust, which is a branch off of Scottish Fishermen's Federation. They give us a good amount of money every year which is fantastic. They're very supportive actually, a very supportive company that are helping us. We also get money from Aberdeenshire council who also helped facilitate my role at KIMO. They're very kind and house me, let me use their facilities. They're actually one of the founding members of KIMO UK, one of the founding council members so they have a very longstanding relationship with us which is great. We also get money from Ullapool Harbour Trust, and we also get money from Peterhead Port Authority – so the larger ports in the UK. They give us a donation every year, and they give us their litter which is even better! They're very supportive.

9. What does KIMO UK do with the waste collected?

At the moment, it just goes to landfill which is something I'm actively trying to change – that is, I think getting it to this point has been really difficult, even just to get people signed up for it. But now that it's running pretty smoothly, I am very keen to add a recycling element to it. It will need to be approached; I will need to approach each individual waste company that we use. We tend to use local waste collection facilities for logistic purposes. It brings money into the area we're working in and it also logically makes sense, you know. I'm not gonna have someone up in Inverness drive down to Edinburgh to pick up a skip. You've seen the skip here, stamped by Frank Flannigan's, which is a local company. That's usually the first step is: we tend to use the waste companies that the harbours already use. That just makes more economic sense. But moving forward, that's something I need to speak to each individual waste company to see: do they have a sorting process? Is there a possibility for recycling? If so, maybe there's a fund I can somehow get from government to help pay for that additional recycling at the end, to give the waste companies. Or, if I can manage to secure tax relief from the landfill tax then maybe that money can go towards recycling. So it's all in my head at the moment.

Understandable then, as it all seems like a big logistics challenge, even as far as collection goes before we bring in recycling. As we were discussing with Richard earlier, there's not enough of an established localised system in the UK.

No, there isn't but I think that's where the local councils can come in, because they should have recycling in place and if household waste is going to certain places then there should be something in each area. That's something I'm keen to work on with each individual council to see if there's something in place, something we can set up. I mean, we're getting tonnes, over thousand tonnes of litter collected in a few years. Even since last April, we've collected around one hundred and twenty seven/something tonnes of litter- and that's not even in one year.

And that's not even the total figure for what the potential could be if the whole UK was actively involved, if all harbours were involved.

Yes, and that's not even including all of our harbours because some of our harbours - we've got 3 in Shetland - a couple of them are collected by local councils and it's just not measured. Some of them down south on the borders, they don't have their own skip because there's not enough litter to justify it so it just goes into their normal skip so they don't measure it. We know that they take part but we don't know how much it is, so the figure could be even higher. It must be, because we are excluding some numbers.

10. Those are big numbers and there's quite a lot of work involved in ocean waste management, do you think there is potential here for a commercial model, for this waste to be treated as raw material for production by private companies?

I completely think it could be: absolutely. I'm interested to know and I'm keen to get maybe a student or undergrad involved to work out a composition. And we've done that in the past, we've done studies to try and work out the percentage of each type of litter we're getting. We do actually, we helped OSBAR write a sort of guideline for fishing for litter and we have set criteria, similarly to what you'd get on a beach clean; you count X amount of bottles and stuff like that. It gives you as rough idea of what's coming in off the boats. We've done that before and I'd be very keen to do it again to see if there's anything we've missed or if numbers have changed or I'm assuming they'll be different per harbour maybe. I think, more once we know what we're collecting but definitely most of it can be recycled easily and turned into something that we could reproduce. The net recycling, even though it's separate from fishing for litter is the perfect example of that and how that could easily be used for raw material. They're doing it in other countries but we're just not seeing it here yet.

Yes, I've seen backpacks online with recycled net elements!

There's so much you could do; even thinking today when we saw those nets and I thought, "hmm, looks like my horses' hay net", you know? I'm kind of tempted to steal this, save myself a fortune.

11. We've discussed how funding is a challenge and especially when we want to keep growing and I imagine budgeting would be pretty tight to start off in this type of project; do you think things would be different if we considered waste a valuable material, as a new raw material?

Yes. The difference between fishing for litter and net recycling is: net recycling is driven by profit. Fishing for Litter is not. I have found it very difficult with net recycling at this point because I actually have a lot of people wanting to be involved purely because they have money in their eyes. KIMO is a non-profit organisation; we don't make profit from what we do. So if someone does want to work with me, they're not going to make any profit and they need to be aware of it – that's not why we're doing it. I'd be more than happy if someone else set it up and made an absolute fortune but that's just not what KIMO do.

And we're back to just not having the infrastructure in the UK for it yet at all.

Definitely not. The amount of people I've spoken to about this, I'm sure I would've heard about it by now. There are lots of small projects but that's it. Take for instance, there's a guy down south [England] who makes 3D ink, for 3D printers, out of nets – which is fantastic. But it's very small scale.

And 3-D printing isn't yet a commodity product?

Not yet, but it's coming. That could be, that's just one example of how that net could be taken as produced as something else – of *use*. It's upcycling, rather than downcycling, which I think is really crucial. But, that seems to be the thing: lots of small things going on, but at the moment nothing huge – which is what Denmark are offering with this Plasticz company.

That's definitely something I've come across in my research so far: that we have so much potential in small-scale projects but it takes something bigger, like KIMO, to bring it together. It's great to see that you're collating lots of harbours. The UK needs infrastructures like this to establish itself [in the area of recycling].

I think if I got this net recycling up and running, this Denmark company - Plasticz Global - would be my primary source. They're paying for this net but if I'm gonna be working on a scheme that's funded I'm very keen to distribute to them the main bulk but the rest of it, I can also: *hey do you need some for your 3D printer ink, you can have some of this* and prioritise the smaller UK based companies first. They obviously can't take everything but at least I can give them some to make their businesses work and the rest of it goes to Denmark. That's how I would like for it to happen.

It's a great way to raise awareness of the work you do too.

It's local; it's got to be local. It has to be local at some point, and I really would like to help local businesses grow because then eventually we'll move away from exporting it [waste] and just make it completely UK-based, which is really the ultimate goal.

So you're definitely on board with believing in a circular economy within the UK?

Oh yeah- absolutely!

Thinking back too, to an earlier question: you mentioned surveying litter, did you by any chance record data on how much of the waste collected is made up of plastic, or plastic bottles in particular?

I can tell you right now (she opens laptop). It wasn't during my time, it was a few years ago but we do have the percentages somewhere on our FFL website if you just bear with me ... I think plastic was one of the highest from what I gather. I can actually send you the entire report; it seems just from looking at these images that plastic bottles were 38%, which is really quite high. 88% is miscellaneous plastic; 11% is nets – I can give you the full breakdown and dates as I'm just looking at an overview, and that'll give you a better idea of what we collected and that, but plastic just looking at this is easily the biggest.

What we're looking at essentially then is an untapped market?

Something we're just not using, yeah.

12. Some of these we may have touched on, and I won't keep you much longer! But here's the next one: what do you define personally as the biggest challenged involved in coordinating the whole KIMO project in Scotland?

Possibly just lack of awareness and lack of communication between ... I feel like the middle man quite a lot, and a lot of people are really keen and want to do something but there just doesn't seem that connection and I feel like KIMO acts like that connection quite a lot. I think it helps that we're, you know ... local councils could potentially drive harbours to do things but maybe they're not being as positive about it and its maybe better to have someone impartial like ourselves and maybe we're ... even though I represent the government and the councils that we've lobbied, I still also feel I represent the industry because I would rather they were seen in a better light and help them rather than work against them ... yeah, I'd say just lack of communication and lack of knowledge – or awareness: maybe awareness is better as a word because it's not that they're [the fishermen] not educated, it's just that they're not aware that something's going on. Some of them probably don't even know what Fishing for Litter [the scheme] is.

Most of the fishermen I surveyed weren't that any scheme like this was in place, although it was one respondent who initially led me to you.

Well, we're actually planning a massive event in the summer, hopefully. I've actually had ... I've been approached by a guy from ... not sure if I'm allowed to say the name but, a massive fishermen's organisation – not a company, it's just a social media group and there's over 1000 members or something and they're just fishermen. They don't talk about politics or anything like that, it's just *what are your fishing problems* and maybe we can come together and solve them so things like buy-catch and quotas and discards and all that kind of stuff gets chatted about but also you know they're quite keen to get involved with litter and the man that approached me is one of the most senior members of the group and he would love to do a big nationwide event – preferably in the summer when the weather window is good – and get as many new members signed up in terms of fishing boats and then over the course of maybe a week have this huge PR event where they al go

out fishing for litter and then at the end of the week we weigh how much was gathered just during that week and see how much of a difference it can make. And then at the moment – haven't spoken to him in a bit 'cause he was trying to get an idea of where people land their fish, cause if there's fishermen that are keen to do it but they're not landing at a port that's Fishing for Litter friendly, then that's also another opportunity to get a new harbour onboard. 'Cause if the fishermen are driving [it], I'm sure the harbours would be more than happy for it to happen. So that's the kind of thing ... I don't know if it'll happen this year. I'd like it to, but I don't have a lot of control over setting it up. They just want to use FFL as a kind of way of doing it. I've certainly given my support and there's just not a lot I can do until he gets back to me, unfortunately.

Yeah, it seems like a great system – and potentially a way to get the interest of new council areas?

Yeah, just raise the profile and also, I would be quite keen for the fishermen to get the glory for it as well. The guy was very much, "*make it all about KIMO and all bout Fishing For Litter*" and I'm like "well yeah but I would rather it was about the fishermen because they're the ones who are driving it. You're a fisherman who's approached me and if you guys are wanting to make a change I'm more than happy to support you". But they're the ones who should get all the glory for it; they're the ones out there doing it and taking the litter out.

13. You mentioned the landing charges, the landfill tax, by email as a key challenge for fishermen, ~~are these from the UK GOV?~~

- a. Please explain these further – **do you consider legislation to be one of the biggest barriers to change in the industry?**

Yes and no. I think the industry need a drive; they've got something blocking it which is the landfill tax. The fact that that's a thing that ... I think even if the PRF directive removes that cost, there's still a need to drive and educate because otherwise it may not get done. That would be something that would be quite interesting to see; I think it's a combination of both [lack of education and legislative barriers]. I think if there's a few fishermen who want to make a difference but they're getting charged, obviously that cost and the legislation is what's stopping them but then if they're fishing at a Fishing for Litter harbour maybe it's just a lack of education that's stopping them so I think it's really about 50:50. More than anything else, it's driven by both.

That brings us back to another thing on education, whereby we're increasingly becoming aware of the impact that the litter can have on the quality of the fish, and in the end on the fishermen's livelihood.

People just won't want to eat fish, so yeah.

14. Do you agree that reform is needed in the UK waste management industry?

Yes.

Faron's phone rings, recorder is paused until the end of the phone-call

Interview resumes

I'm just turning the recorder back on now as I wanted to protect the confidentiality of your phonecall.

It's no worries, there was nothing private on there anyway.

Just incase! For the record, you were on a KIMO phonecall with a Scottish local councillor there, and you're getting a lot of support from them which is great and drives down one of our points today: that getting them involved helps move this forward.

Yes, absolutely. We've got the likes of the Marine Scotland and MMO giving us the funding and they have budgets specifically for this kind of change – marine litter – but then you've also got the pressure from the local councils; they want to see their areas improve. They'll also feel the pressure from the communities; it all trickles down. It's just a case of collating all that and making a change somehow.

15. I notice that KIMO lists lobbying as one of its key aims, which current policies, aside from the landfill tax, are you aiming to tackle?

I mean, the landfill tax is obviously a financial blockage. Additional to that, in terms of specifically marine waste and litter – or plastic ... from a net perspective – obviously, this isn't fishing for litter – I think there's issues with... to do with the material and the material's nature. A lot of it's subject to what's called shrinkage. I don't know an awful lot about this, but I know that that alters the lifespan of a net and what it can be made with. I think that's a big issue because maybe there's more recyclable materials that could be used but because there's this really strict legislation about the sizing and spacing - you know there is no allowance for shrinkage or things like that – and fishermen can be questioned at any time. You know, they can be out fishing, and someone could come and inspect them without them knowing, that's how it goes. I've had some people talking to me about that briefly saying that that's something that they would love to change – even the netmakers. That's something next week; hopefully I'll go and visit net makers and go find out a bit more about that. Because if legislation is the reason that nets have to be replaced so often, those nets are going to landfill or at sea most commonly. That's a huge issue. If that's a legislative issue making that happen then it's obviously something that needs to change. In addition to the net recycling, which is something I'd really like to do, I'd also like to put in place something [to] push the government to help us; there's always pressure – you know, *you're not allowed to do this, and that*.

Instead of focusing on promoting positive action?

Like KIMO is trying to do, yeah!

I hadn't any questions prepared on net recycling before today but we've covered a lot and it seems like a really interesting issue. It seems we all owe the fishermen a lot, the textile industry: a reliable nylon net which is tested to avoid shrinkage in salt water, and the government: a way to perform their jobs sustainably without being charged. If they are forced to replace their nets and forced not to land waste, they're very limited in what they can do.

They can land their litter, they're just going to get a pretty big bill. It's just not financially sustainable.

16. What, if any, social risks do you consider to be immediately threatening as an immediate result of ocean waste, thinking about...?

- a. For fishermen themselves, or
- b. local communities

I find I get a lot of complaints on social media about the litter that washes up on the shore, especially from the fishing industry. They're blamed a lot for ... gloves are the biggest thing. They use a very specific kind of glove and I think that the public can see that and they blame the fishermen for that. It's just very easy to blame.

It just takes one person on facebook to say, "look out for this pair of gloves!" and that's it.

Yep – oh twitter: a couple weeks ago I was absolutely bombarded, this one guy was like "*every time I go to the beach there's this glove packet*" and actually my colleague down south: she is on a board – I can't for the life of me remember but I do have the emails – and they're pushing for the supplier of those gloves to remove the packaging. Because in every other country - like America I think – [they] don't have the packaging; they sell them as they are but they don't do it here. They put them [the gloves] in plastic packaging – which makes no sense. And their argument [the supplier] is well *it's safer* or whatever – it's illogical. There's no reason, because the same supplier is selling to other countries without the packaging. So why do we have to have this extra layer of wrapping that we don't need?

That single-use packaging can be useful, for instance in assisting with pre-portioned food prep for people with reduced mobility, but surely this is a very active job and there's no need.

No, not at all.

So what we're seeing is a lot of needless plastic which gets in the way?

That's one of them, the gloves. They stick 60 gloves in this packages or something; I can send you information if you're interested. That's something where Cornwall – it's down in Cornwall that they're really attacking this company – are trying to make a change. All of the fishermen use these gloves and they just are fed up of the packaging that comes with it; it's so unnecessary. It's gonna be an

outdoor glove for handling fish; there's no seal needed. The fact that other countries get sold these gloves without the packaging means it's just not necessary.

17. Thinking in terms of positive feedback then, what kind of positive stories do you get back from people who've been involved with this scheme?

I think for fishermen it helps them feel like they're really making a difference because I think they're fed up of catching the same litter. They want to fish – it's their work environment. No-one wants litter in their work environment and for them, their work environment is the sea. And for them, to be fishing all of this stuff out with their catch, I imagine it's quite soul-destroying. So I imagine it's quite helpful for them, to feel like they're having an active role in cleaning up the oceans, which is great. It also helps public perception, which is a huge thing for fishermen as well. They get a lot of negative press. I get a lot of volunteers, members of the public email me randomly to say they love the concept: *why isn't everyone doing it? How can I make it happen in my country?* – that kind of thing. It's a lot of random members of the public all over the world, messages like that. Students as well: I get a lot of positive feedback from students and some universities. The harbours as well: it's a good thing for them, it helps them to clean up essentially. And they're leading by example. I think it's a very positive thing all round really. And even the local councils that are involved: Aberdeenshire council were installing a sea bin which is the first in Scotland and that's driven by them and they feel very proud of that because *hey look, we're annoyed at the litter here so we're gonna take it out and do something*. It's kind of everyone's ... there's positive sides from all aspects really.

The floating bins are something else I wasn't aware of until today; it's all very interesting. What's the scale you're hoping to take that on with?

I would love one at every fishing for litter harbour, where necessary. Some harbours I've spoken to, it's just not necessary; either the harbour's not big enough or it's not the kind of place where they would fill it. My goal then is to have one in every harbour that wants it, that's part of Fishing for Litter and to have that funded for them in terms of installation costs. Then they pay for the running of it and everything – that would be my goal. *You're already taking it from the sea, let's take it from the harbour as well.* All well and good having out there [at sea] cleaned up but then you come back and there's a lot of litter floating about day-to-day, that's a reality at a lot of harbours. That would be my goal. It'll probably go into my proposal to get it funded is how many harbours want me and that'll give me an idea of how much funding I need to get that off the ground so hopefully quite soon.

And another great benefit that we discussed earlier is that the floating bins can get rid of micro-plastic, which answers a question that's been highlighted in the media and is currently pressing the industry.

And it also, I think you can install a sponge or something in it too where it will remove surface oils and diesel and things like that which is inevitable; you've got engines on the boats. Of course you're going to have oil on the water. So that also helps just a little bit more. They seem like a really good concept.

18. You're very experienced in this area; at the moment what do you consider the most immediate environmental consequences from ocean waste? Whether it's human impact, or an impact on eco systems?

Pause as Richard Lawton re-enters the room

Lawton: Don't want to rush you but we are kind of locking up! We close soon.

Sorry, we're just finishing up! Just on the last two.

Okay, thanks Richard.

Probably, well me personally, I'm obviously more interested in the environment; I'm a marine biologist so that's my take on things. I hate the idea of single-use plastic; I just don't see the point in it. I think the issue is we need to change how people use plastic especially but the problem is unless it's forced it doesn't happen. That's the issue and I think that's why we need government involved and local councils: to make change. If things aren't available for people to purchase, then it's gone, which is great. The Marine Litter Strategy group that I'm part of were responsible for the removal of plastic cotton buds for example. You'll not find the old thing- very difficult to find plastic cotton buds in Scotland now. We have paper ones which is a small change but it's a huge step really. And ideally, I'd love for plastic bottles to be an absolute stop. That just shouldn't happen.

They do seem to be one of the biggest specific factors in ocean waste.

Absolutely. I mean, I just cannot buy a bottle of water anymore. I live in Scotland; we have the best water in my opinion. You can just go to a tap! I'm quite happy to do that – and it's free. I will always have a bottle with me that I will refill cause it just seems crazy otherwise. I think yeah, for the public and things it's good that we can change things but for me it's mainly the ecosystems – that's my passion.

19. Thinking more positively, what are the next exciting challenges or big aim for KIMO in the future?

Probably net recycling, I would say so. I can send you more but it's still very much in its infancy but, yeah. Fishing for Litter is well established but I still want to grow it, but it's still pretty well established as it is and then net recycling just doesn't happen so that's something I really, I'm excited to go crazy with.

Brilliant! Thank you very much.

That's alright.

[END OF INTERVIEW]



Informed Consent Form – Interview

You are invited to participate in a research project.

This work is being carried out as part of the Honours year dissertation research of Hayley McCullough from the School of Textiles and Design at Heriot Watt University, Scotland. I am exploring the viability of alternative fibre types for fabrics which can be sourced from the ocean – in particular, recycled PET.

The **interview** will be on **your organisation's role in plastic waste management and the possible future developments of this market**. I will take notes and record the interview digitally. This research has received ethics approval.

The length of the **interview** will be approximately **20 minutes**. You will be under no obligation to answer any of the questions.

Your information is confidential and your answers will be anonymous, unless you wish to be recognised. All data will be collected and stored in accordance with the UK Data Protection Act, 1998. You have the right to withdraw without giving a reason and prior to the publication of the research before April 2018.

Participant

I have been fully informed as to what this research will entail, and am aware of my right to withdraw at any time. I hereby fully and freely consent to participation in the interview, which has been fully explained to me.

Participant signed

A handwritten signature in black ink, appearing to read 'R. LAWTON.'

Contact details

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18/03/18

Harbour Master Interview

- with Richard Lawton, Harbour Master
@ Exmouth

1. How long have you been working with KIMO UK?

4+ yrs plus

2. What motivated you to work with this organisation?

- a. Amount of waste
- b. Want to do good for the environment
- c. Complaints from fishermen
- d. Complaints from locals

main exp.

of needing done

to clean up →ermen
outting pressure visible work on beach ratios

3. How much was the plastic interfering with daily jobs?

a lot more than being interfered with
 Trawlers nets etc, industry, land from plastic
 but key issue fisherman's waste mostly plastic

4. What difference has the scheme made on the people who work in this harbour?

- a. Happier
- b. More job satisfaction

from cleaner

7 Yes it's a big problem

makes them feel good

5. Do you think this has helped protect jobs in Exmouth?

Yes. be of perceived consumer needs

Harbour Master Interview

6. Is there a feeling that the local industry is under threat from quotas/pollution/fish numbers?

also mentioned issue of flood which came from harbor → not giving some areas a chance to recover

creel damage to sea birds (from nets) (biggest complaint)
really time from nets hinder work

7. Do you think there is a potential to make the fishing for litter concept into a commercial venture – i.e. selling plastic collected onto private companies?
- Viable?
 - Optimistic?
 - Enough waste that it could sustain business?

regional collections → 1 ch UK

c. should be from anywhere as a whole
changes change big factor

(but small quantities @ monthly)

8. How would you feel about this with the textile industry in particular?

great,

9. Are you aware that companies in the Mediterranean are already employing fishermen to collect plastic waste to be sold for making into yarn for fabric?
- Does this change your feeling?

1. How long have you, at Eyemouth been participating in KIMO's Fishing For Litter Scheme?

It had already been subscribed to when I came here 4 and a half years ago, so I took it over from a previous harbourmaster.

2. What do you think then was the biggest motivating factor, in the harbour getting involved?

I think there's a realisation something needs to be done about the problem of plastic litter, in particular going into the sea, and there's a general movement to try and do something about it. It's, you know, vague at first but we can all see that there's a problem and that we must all do whatever we can, take whatever measures in order to be effective.

Did the pressure come more from the fishermen themselves or the local community, or was it a combined effort?

I don't think the pressure came from the fishermen, it was more the other way around – the local community, yes and just generally people who can see what's happening, and heat up on that.

So, seeing the visible waste on the beach was enough [to motivate them]?

Yes, and of course we have sport diving activity going on from here as well, so the divers were interested in this as well. They see their resource as the sea bed so they had an input into initiating it initially as well.

3. How much, as a general rule, does waste interfere with daily jobs here and has that changed significantly?

How much does it interfere with jobs? I don't think so much that it interferes with it, it's more the fact that what we do here is a cause; it's a source, a partial source of the problem. But we can split it into the two different areas, we have the industry material: the nets and the ropes and so on. There's also litter which is from the land source, which is plastic bottles and that kind of thing coming in.

You've mentioned plastic a lot, is that the most visible thing that you see regarding waste?

Yeah and it's the fact that it takes so long to degrade; we know it's going to be around for a long, long time.

4. In terms of this scheme, it's been implemented since before you were here but what's the general feeling on the ground – has there been an improvement in well-being or job satisfaction? Any kind of positive social benefit?

I think there's a certain amount of job satisfaction from our point of view. We're making some attempt to tackle the problem, and it's evidence that we are doing something when we're approached by the public and the people round the town saying, "What are you doing about this?". It's useful to be able to say, "yes, we're doing this, this and this." You know, we're attempting to make some difference. As far as the fishermen are

concerned yes, the ones that have subscribed to the scheme are very happy that they are doing it. If that can be increased during that would be fantastic.

5. Do you think this has in any way, thinking quite long term, helped preserve local jobs in Eyemouth – thinking about what we discussed walking round the harbour with possible plastic contamination of fish. Do you think [the Fishing For Litter scheme] has a long-term effect that way, in terms of preserving the local fish and industry?

Yep - as we were saying [during the harbour tour], if there's a public reaction against the fishing industry because of the perceived problems of the plastic pollution, then in the end it's going to be detrimental to them [fishermen], to the industry as a whole and in the long term they'll lose jobs. Anything that can be done to ensure that the measures are being taken is going to be beneficial.

Definitely – so it's about preserving the public's view of [the industry] as much as it is of clearing it up? As we discussed, consumer perceptions and the media can have a massive effect.

I think the industry's in a bit of a dangerous situation at the moment from that point of view, because there's been massive public awareness suddenly. The Attenborough programmes [*Blue Planet II: The Prequel* (2017, BBC), *Deep Ocean Series 2* (BBC, 2017)] and so on seem to have suddenly pushed it into the public gaze, and if they're [the fishermen are] not careful, if that is carried forward into micro plastics in fish, in flesh then the consumer will react against it and you might find that if there's a problem that the product isn't as popular as it used to be. Things will start to go down hill from that sort of thing.

6. Is there a feeling in Eyemouth that the local industry is under threat at all, from either quotas/pollution/any decline in fish numbers? That was a three-in-one there - but any of those?

They always complain about quotas, the fishermen – they always have done. There's the feeling that, with Brexit, maybe it'll be a means of getting away from quotas – I mean, dodging them and coming up with a new system perhaps. The fish stocks you can see are under pressure; we can see from the prawn fishing industry that they're under pressure, because they'll come and flesh out a certain area and it'll then not recover for a couple of years so then the fishing industry, especially for prawns, tends to be very peripatetic – they'll move onto an area; boats from Northern Ireland, the west coast [of Scotland], from the north of Scotland they'll all come down and fish in one area 'til the fishing goes down on that particular ground. Then they'll move on to somewhere else. We can all see that this is happening all the time. As far as the lobster and the crab fishing industry - the static gear - is concerned, we can also see that this is under heavy pressure as well. There's an awful lot of gear being put out there and we're all wondering how long it will last, how long those fish stocks will support the industry. So yeah, there is pressure all the time. The local fishermen will obviously want to preserve the area for themselves, [they] aren't keen on the visiting fishermen coming in. The trouble from their [the foreign fleets'] point of view, is needs must; they have to go somewhere to catch. But it's what they're doing.

That brings us to something else we discussed earlier [during my period shadowing Faron as we worked at the harbour] regarding recovery time; is this another thing which you think would be a significant factor in motivating efforts to reduce waste and the amount of nets which are thrown down, or is this inevitable?

Yes, possibly. Nobody knows yet exactly what the effects of plastic waste etc., are on the fishing industry. Obviously, we can conceive that it will maybe become a factor that is significant in the future.

7. **Do you think there is a potential to take something like the fishing for litter concept and creating a commercial venture for example in places like Eyemouth where plastic collected can be sold on to private firms for recycling and potentially in the [overall] UK in the future in building local production – would that be something you think ...?**
 - a. **Is Viable,**
 - b. **Optimistic?**
 - c. **Has enough waste that it could sustain business?**

Because of the quantities you've got, we're talking something more in terms of regional centres for recycling and such. If there was one in Britain that could take all [the regional waste], that was proved to work, then that would be great. On a more localised scale, I don't think it would ever work as we don't have the continuity of material to work with.

Essentially though, thinking about the textile industry, the way we see it is that this [sort of scheme] could be applied on the scale of cotton farmers; this is always sourced locally and brought to a big regional manufacturer who spins it into yarn so thinking specifically about the textile industry, it would actually reduce some of our carbon footprint - in comparison to sourcing from the likes of India, America - to produce a material that had been sourced from points around the UK. How do you feel about the textile industry in particular, does that strike you as possible?

If it could be used for something like that then it would be fantastic, yeah.

It's always interesting on that note to see the reaction from people, giving the industry's quite tainted reputation; some reluctance would be understandable.

8. **You touched on this, but obviously there's not enough waste in Eyemouth to sustain business in the form localised, circular recycling to production system, but do you think in terms of waste – you've said that it's more often industry waste than consumer waste – do you think there's enough to sustain an industry in the UK if we were building a recycled product or would there be more a case of a back-log first that would give us a high quantity which might then trickle off?**

I think there should be enough for the country as a whole to support at least one recycling centre and the feeds into it need to be established, so that the regular feed into it from the whole country then [could] sustain it. Especially now as we're losing

some of the [business,] such as the Chinese refusing to accept any more [waste for recycling] so some of the traditional outlets for this sort of stuff has been closed off to us now, so if it could be re-directed [domestically]. But I don't know enough about the industry to give an educated opinion on that as to how much would need to be collected, whether it would be enough to keep one recycling plant running in this country or not – or whether [the waste] would need to be collected further even afield [as well] to make it viable. It would be good if it could be kept to one country, so it didn't have to be transported far; I mean that would be great.

Effectively, it reduces a lot by way of trade tariffs. Pretty much, we could build an economy and create jobs out of it. Like you said, we've not got enough awareness of the industry and I think that's a UK wide problem. We have been out-sourcing our recycling for too long and there isn't really an established economy here, would you agree?

Yes, definitely.

9. One last one: out of curiosity, are you aware of schemes where companies are building mostly circular, localised economies with one firm sourcing plastic, sorting and collecting too in the local area? It's mostly happening in north western Spain and this is being sold as yarn for fabric and it's become especially profitable because it's got a premium for consumers who love recycled ethical garments: the guilt-free purchase. Are you aware that companies in the Mediterranean are already employing fishermen to collect plastic waste to be sold for making into yarn for fabric?

a.—Does this change your feeling?

That's fascinating, I don't know much about it at the moment in that area but it is actually fascinating. If it can be proved to work in one part of the world then it can work elsewhere.

It's interesting too that you mention our waste no longer being collected by others, as Spain had experienced having its waste refused by other countries, and in fact reacted by starting to build their own recycling centres and even to collect from others, including ourselves. They've got a first-touch competitive advantage there. There are start-up schemes in South East Asia too, and from our discussion I'm hopeful that with this type of venture we too [in the UK] could benefit from the initial competitive advantage and establish a production chain where we profit could be spread sustainably throughout.

But that's everything, thanks so much for your time!

[END OF INTERVIEW]