# Green Development Strategy Project

## Pathways to Change in the Inshore Creel Fisheries in Orkney

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**Abbreviations**

**CF**- Carbon footprint

**EMFF-** European Maritime and Fisheries Fund

**FEK**- Fishers ecological knowledge

**MLS**- minimum landing size

**SLA**- Sustainable livelihoods approach

## 1. Executive Summary

Creel fishing in Orkney is a mixed enterprise with target species including Brown crab (*Cancer pagarus*), Velvet crab (*Necora puber*), Green crab (*Carcinus maenas*) and European Lobster (*Hommarus gammarus*). Orkney has a diverse fishery including other whitefish species, scallop diving and dredging, whelk fishing using pots as well as hand gathering and diving for whelks and razor clams. This makes management of such a diverse, dynamic and fluctuating fishery more complex than others. Orkney Fisheries Association received funding from European Maritime and Fisheries Fund (EMFF) to investigate green development strategies which could be adopted within the fisheries to secure its sustainability into the future.

This green development project focused on three main areas of interest, the first being the development of a multi-species escape gap which could be fitted to creels to prevent the landing of undersized commercial shellfish species. The second area of interest was to devise a seasonal time table blue print would allow the fishery to return to a more seasonal fishing pattern where shellfish could be landed at their peak conditions and allowing rest of species when they are not in season. Thirdly, this project sought to define a carbon footprint for the inshore creel fisheries and evaluate the amount of fuel, gear outlay and antifoulants used within the fishery. From these areas of interests, suggestions through which the fishery could benefit in order to enhance its sustainability by introducing greener fishing practices or management options are described as pathways to change.

Pathways to change for escape panels includes the continued development, sea testing and fishermen's input of next stage escape gap designs along with researching biodegradable aspects. The continued involvement and participation of existing and new fishermen and full acceptance and integration of this greener fishing technique into common fishing practise is essential to its success. Pathways to change within the carbon footprint of the industry should focus efforts on reducing fuel consumption and employing greener fishing techniques to help reduce fuel consumption. Effort should also be focussed on carbon offsetting through better recycling opportunities for fishermen at pier side facilities. Pathways to change in fishing moving to a seasonal timetable should take steps to encourage local fishermen to develop better fishing habits. Certain species should be avoided and not targeted during months when they are in poorer quality or berried (egg bearing). The need and opportunity for diversification would alleviate some fishing pressure and allow the targeting of other commercial species.

The challenges in the pathways to change are mainly associated with change in fishermen's attitudes, change to fishing patterns, challenges over opportunities and financial constraints as well as funding opportunities, time and effort. Overall, fishermen and fisheries management have the capability to make regional changes within their area to help improve the sustainability and perceptions of the fishing industry. Now, more so than ever in the political climate, should green practices be adopted to allow the continued success of fishing for future generations and to sustain remote coastal communities such as Orkney.

**Key words: Inshore, Fishing, Carbon Footprint, Creels, Sustainability, Climate Change, Shellfish, Orkney.**

## 2. Introduction

Fishing communities are a vital and important part of Scotland's rural life. Fishing makes a valuable contribution to Scotland's economy, cultural and social heritage. Coastal areas account for over 40% of Europe's population and are clear destinations for development opportunities (Farnet, 2011). In 2017 there were 4,799 fishers employed on Scottish based vessels (Scottish Sea Fisheries, 2017). Many fishing communities are situated in remote and rural areas and provide an important source of employment, income and transferable maritime skills for these communities (SWT, 2017). Employment in fishing in 2017 accounted for a high percentage of employment in island communities (Shetland, Orkney, and Na h-Eileanan Siar local authorities). In Orkney alone, the number of fisher's employed as a proportion of the total employed in Scotland represents 2.34% (Scottish Sea Fisheries, 2017). However, over the next decade the impact of Brexit and new regulations are likely to cause significant changes to the fishing sector, bringing new and potentially unexpected challenges and opportunities (Seafarers UK, 2018).

Fisheries are highly variable enterprises but are risky as an income source as the populations they depend on can fluctuate (Cline *et al*, 2017). Furthermore, fisheries are also subjected to socio-ecological systems which are affected by biological changes to oceanographic variability but also socio-economic conditions and market demands (Cline *et al*, 2017). Therefore, communities which rely on fisheries for their source of revenue need to fully appreciated how these systems integrate to help sustain their economies and livelihoods over periods of variability and shock (Cline *et al*, 2017). In taking a wide view of sustainability, four key dimensions are often summarised; economical, institutional, social and environmental sustainability (Allison, 2002).

Inshore fisheries contain a range of mixed-fisheries in which multiple species are caught at the same time. The inshore fishery in Orkney contains a mix of creel fishing, diving, handlining and trawling for commercial shellfish species. The inshore fisheries can take several pathways to change to prevent damage to the marine environment and promote sustainable fishing into the future to secure long-term profitability (SWT, 2017). An environmental approach to sustainability would address ways to reduce impact on;

- Overfishing- the depletion of fish stock levels
- By-catch of non-target species
- Physical damage to marine benthos
- Ghost fishing and entanglement
- Marine litter

A livelihood's approach to sustainability seeks to improve rural development policy and practice by recognising the seasonal and cyclical complexity of livelihood strategies, helping to remove access constraints to assets and activities that complement existing patterns and by identifying ways of making livelihoods more able to cope with adverse trends or sudden shocks (Allison, 2002). Therefore, sustainable livelihood approach (SLA) aims to put people's social and economic activities at the centre of analysis rather that just using 'fishing effort'. In recognising and combining all approaches to sustainability, greener pathways to change can be more beneficial in policy development and management of the inshore fisheries.

Abrupt shifts in ecosystem and fish stocks are common in the marine environment. These regime shifts can have major economic consequences as biological communities reorganize in response to ecosystem and ocean dynamics. Diversification (the distribution of participation across a number of

fisheries) and turnover (reorganization of fishing effort among fisheries to capitalize on emerging opportunities) should alleviate economic hardships and provide resilience in the face of large and abrupt hardships and provide resilience.

However, with any change challenges exist in adopting pathways to change. These will be discussed further on throughout the report. Challenges to change can exist as economical, financial, management, scientific and through regulation. These challenges can exist at individual fisher level, community level or a national level. Further challenges to change also exist within individual personal conflict towards behaviour and change of attitude.

**2.2 Fishing activity in Orkney**

In 2016, the total value of all fish landed by Scottish vessels was £557 million (Scottish Sea Fisheries Statistics, 2017). The value of shellfish landings by Scottish vessels has seen an increase from 2015 to 2016 of 21 percent to £166 million and accounted for 14 percent of landings by quantity (64 thousand tonnes (Scottish Sea Fisheries Statistics, 2017). Orkney in 2016 landed 4,936 tonnes of shellfish which valued at £9,135,000. Table 3 shows the quantity and value of lobster and crab species landed into Orkney in 2016. This in turn supports a fishing fleet in Orkney waters of 131 actively registered vessels, 199 regularly employed and 93 irregularly employed fishermen (Scottish Sea Fisheries Statistics, 2017).

The inshore fishery amongst Orkney's archipelago is diverse and complex, characterised by strong tidal flow. The inshore fishery is dominated by a mixed fishery fleet of 91 boats 10m and under. Orkney's mixed fishery is made up of numerous target species including Brown crab (*Cancer Pagarus*), Velvet Crab (*Necora puber*), Green Crab (*Carcinus maenas*), European Lobster (*Hommarus gammarus*), Nephrops (*Nephrops norvegicus*), Whelks (*Buccinum undatumn*), King Scallops (*Pecten maximus*) and Queen Scallops (*Aequipecten opercularis*). Scallops in Orkney are fished for using both hand diving and dredge fishing methods. The main method of shellfish capture is through baited creels. In addition there are handlines for fin fish such as mackerel with further potential to catch other species such as Cod (*Gadus marhua*) and Haddock (*Melanogrammarus aeglefinus*). However, the main shellfish species landed in Orkney is targeted towards Lobsters, Brown Crab, Velvet and Green Crab, as seen in Table 1, of which conservation measures exist for these species in the form of various minimum landing sizes (MLS).

Table 1. Quantity and value of commercial species landed into Orkney in 2016, adapted from Scottish Sea Fisheries Statistics, 2017.

| | Quantity (tonnes) | Value (£'000) |
|---|---|---|
| Lobster (*Homarus gammarus*) | 102 | 1,286 |
| Edible Crab (*Cancer pagarus*) | 3,404 | 4,769 |
| Green Crabs (*Carcinus maenas*) | 80 | 58 |
| Velvet Crab (*Necora puber*) | 393 | 1,210 |
| Scallops (*Pecten Maximus*) | 379 | 1,197 |
| Whelks (*Buccinum undatumn*) | 452 | 410 |

Further fishing around Orkney waters also includes fishing for whitefish with three Orkney registered whitefish fishing vessels. However, Orkney has no designated landing port or fish market, therefore landings operate at other local registered ports such as Shetland, Scrabster, Fraserburgh, Peterhead, Aberdeen or ports on the West Coast of Scotland. The quantity and value of demersal and pelagic fish landed into Orkney can be seen in table 2. Mackerel quantities can be seen to increase in this table

from 2014. This was due to the Scottish government launching a trial to expand the fisheries in the inshore waters through allocating 10 meter and under vessels in the non-sector access to 1,000 tonnes of North Sea Mackerel (Marine Scotland, 2017).

Table 2. Adapted from Scottish Sea Fisheries Statistics, 2017. Quantity and value of total demersal and pelagic fish landed into Scotland from 2012 to 2016.

| | Quantity (tonnes) | | | | | Value (£'000) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2015 | 2016 | 2012 | 2013 | 2014 | 2015 | 2016 |
| Total demersal | 40 | 33 | 19 | 24 | 6 | 52 | 38 | 61 | 38 | 19 |
| Total pelagic (Mackerel) | 13 | 7 | 41 | 37 | 36 | 20 | 4 | 25 | 17 | 22 |

Processing of shellfish in Orkney is conducted through the Orkney Fishermen's Society Ltd in Stromness. It was established in 1953 and is one of the foremost processors of Brown crab in the UK. This co-operative handles the largest share of Orkney's Lobster, Velvet and Brown crab catches from ports of Stromness, Tingwall and Kirkwall, along with the islands of Westray, Sanday, Stronsay, Rousay and Hoy. Westray also has its own processors (Westray Processors Ltd) which was established over 40 years ago for the production of fresh and frozen crabmeat from the local fishing fleet.

### 2.3 Aims of Report

The aims of this report are to identify green fishing pathways to change within the inshore fishing fleet in Orkney. Though close collaboration with active fishermen the report takes account of all views on how to move forwards towards a reduction in effort, the ways towards adaptation of fishing behaviours while at the same time maintaining incomes, consuming less and protecting the ecosystem which would be key to further sustaining the fishing community.

Aims arising from suggestions for pathways to change and which will be developed through recent work on:

- Multispecies escape gaps
- Seasonal fishing timetable
- Carbon footprint of the inshore fisheries
- Further steps for pathways to change

## 3.Pathways to Change

### 3.1 Multi-species Escape gaps

Multi-species escape gaps were investigated within this study as a mechanism by which 'greener' fishing practices could be adopted to allow continued sustainability of the fishing industry. Escape gaps for individual species currently exist within the market, however due to Orkney's diverse inshore fishery, the development and creation of a bespoke multispecies escape panel was recognised as a step which could be taken to benefit the fishery.

The benefits of introducing escape gaps to the inshore fishing fleet include reduction in potential of undersize crab being landed, reduction in sort time, better fuel use efficiency, less damage to juveniles and displacement from home habitat. A multi-species escape panel which could be easily fitted to creels and escape gaps selected for the species type would allow gear to be placed in a variety of areas and allow a variety of undersized shellfish to escape. This is unlike current escape sizes which are selected for only one species type at a time.

Two multispecies escape gaps were designed and tested on commercial creels within Orkney. The panel and swivel plastic escape gaps were designed to be used on Lobsters, Brown, Velvet and Green crabs. Their fishing effort was compared against creels fishing in the same area with no escape gaps present. The catch per unit effort of creels, sorting time and size frequency of undersized crabs retained in creels were measured to compare and evaluate the design with greatest fishing potential.

This research found that multi-species escape gaps were found to make an improvement to commercial fishing practices with creels tested in Orkney. An improvement in sorting times of creels through a reduction in undersized crabs kept in creels but still allowing the retention of marketable crabs. It was found that 3 seconds handling time could be saved per creel with the addition of escape gaps. From the two escape gap designs chosen to be tested, both designs showed relatively the same fishing effort results. Despite this, it was seen that the panel design was more popular with fishermen due to ease of use and fitting.

Pathways to change were identified as the continued development and testing of the revised panel designs, based on CAD designs already produced. This would allow further at-sea testing on commercial vessels to establish their overall efficiency in fishing ability. Further to this, the possibility of mass production or partnership with plastics manufacturers could allow for commercial production of these escape gaps. The development of a bio-degradable element within future escape gaps was identified as another pathway to change. A biodegradable panel or a panel secured to creels using weak links such as galvanised time released or biodegradable twin would also contribute to reducing the effects of ghost fishing by the industry if creels were lost at sea.

The ultimate success of these pathways to change would require further research funding and participation of local fishermen. Continued outreach and liaison with fishermen to encourage use of escape gaps and feedback to allow for successful integration of escape gaps as a green development strategy in Orkney. Further to this, the free distribution of escape gaps to fishermen would also be a necessary step to engage participation and ultimate adoption of greener fishing practices. This project also helped to encourage local fishermen to work and help deliver real benefits and to incorporate them into their regular fishing practices for more sustainable fishing going into the future. Not only this, projects such as this can help improve some negative public images associated with fishing and ghost gear. Long term and successful sustainability of the inshore fishing fleet must be bottom-up and community driven to help set standards and incentives that policy managers can take lead from.

### 3.2 Seasonal Fishing Timetable

The seasonality analysis of the inshore fishing industry within Orkney was carried out to help support the sustainability of commercial species into the future. Creel fishing in Orkney is a mixed enterprise with target species including Brown crab (*Cancer pagarus*), Velvet crab (*Necora puber*), Green crab (*Carcinus maenas*) and European Lobster (*Hommarus gammarus*). This makes management of such a diverse, dynamic and fluctuating fishery more complex than others. In identifying historical and current changes to fishing areas, how specific fishing patterns relate to these, how tides and subsea characteristics influence deployment of gear and connections to home ports, and the importance of economical and logical navigation routes, pathways to change can then be suggested to secure the longevity of the inshore industry through 'greener' fishing techniques.

Information on the seasonality of the fishing industry was collected during face-to-face interviews with individual fishermen who routinely fish or are retired from fishing in Orkney waters. Those interviewed were asked to provide associated information about their fishing vessel and Fishermen's Ecological Knowledge (FEK). Fishermen have an immense wealth of information and knowledge of the seas they fish in. Fishers can best explain how a fishing ground has changed over the course of a few weeks, years or decades. They can provide intimate fine-scale ecological and environmental information that is not otherwise available. Therefore, fisher's ecological knowledge is extremely important in informing science and addressing gaps in the current knowledge and management picture. During interviews fishermen were asked to provide information on aspects such as species targeted, fishing gear used, fishing seasonality, historical changes, species abundance, biological conditions, subsea characteristics and fishing sites.

Results from this investigation showed that inshore fishing activity within Orkney is a seasonal enterprise. Differences in catch abundance, quality and prices can be seen to vary throughout the year for many of the commercial shellfish species within Orkney, reflecting changes to their biological characteristics. However, the fishing activities are not as seasonally dependent as they had been in the past as described through fishermen's ecological knowledge. This is due to several factors such as development of new markets and species to fish for, increased fishing pressure and environmental driven pressure and biological timings. Ecosystems dynamics are notoriously variable but general trends identified by fishermen highlight an increase in fishing effort for commercial shellfish.

Pathways for change into the future suggest that returning to a more seasonal fishery would be ideal in alleviating pressure on current stocks to secure top-quality crab at peak condition (Table 3). From the table, highlighted in red, are the months in which the targeting of species should be avoided due to poor quality conditions and in the months in which the shellfish are soft or white. For Lobsters this is from May to July, Brown crab during July to September, Velvet crab from May to August and Green crab in June and July. Out-with these months fishing for these species is recommended, as seen in green. Best practice would also avoid the landing of shellfish species which are berried (presence of eggs) as seen in yellow. The best prices for catches are also highlighted in orange. However, better fishing weather is generally correlated during the summer months along with increased day length. Therefore, the non-targeting of these listed species during this time would be difficult and would require additional ability to target and land other species in order to generate revenue.

Fishermen can take steps to change this now by avoiding the landing of 'soft' or 'white' crab and reducing fishing efforts when crabs are in poor condition. Additionally, avoiding the landing of berried individuals and better care of catches onboard vessels can help in preventing unnecessary loses and the fecundity of the next generation. The seasonality of commercial species is further varied by the species movement into and out of fishing areas. For example, the 'harvest run' of Lobsters and Brown

crabs occurs during August to September time and so the targeting of these species increases during this time as there is more movement of them on the sea floor. However, the months during which the harvest run occurs has changed over time throughout the fishing generations and is generally arriving earlier within those months. Targeting of fishing effort for species is also highly dependent on market prices and supply and demand of shellfish. Best prices are often received during Christian holidays such as Christmas and Easter, therefore an increase in effort in order to land higher volumes of shellfish during these periods increases.

Table 3. Seasonal timetable for Lobster (Lob), Brown crab (BC), Velvet crab (VC) and Green crab (GC) as commercially fished species within Orkney throughout the year. Green highlights when the species could be fished and are in good quality. Red highlights when the species are in poor quality when they have recently moulted and are soft. Yellow represents when the species are berried and blue is when the species receives the best price.

When to fish for species as they are good quality

Presence of berries on shellfish

Fishing of shellfish to be avoided

Best prices for shellfish

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lob | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| BC | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| VC | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| GC | | | | | | | | | | | | |
| | | | | | | | | | | | | |

Better care of catches on board is associated with the handling, exposure to air and light, and correct storage on board or in the water at moorings for an optimal length of time. Further improvements could be made at landing whereby ponds (holding tanks)/ cold chills could be placed on piers so that catches are chilled instantly, allowing an increase in the freshness of catches.

Failing this, management measures could be put in place by using seasonal closures of species, restricting days at sea or further management of creel numbers per vessels. A regulating order could also be enforced through agreement of local fishermen to protect their fishing rights against nomadic boats, as is enforce within Shetland. Further pathways to change identified would also consist of diversification within the inshore fleet by fishing for other species to reduce pressure on current species, allowing rejuvenation of stocks. This would require investment of time, money and gear but

also research into the commercial and marketable opportunities as well as stock levels of other fish and shellfish species. Diversification as a pathway is discussed further on within this report.

### 3.3 Carbon Footprint of Inshore Fisheries

With increasing concerns over the effect of climate change, it is important to consider the wider impacts that fishing has on the ecosystem. The inshore creel industry is a vital resource to Orkney economically and socially, therefore taking steps to identify and reduce carbon footprint (CF) could help reduce impact as well as show action as responsible users of the sea. Further to this the amount of fuel use and evidence of current use and outlay of gear, labour on repair and loss of gear was also investigated. From these results it is hoped that pathways to change could be identified and 'greener' fishing techniques would be adopted by fishermen to further enhance the sustainability of the shellfish industry.

Data was collected from fishermen's questionnaires and through direct figures generated from landings data to buyers and fuel purchase track history from fuel suppliers. CF of the inshore creel fishery focussed on the capture (cradle) to landing (gate) phase of Brown crabs and Velvet crabs. Data analysis of GHG emissions was conducted using SeaFish GHG Emissions profiling tool online.

Results from this study found that CF values generated were uncharacteristically high for the catch to landing phase of the fisheries in comparison to other fish and meat product industries. Fuel consumption by vessels was shown to vary due to season, travel distance and species targeted. Gear outlay was found to be substantial however proper care and maintenance of gear was found to reduce costs and replacement. Overall for the inshore shellfish industry the greatest contributor to CF was fuel consumption.

Pathways to change were identified as mainly fishermen's incentive to reduce fuel use, better fishing practices and increased focus on different avenues and potential for recycling efforts. Pathways to change included strategic and operational changes to fishing vessels which can aid towards reducing fuel consumption. This comprises of modifications to reduce steaming speeds in order to improve fuel efficiency, fuel efficient engines, removal of excess weight, hull maintenance to reduce drag, modifying gear to allow more efficient hauling times such as the addition of escape gaps and the continued use of low sulphur fuels. Strategic changes involved using fishing grounds closer to home ports, avoiding fishing in poor weather, seasonal targeting of species and the use of electronic fuel monitors. Along with these suggestions more cost-effective options include gear fixing, monitoring and continued use of antifouling agents to extend the lifetime of gear.

Another pathway to change identified was increased recycling opportunities offered to fishermen to offset carbon emissions. Suggestions for the pathways include better on-pier recycling facilities to allow easy disposal of old rope and plastics. Several small start- up companies are currently in existence which sees the recycling of old rope as another option for disposal. Further pathways to change should focus on research to determine the whole-chain analysis of CF. Not only this but a change in the attitude of consumers to use locally sourced seafood products and less popular species would also be beneficial. This would help reduce CF in the overall process chain but may also alleviate pressure on current demand and potential for overfishing in current shellfish species.

### 3.4 Further Steps for Pathways to Change- Diversification

Further pathways to change within the inshore fisheries community should include ways to diversify its local economy. Diversification in the context of fisheries has several forms and is further summarised in table 4;

1. Diversification of primary production activities (new fishing gear and techniques), diversification within the fishing sector.
2. Diversification of activities within the fish value chain (adds value to fish products, direct sales, marketing)
3. Pluri-activity, fishermen and their families obtain income from fishing but also through other activities.
4. Broader diversification into areas unrelated to fishing such as renewable energies or other emerging sectors.

Table 4. Adapted from Farnet, 2011. Different aspects of diversification within fisheries.

| | | |
|---|---|---|
| Fishermen and their families | new gears, techniques, species etc. | diversification within the fishing sector (a) |
| | new activities in addition to fishing | pluri-activity (c) |
| | new activities instead of fishing | diversification (d) |
| Products (fish) | direct sales, short distribution chains, valorisation of local products, small scale processing etc. | adding value (b) |
| Area | activities in sectors new to the area, e.g. tourism, culture, services, maritime sectors etc. | diversification (d) |

Diversification can offer fishermen, their families and the local community a possibility to create new sources of income and employment, while also providing services which aid remote fishing communities in remaining a viable place to live, fish and do business (Farnet, 2011). Diversification can therefore help alleviate the dependence on a certain resources (fish stocks) (Brugere *et al*, 2008). Diversification enables another source of economic income and stability when an increase in fishing effort is no longer an effective response to constraints within the industry, such as decreasing stock levels (Henichart*, et al*, 2010). These constraints could include economic crisis, changes in consumer demands, storm events, disease in shellfish, decrease in natural resources due to overfishing or climate change among others (Figure. 1) (Allison, 2002; Henichart *et al*, 2010).

In a 2017 study in Alaskan fishing communities, Cline *et al*, showed that diversification and the ability to opportunistically shift the composition of species exploited can buffer communities against unexpected and large-scale ocean regime shifts and changing markets. While delivery of ecosystem services provided by primarily abundant species, the species that are abundant now may not be in the future. Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. They maintain biodiversity and the production of ecosystem goods (Daily, 1997). Additionally, species that have small market share now may demand premium prices in the future. The diversification process enables opportunities to take

advantage of emerging changes and buffers against disasters; it is a tangible means to increase the resilience and adaptive capacity of coupled human-natural systems.


Figure 1. Adapted from Farnet, 2011. Reasons why a local fisheries community may choose to diversify its local economy.

### 3.4.1 Diversification- Fishing opportunities

One avenue in which diversification could be brought to the inshore fleet in Orkney is through more varied fishing opportunities. Currently in Orkney there is a high reliance on a small range of shellfish landings. The opportunity to fish for different species, such as finfish is one pathway to change and could provide a more sustainable inshore fishery. Throughout this research local fishermen have clearly demonstrated a keen interest and need for this form of diversification. Throughout interviews and observer trips fishers have reported catching good sizes of cod and haddocks as bycatch and demonstrated that their presence and size has recently been increasing in the past few years within inshore waters. The challenges and opportunities to diversification through fishing opportunities are summarised in table 5.

Table 5. The challenges and opportunities to diversification through fishing opportunities.

| Opportunities | Challenges |
|---|---|
| • Less reliance on small range of shellfish<br>• Varied fishing opportunities<br>• Provide sustainability in shock even (e.g. shellfish disease, stock crash)<br>• Provide additional source of revenue<br>• Encourage new entrants | • Quota and Licences<br>• Seasonal availability of fish<br>• Capital costs- gear (nets/lines), boat modification.<br>• Access to markets- no fish market on Orkney, remoteness from major fishing ports.<br>• Local infrastructure- Ice, factory processors. |

| | |
|---|---|
| • Resting of pressure on shellfish<br>• Seasonally diverse inshore fisheries<br>• Reduce bycatch<br>• Ability to fish for bait, reduce cost of buying in bait<br>• Support local businesses such as local fishmongers, restaurant, processors.<br>• Development of fish processors- job creation<br>• Eat more fish campaign- increase of omega three<br>• Development of an Orkney brand for fish | • Transport- specialised transport, cost, distance<br>• Fishing knowledge gap<br>• Physical Risk<br>• Physical access- tides, weather.<br>• Human behaviour barriers |

In 2014 the Scottish Government trialled the expansion of handline mackerel in Scotland's inshore fisheries, which was deemed a success. In each of the past four years 10 meter and under vessels in the non-sector had access to approximately 1000 tonnes of North Sea Mackerel and 300 tonnes of West of Scotland mackerel (Scottish Government, 2017). From this trial there had been effective utilisation of the quota allocation in the North Sea fishery, between 2013 and 2017 and substantial landings were made in Moray Firth, Shetland and Orkney. There was a substantial economic benefit which saw landings rise from £4,462 to £21,739 with a premium of 20% paid for line caught mackerel. For Orkney this clearly highlights the benefits in being able to diversify and the opportunity to small vessels in the under 10-meter category. However constrains exist with supply chain issues relating to keeping this fishery operating and realising best prices for catches.

Diversification of fished species would allow local fishermen to expand and diversify their source of revenue, encourage new entrants, increase knowledge and support local businesses and communities (Kasperski and Holland, 2013). In fishing for other species, this could also reduce pressure on current shellfish stocks. The ability to fish for other species at a time of year when quality of catch is poor would allow a continued income for fishers and prevent the landing of poor quality, unwanted shellfish. An example of this would be when Velvet crabs have recently cast their shells and are soft. During this period, they do not handle or travel well resulting in high mortality and have less meat yield to them. If fishers could target finfish present at this time it would allow Velvets to rest until their shells have hardened and returned to better quality with more individuals surviving during post landing.

Fishing for other species can also lead onto a more diverse and seasonal inshore fishery. It would allow species to rest at certain times of the year throughout their biological cycle such as when they have recently cast their shells are breeding or spatting. This in turn would lessen pressure on stocks through reduced landing quantity and in turn hopefully allow time for reproduction, further contributing to the sustainability of the industry. In having a quota to catch fish, unwanted discards or bycatch could be reduced if fish caught in creels which met MLS could be landed. Further to this, fishermen could then be able to fish for their own bait and reduce costs in buying bait in. The use of bait between vessels varies and is its use, type and quantity are at the discretion of the skipper. On an average inshore creel boat within Orkney fishing for Lobsters, Brown, Velvet and occasional green crabs, bait use is dependent on the target species fished for. On average, a fisherman can use up to five 20kg boxes of bait per day when fishing for Browns, with each box valued on average £20. The ability to fish for own fish could help reduce these costs of £100 spent per day on bait.

Diversification within the fishing sector could also support local businesses within Orkney. Marketing of locally caught fish within restaurants, hotels and also fishmongers such as Jolly's, Kirkwall Bay Shellfish and Orkney Fish. At present there is a market for Orkney fish products with these suppliers offering a range of locally smoked mackerel and salt fish. Further diversification could allow for a more developed 'Orkney fish' brand through improved marketing opportunities and better prices due to higher volumes of fish. It would also allow the opportunity to develop onshore processing activities and employment opportunities. Infrastructure from processing currently exists in the form of shellfish processors in Stromness, Westray, along with a herring factory which is currently not in use.

Increasing the amount of fish caught would also be in line with health recommendations made by the NHS to consume at least 2 portions of fish a week, including one oily fish as a good source of omega-3 fatty acids (NHS, 2018). In 2015 the Scottish Government also recommended that people across Scotland should make the most of fresh and in-season local food in their 'Happier Mealtime' campaign, therefore further promoting the need for the opportunity to catch local fish. The UK retailer Iceland has recently launched its latest sustainability campaign 'What the fish' consisting of a tray of mixed bycatch species to reduce fish waste and encourage the consumption of less popular fish species (Navarro, 2018).

The main challenge which would affect diversification in the pathway to change is mainly associated with the lack of access to and uncertainty over quotas (SeaFarers UK, 2018). There are political and scientific challenges which affect the availability of quota which is not released quickly or easily. The allocation of quotas to the non-sector members is by catch limits, set by government, which may be monthly or quarterly which sometimes does not accurately reflect the species present at certain times or with too late notice of availability for fishermen to catch them. Boats would also be restricted in diversification if they did not hold the correct fishing licences to permit them to fish for additional fish (Kasperski and Holland, 2013). The availability of fish locations vary from year to year as local areas may have more natural nutrient abundances than others (Scottish government, 2017).

Challenges in fishing opportunity diversification exists in access to markets. Orkney does not currently have a designated fish landing port, the nearest being Scrabster and Shetland. This remoteness from ports requires high costs and specialised transport, making exporting fresh fish without additional costs difficult. The risk to fishermen would be the difficulties of selling fish once they have landed. Local infrastructure at landing ports would be needed to support the fishing vessels with onshore facilities and processing factories. While facilities exist for fish processing there would need to be modifications to adapt from shellfish processing and changing to other types of operational management.

Along with the purchase of additional licences, diversification may be costly with regards to capital goods (Cline *et al*, 2017). Different gear would be required to fish for finfish such as jiggers, lines, hooks and nets. Additional equipment would be required on board boats for the storage and chilling of fish such as bins, boxes and ice (Scottish government, 2017). To prevent adverse reputational damage to a fish species correct handling and storage would need to be ensured (Scottish government, 2017). Another challenge for fishers exists in the physical and natural constraints that tides and weather have on participation and transportation of goods in the creation of a new fishery (Scottish government, 2017).

Another risk is of loss efficiency due to fishing for new species about which there is a lack of specific knowledge and taking time to find grounds and understanding behaviour and seasonal timing of species (Cline *et al*, 2017). For fishers there is a physical risk in fishing in less-familiar grounds and possibly travelling further from home ports (Kasperki and Holland, 2013). In taking the time to diversify

into other species it may emerge that boats are not optimized for other specific fisheries and that skipper and crew have less time to develop knowledge about other individual fisheries due to revenue constraints (Kasperki and Holland, 2013). Further barriers to change exist in the human behaviour barriers, some of which involve resistance to change.

The next steps in pathways to change in the diversification of fishing opportunities would be the availability of quota and licences to fish for different species. A trial similar to that of the 2014-17 handline mackerel would give good indications of the impacts and practicality of fished species diversification possibilities within Orkney. Expansion of the fishery may lead to higher volumes of fish which could help establish markets. In turn, this increase in opportunity could help support the development of a high-value small scale fishery and the development of onshore processing activities and employment opportunities.

### 3.4.2 Fisheries Research

To further support the sustainability of the inshore fishing sector in Orkney, further research is needed to address various aspects of biology and stocks of fish and shellfish within the environment. Pathways to change would require the continued scientific collaboration of fishermen and scientists. There is further scope to improve sea fisheries science through collaborative work with fishermen (surveys and mapping), helping address the current time lag between knowledge and action (Sea Farers UK, 2018). By adopting this bottom-up lead research, it can further benefit fishermen as research could be addressed where fishermen believe their industry could benefit. Having a better more well-rounded view of the fishing dynamics in Orkney could help inform local management decisions and marine spatial planning into the future.

Fisheries research that could be beneficial to the inshore fisheries in Orkney would address different biological and environmental aspects associated with commercial species. This research would improve understanding of the life history, genetics and movement of whelks, crabs and lobsters in an Orkney context. Current literature on these species is usually geographically different and can provide different biological parameters such as growth rates. With further research on local shellfish this can provide a better understanding of appropriate stock management which can enable more sustainability into the future.

Research which investigates the availability, seasonality and methodology of fish abundance within Orkney can provide more evidence of the ability to fish for other species of fish. Diversification within the inshore fleet is important for the sustainability of the inshore industry as it would allow fishers to fish for other species throughout the year, create markets and alleviate pressure on existing shellfish stocks. Understanding the spatial and temporal availably of inshore fish can provide evidence and generate the start of stock assessments which could be used as evidence to obtain quota and sustainably maintain stock levels.

Further aspects of fish research could investigate the use of innovative scientific methods and more selective environmentally friendly fishing methods of catching fish. Such studies have investigated the commercial use of pots to catch Cod (*Gadus morhua*) in Canada (Safer, 2010), Norway (Furevik and Hagensen, 1996) and Sweden (Konigson *et al*, 2015). The use of fish traps and pots provide a low impact alternative to fishing compared to trawling and these methods of fishing can exploit areas where trawling cannot operate such as inshore or on rocky sea beds. In addition, the use of fish traps has better selectivity which in turn reduces the bycatch, discards and has relatively high survivability (Macdonald and Mair, 2016). However, discussion into fish traps/pots has been conducted with reference to design, suitable fishing areas, potential species and suitability of pots/ traps, yet little

direct research has been carried out. This could provide a pathway to change in gathering evidence on how this gear type could work in Orkney and provide an alternative fishing method for inshore fishers.

More scientific research which would be beneficial in pathways to change to support the sustainability of the fishing industry could investigate the planktonic spatial and temporal larval abundance of crabs, lobsters and prawns. Very little is currently known of this life-cycle phase within Orkney. Understanding how far crustaceans can travel within their planktonic phase can provide insight into where juveniles originate and settle and the distance they can travel carried along with the oceanographic affects. Better understanding could lead to a protection of nursery areas, habitat types or the harvesting of shellfish from certain areas when likely to be releasing juveniles from brooding females.

A genetic study would also compliment further knowledge of the life history stages as it could help show how much breeding occurs between geographical regions around Orkney of commercial species. Determining the population structure of commercial species would be beneficial in the sustainable management of stocks and fishing effort. Identifying the genetic structure, connectivity and level of gene flow between populations of commercially exploited species could help prevent over exploitation of the species and potentially depletion of populations and their associated genetic diversity.

Other scope for scientific research could seek to address the environmental impact of natural and man-made activities on marine areas. There are many activities conducted within the marine environment in Orkney and a better understanding of the effect of those would be beneficial in order to understand how to best protect fishing interests into the future. Along with damage to the marine environment there are some risks to human and animal health from contaminants and disease. Most notably, microplastics have drawn much attention recently and microplastic contamination has already been noted in intertidal sediments of Scapa flow (Blumenroder *et al*, 2017). The risk is that this can pass throughout the food chains and its presence within Orkney shellfish could pose a commercial threat.

The potential barriers to scientific research for pathways to change is strongly associated with the availability of funding opportunities. The EMFF is a main contributor to scientific research within Scotland, however uncertainty over future funding exists once the UK leaves the European Union. In securing a reliable time series and length batch analysis, long term funding would be needed to contribute to continued scientific research. Other barriers to change exist with fishermen participation and acquiring their fishing knowledge. There is a risk that fishermen will not be forthcoming to project participation as providing fishing knowledge may be perceived as harmful to their business. From this project it has been demonstrated that this is not the case with many fishermen willing to partake with the assurance that their knowledge would be handled appropriately.

### 3.4.3 Marketing

Orkney has a strong reputation for providing premium products of fish and shellfish locally and south to upmarket retailers. In Orkney there is an opportunity around food branding to add value to fish caught locally. This has the potential to mould consumer demand to the type of niche products which the fishing industry can supply. This can present a real opportunity for local producers to develop a special link with the consumer and supply them with high quality locally produced seafood (Farnet, 2014). In pathways to change the future of the fisheries sector is just as dependent on the relationship with consumers and other parts of society (tourism, restaurants and hotels) as it is on maintaining

high quality standards (Farnet, 2014). In todays consumer minded market, it is not enough to produce quality fish but it must be caught in a sustainable manner and be able to tell its story showing how it contributes to improving the situation for local fishing communities. The benefits from a fisher's perspective in developing local and existing markets are summarised in table 6.

Table 6. Adapted from Farnet, 2014. Benefits to local fishers in local branding and marketing.

| FISHERMAN | TERRITORY |
|---|---|
| Improves the image of the product for consumers and perhaps allows for premium pricing | Creates a link between the producer and consumers |
| Makes the product stand out from the crowd (avoid the mass market, develop niche markets) | Ensure traceability and trust in local products |
| Acts as a promotional tool | Can help to improve sector organisation as a federating project |
| Creates an identity for the product | Can help to improve the image of local producers and of the sector as a whole |
| Increases recognition of the quality, authenticity and sustainability aspects of the production | Promotion for the whole territory through iconic products or activities |
| Helps to build customer loyalty | |
| Opens new market opportunities or helps to keep existing ones | |

There is scope for development in pathways to change for the creation of short chains as a good way to meet consumer demand for authenticity, quality and traceability. This form of direct sale is frequently used by coastal fishermen to sell part of their fresh produce and diversify their sources of income. There are some barriers to this change existing in EU legislation determining fishers to be registered buyers. Some flexibility is granted to buyers depending on the amount of fish, its use and the value of the quantities which should not exceed a maximum figure sold to customers per day.

Direct sales could take place pier-side off the boat or on permanent or removable stalls. In the busy tourist seasons whereby, pedestrian traffic increases around the harbour this would provide an easy and convenient way in which to sell landings as well as producing heritage appeal. Fishermen in Stockholm have developed a successful collective project to facilitate direct fish sales in the heart of Stockholm. Other schemes include fish basket schemes in which consumers agree to buy a fixed quantity of fish on a regular basis at a set price. For this to be successful improved infrastructure is needed at harbours along with improved handling of catches. Items required would include water, power, ice, cleaning table, knives, pens, bags, packaging for customers etc. Improved handling of catches could include better chill and ice facilities pier-side and would add value to produce in keep fresher for longer and provide better storage facilities. Better handling could also take place onboard boats with better handling practices and further research into a change of design for bongos and boxes used.

Digital marketing is a technological improvement that could be taken as a pathway to change to improve the sustainability of the inshore fishery. The digital market place refers to a variety of tools

and communication channels that use new technologies to give seafood merchants a way to promote and sell their products. Social media has been used by Cornish fishermen (Drecklyfish) which faced low profitability to raise awareness about the quality of their products and achieve a better price. They developed an auction on Twitter to achieve a higher price for their catch and generate enough profit to deliver to local customers for free (Farnet, 2014). Quick Response (QR) codes have also been applied to products which foster traceability and communication on quality. Mobile apps have also been employed, an example being 'Local Catch' in England which provides customers with information on the source, type and availability of local seafood. Norway Fish Auction have also a linked app used at live fish auctions where consumers can see the fish available for sale and what it was sold for from producers in Norway. In this way, catches can be sold even before being landed which shortens the chain.

Increasing marketing opportunities as a pathway to change is highly dependent on the availability of quota in order to diversify into targeting more fin fish. Improved connectivity for wifi and mobile signal would be beneficial in the development of a digital market as those that live on islands or outside large settlements face access problems.

### 3.4.4 New entrants

Further pathways to change to promote the sustainability of the fishing industry should seek to address issues relating to challenges facing new entrants to fishing. As with most rural, remote and island communities there is a general migration of young people from these communities into larger towns and cities (Highland and Island Enterprise, 2009). There is a general net migration of 16-29 year olds from Orkney mainly for further education and mainly motivated by employment progression (Highland and Island Enterprise, 2009). Islands are most at risk from long term sustainability, therefore providing employment opportunities for local populations could help encourage those of working age to stay.

Orkney's fishing industry structure has an aging and declining population. The average age of fishermen employed in Scotland was 39.4 years and the highest proportion of fishers are found within the 35-49 age cohort (Stewart, 2014). Of the 41 fishers interviewed in this project, over 36 of them fell within the age category of 35 to greater than 65 years old with very few younger generations entering the fishing industry. The fishing industry is therefore at risk of losing skills from long-term fishermen, local environmental knowledge and increased dependence on foreign workers when the current body of fishermen retires. Failing to leave the industry after retirement age and static shellfish prices along with higher operating costs have also contributed to an unfavourable age profile. However, there are numerous young people interested in seafaring through sea cadets, naval cadets and sea scouts, providing a potential pool for recruits into the industry (Sea Farers UK, 2018). Therefore, engaging young people into the industry now could benefit the sustainability of the industry into the future.

There are several barriers which will affect the pathways to change. One of the most prominent is the rising cost of entry into the fishing industry (Sea Farers UK, 2018).Those barriers include financial start-up costs, low exit levels, skills and training requirements and expectations of profitability and returns on investment (Stewart, 2014). A new entrant must finance the purchase of a boat, a fishing licence and quota if they intend to target species which require one, which is an additional barrier (Stewart, 2014). Added further costs exist in the buying of gear and equipment along with establishment of fishing grounds.

The inshore creel industry can provide a low-cost alternative to entry into the fishing industry as a vessel can be bought for £5,000-£10,000 along with acquiring a licence (Stewart, 2014). From here fishers can work their way up through the industry gaining skill, quota, financial capital and build capacity (Stewart, 2014). Further to this they can build up to owning a second-hand trawler or scallop dredger which ranges between £100,000 and £800,000 (Stewart, 2014). Despite the inshore fisheries being a low cost alternative to entering the fishing industry, inflation in the costs of licences means that the price of a new licence is exponentially increasing. This can easily go beyond the price range of those entering the industry for the first time and prevents those without financial assistance from entering the industry. Vessel prices can also depreciate rapidly when the value of the vessel is restricted by the licence.

For new entrants entering the fishing industry, they must compete with existing fishers who can only expand their operations by gaining additional quota. Due to restrictive licencing, capacity aggregations and quota tradability, the cost of purchasing or leasing quota has significantly increased as fishing opportunities have become concentrated in the hands of fewer operators. By providing further financial assistance, reducing financial barriers and making quota more accessible it could further encourage more new entrants.

Other challenges in pathways to change in recruiting new entrants may be education and training requirements. Fishers must undertake basic safety training as well as future skipper and mate tickets. Access to funds for training may deter new entrants from undertaking training. Basic safety training must be completed before new entrants go to sea, this also acts as a barrier to those new to the industry from gaining experience before choosing a career path. The fishing industry also faces competition from other maritime careers such as oil and gas, renewables and the merchant navy in which more stable financial security can be offered (Stewart, 2014).

Pathways to change which should enable new entrants to gain a career at sea, skills and qualifications. Increased investment in younger entrants by making access to the fishing industry easier through financial incentive or subsidised training would benefit the longevity of the fishing industry in Orkney.

### 3.4.5 Outreach

*Festival*

Cultural events and festivals not only help to build a creative environment but also to establish a real connection between cultural policy and local economic development policy (Farnet, 2011). In small towns and rural areas festivals can provide an opportunity to attract visitors to the area and generate revenue to local businesses such as transport, hotels and restaurants. Events and festivals can further be used as a catalyst for further development opportunities in pathways to change.

Orkney already supports a large host of popular festivals throughout the year which receive a large amount of local community support. Festivals include Drama and Storytelling, Dance (Ceilidh weekend), Agricultural shows, Science (Nature and science festival), Sports (marathons), Music (Blues, Jazz, Rock festivals) and Community events such as ‘The Ba’ and ‘Shopping Week’. Many of these festivals are long established, for example the science festival started in 1991 with 4,800 attendants in 2016 and a total overall of 12,800. Therefore, there is much scope and possibility for the development of a fish/sea festival within Orkney.

Other sea food festivals currently operate throughout Scotland. The Stranraer Oyster festival which first commenced in 2017 received over 10,000 visitors. The Galway Oyster Festival is one of Ireland’s biggest festival and features in the Rough Guides’ ‘50 things to do before you die’ list. Again, this

festival is very popular, originating in 1954 with just 34 guests it has grown to attract 22,000 in 2012. These festivals present an opportunity to highlight exceptional seafood and to engage with the wider public. The festivals provide a variety of activities for engaging with the sea, offering workshops and children's activities, an oyster shucking championship competition, cookery demonstrations from chefs and a variety of food and music. A seafood trail is also offered in the Galway festival highlighting local restaurants providing locally caught seafood to try.

In pathways to change, to have a local sea food festival in Orkney would provide the opportunity to showcase the high standard and variety of seafood that Orkney produces. It would also be an excellent occasion to engage with the winder community (locals and tourists) about fishing and the industry. It would also provide a platform for fishermen to come together and showcase their boats, knowledge and products. A sea food festival may also benefit local businesses such as restaurants and hotels which sell Orkney fish products. Again, a similar format could be followed in which local shellfish is sold, there is music, children and cookery engagement along with opportunities for wider users of the sea to highlight the use of the sea.

*Educational*

Outreach and education are an important aspect to address in the pathways to change. Increased engagement with the public would bring more awareness and recognition of the hard work of fishermen and the unpredictability of the amount and type of fish caught. This in turn would help to build support for the sector within the community and raise awareness among consumers with regards to their choice of fish. By also capitalising on and promoting the heritage and tradition that fishing and its history represent in the area, greater awareness can be brought to the fishing industry, which in its nature is quite a closed industry. Fishermen are often seen by others within the community as 'authentic locals' and are viewed without any detailed knowledge of the fishing industry or of fishermen (Reed et al, 2013).

Educational outreach can be created through talks to high school and primary school pupils along with other organisations such as Brownies, Guides and Scouts. Engagement can help educate and inspire science towards improving our understating of ocean life, help conserve and protect our ocean resources, encourage stewardship to care of our oceans and coasts and highlight the employment opportunities (Seafarers UK, 2018) associated with fishing. Information sessions could be set up to tailor talks to correspond and compliment areas within the current curriculum for excellence, thus providing real world examples of applications.

Further educational outreach could be provided to fishermen themselves which would address aspects of fisheries science. This outreach could explain current research, how research is conducted, the biology of commercially caught species, how data is collected by regulatory organisations and how that data is used. It is hoped that this could provide insight into fisheries science and aspects of compliance to help develop working relationships between fishers and scientists.

*Tourism*

In rural coastal communities, tourism can be a major source of income. Orkney already attracts 140,000 annual visitors providing £30 million of economic boost to the islands (Orkney, 2018). In adopting a community development approach, natural assets can be emphasised relating to harbour, seaside and heritage appeal. Inshore fishing plays a large role in this attraction as it is possible for tourists to gain close access to fishing activities (Reed *et al,* 2011). They can view boats, speak to local

fishermen and view landings of daily catches. There can be a greater economic impact when the catch is tied into the cultural and social offering to tourists. As discussed previously, if catches were made easily available for purchase through a harbour-side facility then it could inspire the purchase of Orkney fresh fish and shellfish, generating revenue and further interest in the fishing industry.

Other avenues of tourist engagement which would require capital expense and funding the development of a lobster hatchery, aquarium or fishing heritage centre. Again, this could generate community engagement, promote Orkney produce, enable collaboration with science and generate revenue which could feedback into fisheries related matters in Orkney.

Another option which is in practice in England is the chartering of local fishing boats by the skippers to accommodate boat tours or sea-angling. This artisanal fishery would face challenges related to insurance but could supply an additional source of revenue during summer months. This could also help the move to a more seasonal fishery by providing a means in which fishermen could stay in their industry and not fish during certain times of the year.

## 4. Discussion

Commercial fishing is marginalised as an activity, both economically and politically with the inshore sector being viewed as generally less important as it is not as economically viable as the deep-water fleet. However, it does play a vital part in the rural coastal community economy and local people value it for its social and cultural contribution to the community. Sustainable fishing, as defined by the marine stewardship council, is 'leaving enough fish in the ocean, respecting habitats and ensuring people who depend on fishing can maintain their livelihoods'. Furthermore, sustainability is defined as sustainable fish stocks, minimising environmental impact and effective fisheries management. Sustainability of a fishery is an ongoing process and needs to respond to the challenges it faces at the time. Scientific knowledge also improves all the time therefore fisheries are encouraged to develop new ways of conserving marine resources for future generations. The pathways to change as described in this report through greener fishing practices can help progress sustainability within fisheries.

Pathways to change with escape gaps includes the continued development, sea testing and fishermen's input of the next stage escape gap designs along with researching biodegradable aspects. The continued involvement and participation of existing and new fishermen and full acceptance, and integration of this greener fishing technique into common fishing practise is essential to its success. Pathways to change within the carbon footprint of the industry should focus efforts on reducing fuel consumption and employing greener fishing techniques to help reduce fuel consumption. Effort should also be focussed on carbon off-setting through better recycling opportunities for fishermen at pier-side facilities. Pathways to change in fishing to a seasonal timetable should take steps to encourage local fishermen to develop better fishing habits. Certain species should be avoided for fishing during months when they are poorer quality or berried. The need and opportunity for diversification would alleviate some fishing pressure and allow the targeting of other commercial species.

Local fishermen interviewed within this research were enthusiastic to take part in scientific research. Orkney has a strong reputation of working closely with fishermen and this partnership is one that should continue and be strengthened in further work. Within this research comments developed a common theme in that 'fishing isn't just what it used to be' and one that was commented by older and younger fishermen. This was mainly in reference to fishing stocks and the apparent decline in

fishing stocks where fishing in Orkney used to be more lucrative according to fishermen. Change in management, regulation, species abundance, seasonality of species were commented on by fishermen having changed over time. A common theme was present amongst these interviews was that greater fishing effort is required get the same returns of shellfish compared to the past. This increase in fishing pressure, along with an increase creel numbers, highlights the need for adoption of greener fishing techniques to help secure the sustainability of the fishing industry.

In adopting the suggested pathways to change this can help support local fisheries in protecting and enhancing their stocks and local management regime. There are many challenges associated with pathways to change including financial, managerial, legislative and behavioural obstacles regarding change. In order to sustain local fishing opportunities consideration must be given for growth and development even more so, in the political climate of Brexit, it is the time for change. In adopting greener fishing techniques and continuing research, local fisheries can take ownership of the effect that they have on the environment and become responsible users of the sea.

## 5. Conclusion

In conclusion this report investigating pathways to change in the inshore fishing industry has revealed several steps which can be adopted as greener fishing techniques to help secure sustainability. The challenges in the pathways to change are mainly associated with change in fishermen's attitudes, fishing patterns, challenges over opportunities and financial constraints as well as funding opportunities, time and effort. Fishing management and regulation success is reliant on continued participation and communication with local fishermen. For those fishermen invested in the longevity of their industry, positive involvement, trialling of new methods, practices or ideas as well as being consulted on management and science is essential.

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