Fisheries Innovation Scotland

**FIS036
A Digitalisation Roadmap
for Scottish Fisheries**
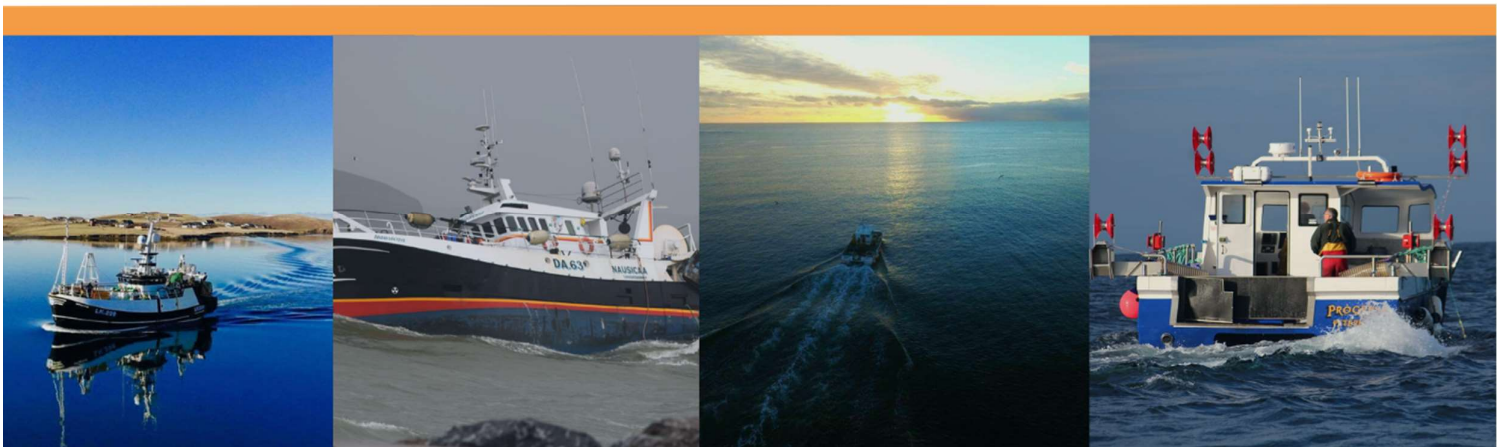
A Digitalisation Roadmap for Scottish Fisheries

May 2021

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Executive Summary

- This roadmap attempts to identify the key steps which may be taken to maximise the utilisation of appropriate digital technologies to enhance data collection, position the industry proactively and strengthen and protect the Scottish seafood brand.
- Many of these challenges concern the efficient collection, verification, integration and communication of data.
- There are several existing building blocks in Scottish fisheries which can be developed as pillars of a Digitalisation roadmap including: technical and human resources in industry-science partnerships; a modern offshore fleet with significant technical resources; a strong domestic market for some target species with relatively short supply chains; a cross-sectoral organisation capable of taking an overarching perspective and a strategic approach.
- There are also some significant challenges facing the sector with regards to the transition to a digital future including: export problems with an increased rather than reduced paperwork burden; barriers to integration of regulatory and other data streams; the necessity to include smaller operators and ensure that not only are they not left behind in the transition but that they flourish.
- We outline a process which we believe will build on the positives and address the negatives.
- In order to do this, we propose a series of pilot projects which can be seen as steps on the pathway towards digitalisation.
- The overall approach to the pilot projects is governed by a number of key considerations:
- The basic premise is that they should incrementally replace the current largely ad hoc and disintegrated approach to data collection with a co-ordinated approach.
- They should aim to capture data once but use it as many times as needed.
- All projects should be producing data outputs which can be integrated with other data streams.
- The pilots commonly feature a central portal where the relevant data is captured, and a set of specific consents whereby specific data streams will be shared with data users. These users may include science, market, certification, marine policy and decision makers. Some of this data may fall under the definition of "personal data" and therefore its recording and processing must be compliant with GDPR legislation. This is dealt with in further detail in Section 4 below.
- The priority or order of the pilots is not intended to be a constraint and they could be done as stand-alone projects or in some cases, for example 1 and 2 listed below, could be merged and done together.

- Pilot 1 Virtual integration and Verification of Scottish Seafood. This proof-of-concept pilot project has linked objectives: firstly to ensure verification of provenance, sustainability and compliance of Scottish seafood; and secondly to provide 2 way visibility throughout the supply chain thereby opening up integration opportunities to

all operators regardless of size. This would be done by implementing a traceability system, based on GDST, on a phased basis in a selected seafood supply chain vertical.

- Pilot 2 "Certification and Standards Integration" aims to fully digitalise, integrate and streamline data collection under a number of different standards which currently require significant duplication of effort and in some cases paperwork. It builds on Pilot 1 and goes further in allowing the differentiation of product based on adherence to various standards. Vessel and processor lists from each standard would be brought into a common database and a single technology-based chain of custody would be developed as a technology "annex" that would sit alongside existing standards in the processing sector but give real-time robust traceability in a distributed ledger (blockchain) solution from vessel to plate.

- Pilot 3: Crew Welfare Data Integration aims to efficiently integrate currently separate datasets regarding crew working conditions, safety and training. This would provide the ability to demonstrate compliance at vessel level with various regulatory and standards requirements regarding working conditions. The pilot could be done through the integration of crew data from vessels, the Seafish training register and possibly from the Online Safety folder. This could serve to add a verification layer regarding crew issues to Pilot 2.

- Pilot 4: Digitalised Scottish Fish Exports is closely focused on the goal of streamlining the export of Scottish fish which has become a problematic area recently. There appears to be a particular issue for smaller operators due to a lack of resources. It may be possible to base this pilot on how some larger operators have successfully tackled the issue. We are aware also of issues with smaller players in destination countries having similar issues with importing Scottish fish. A potential solution could be to look at a cloud-based platform solution where a groupage load is compiled by a Scottish entity arranging logistics and sent to a virtual or physical entity in an export country who would distribute the load to smaller players.

- Pilot 5: Integrating onboard scientific and supply chain data. Currently self-sampling and observer data is available to specific haul level particularly for pelagic species. Processors also have significant levels of data available including size grades, yield, catch composition etc. Having the ability to integrate both data sources would add significant value from scientific, market and management perspectives for all fish categories and fleet sectors including pelagic, demersal and shellfish. Pilot 5 could take inputs from the planned inshore vessel tracking program and integrate with processing data to expand the economic and spatial data from inshore vessels.

- A potential final step towards full digitalisation and integration could be the co-ordination of all of these pilots under a central management system or data repository where all fisheries data will be stored, integrated, queried and distributed in an efficient manner.

- This data repository would ideally be owned by a cross-sectoral stakeholder group from across Scottish fisheries and supply chain and managed by an independent third party on their behalf. Under various agreements specific data streams will be shared with users of the data. These users would include science, market, certification, marine policy and decision makers.

- A significant advantage of the development of such a system is that it would put the fishing industry in a more proactive position with enhanced ownership of the data and would give it greater ability to get "ahead of the game" rather than reacting to an externally driven agenda.

- However, the development of a central data repository will face significant challenges and a realistic approach to this is necessary. The potential pilot projects are designed to support the overall goal of moving towards a fully integrated and co-ordinated data repository if that is an agreed approach by FIS but also to be independently beneficial in addressing specific challenges.

- There may also be currently lower priority uses such as environmental data collected by fishing vessels which may have future value well above current levels.

- We see a key role for FIS in taking a strategic overview of the transition to digitalisation so that progress is both coherent and inclusive. There is a risk that different sectors, with varying concerns and agendas, will not be sufficiently aware of global trends, including those in other protein classes and the issues that different sectors in Scottish fisheries are progressing or struggling with. In this scenario only the larger players with both the sufficient resources and oversight are likely to be successful in the transition.

Overall Goal:

This digitalisation roadmap for Scotland's fisheries sets out the steps that we feel could be taken to arrive at a point where appropriate digital technologies supporting the following outcomes and benefits are implemented:

- The catching sector taking control of its own destiny by being proactively involved in verifiable collection of the necessary data to answer scientific, sustainability and other management questions.
- Value is added to catches through improved access to premium markets and differentiation of sustainable products.
- Processors, retailers and producers have confidence in a de-risked, cost-efficient and transparent supply chain.
- Consumers are provided with clear communication about Scottish fishery products including verifiable ethical and provenance credentials.

We should point out however that the roadmap should not be viewed as something set in stone but as a starting point for a broader discussion of a digitalisation strategy for Scottish fisheries.

The short duration of the project dictated that we take an overview approach rather than looking in depth at a particular issue, for example industry self-sampling programs, where those working within that field likely have more detailed knowledge than we do.

Either in advance of this study or arising from meetings held during it, we became aware of several initiatives relevant to the overarching digitalisation roadmap. These initiatives include but are not limited to:
- Marine Scotland data collection across Scottish fleets and fisheries.
- Industry data collection and self-sampling initiatives in shellfish, demersal and pelagic fisheries feeding into the Marine Scotland data system.
- Bycatch data collection under the BATMAP project FIS032.
- The Scottish Inshore Fisheries Integrated Data System (SIFIDS) project.
- Specific regional management initiatives e.g., the Outer Hebrides Pot Limitation Scheme.
- Marine Scotland Future Fisheries Management Strategy

These initiatives are functioning well in themselves, achieving their specific objectives and our approach is to integrate them into the digitalisation roadmap. To avoid duplication of effort detailed consideration should be given as to how these existing initiatives could be integrated into the pilot projects proposed in Section 5. For example, the Outer Hebrides pilot pot limitation scheme, which appears to be working well in improving sustainable management of shellfish fisheries in the pilot area, could provide additional benefits throughout the supply chain. The spatial and sustainable management data collected in the scheme could be integrated into Pilot 1 or 2 and result in access to new markets with increasing demands regarding verification of provenance and sustainability.

We have attempted to summarise the relevant issues, locate them in the context of the overall roadmap and to propose pilot studies aimed ideally at resolving outstanding questions and testing the proof of concept. As part of that overview, we looked in particular for integration opportunities where different but related datasets were available but currently non-integrated. A related issue was an emphasis on collecting the data once and where possible using it multiple times for different purposes. We also tried to position the fishing industry in a proactive role within the roadmap as we felt that there is an appetite for this within the industry itself.

Section One: Key Questions

The first step in the project involved the creation of a study framework for collecting and analysing relevant information from representatives of all Scottish fleet sectors. This framework was based on the overarching principles and requirements outlined in the FIS project call and on our own experience. The framework would cover the types of data that are currently collected, how that data is captured and transmitted and what additional data would address impending or existing challenges. This framework would include an assessment of the benefits that digitalisation can bring across different datasets and the digital tools that can be used to realise those benefits.
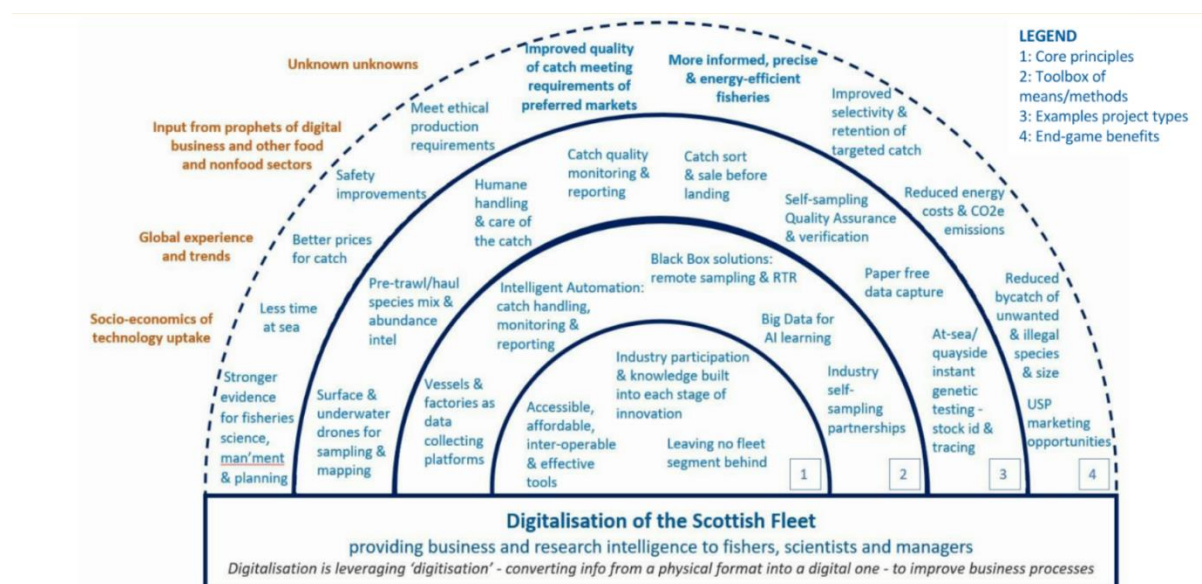
Figure 1: Summary of FIS Principles and Ideas for consideration in FIS036

The framework firstly set questions aimed at outlining the current fisheries data situation:

- Which datasets are currently collected?
- How is the data captured?
- How is it stored and transmitted?
- What are the current uses of these datasets?

We also set questions which were aimed at looking ahead to see how additional datasets or integration across datasets could add further value:

- Within which areas of technological development in fisheries can a digitalisation approach yield additional benefits?
- How can existing datasets be collected and transmitted more effectively?

- What additional uses are there for this information?
- What other datasets could be beneficial to the fleet?
- What digital tools can be used to realise those benefits?

We established categories for different types of fisheries data or different points in the fisheries supply chain and with assistance from FIS we set up a list of individuals that we wanted to meet with.

Section Two: Meetings with Scottish fishery stakeholders.

The second step involved meeting with representatives of the main fleet and supply chain sectors to discuss the topics outlined above and other relevant issues arising. We held 15 meetings with representatives from Scottish inshore, demersal and pelagic fleets, scientists involved in industry data collection, fish sales, processing and retail companies and regulatory bodies. We believe that these interviews gave us an excellent cross-section of perspectives on digital opportunities and challenges for Scottish fisheries. The following section summarises the recurring themes that came up during our meetings.

Key issues arising:

Scientific Data

- The fishing industry are gradually increasing their data collection and self-sampling capacity both in terms of human resources and technical aspects.
- The trend of scientists being employed by the industry points to a greater sense of ownership and responsibility for scientific data collection.
- This ownership in some cases only goes to a certain point however and some participants referred to a so called "black box" problem where data collected by industry can become essentially invisible to them once it enters scientific databases.
- There is a perception that this can limit participation in data collection initiatives.
- Regarding the use of digital tools such as tablets for data collection there were mixed experiences with pelagic data collection progressing more smoothly than demersal.
- The potential to integrate vessel level data with processor data both in order to increase data sources but also potentially as a partial verification of self-sampling on vessels (excluding discards) was stressed.
- The issue was raised regarding whether automated and increased supply of validated industry data could in some way mitigate the time lag problem where fishers felt that quotas were set based on what vessels were seeing on the grounds 2 years previously.
- One respondent felt that this time lag was a significant driver of discard problems.

Fleet issues

- There may be connectivity issues for some fleets, particularly inshore and island vessels, that should be taken into account.
- Payment for collection of fisheries and environmental data could form an additional revenue stream which may be particularly beneficial for smaller vessels.
- There is strong interest in the use of technological or digital solutions to long standing issues such as bycatch monitoring (BATMAP) or reducing effort in pot fisheries (SIFIDS, Hebrides pot limit pilot scheme).
- There was strong interest in the use of digital solutions to differentiate catches based on criteria such as adherence to labour regulations, sustainability etc.

- Duplication of effort was a significant problem when dealing with multiple sets of paperwork or online records for different standards, for example crew records for multiple reasons ILO, RFVS, MCA.
- The option of initiating the tracking of fish through the barcoding of fish boxes on board vessels was raised.

Labour conditions and Social issues

- A frequently recurring theme was that compliance with labour regulations was now a more significant issue than sustainability.
- Verification of good working practices and conditions has become a significant element and in some cases the foundation of ethical sourcing policies and standards.
- The advantages of integration across ILO crew registers required by vessels and safety training databases maintained by Seafish was stressed by a number of respondents.
- The Online safety folder[1] was identified as a useful resource which could be built on as part of an integration with Seafish records.

Supply Chain and Traceability issues

- Due to the internationally traded nature of seafood products, it is still considered by seafood buyers to carry a significant integrity risk.
- Risk factors include regulatory compliance and species substitution.
- Additional levels of verification are a priority for retailers.
- Traceability through the supply chain is not considered by retailers to be a competitive advantage as the consumer assumes it is a default.
- The possibility of applying the GDST standard from the retailer back to vessel level had significant support and was described as a potential game changer.
- The utility of traceability in offering 2-way visibility of supply chains was stressed. Benefits for the catching sector would include the provision of previously unavailable market information and in protecting geographical origin of products.
- Significant fish export difficulties were frequently mentioned. These included greatly increased paperwork requirements and greatly additional costs of paperwork costs of up to £2/kg.
- An electronic monitoring and verification of temperature through the supply chain would be of interest particularly for high value species.
- A digital based DNA verification system as a means to combat species fraud was of interest.

Sustainability and Responsible Fishing Certifications

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[1] (https://www.safetyfolder.co.uk/)

- There are multiple standards which in some cases overlap significantly (e.g., MSC, FIPs and RFVS) requiring duplication of effort in data collection and record keeping whether on paper or online.
- The sustainability requirement was described by some respondents as not being consumer driven as either the consumer assumes it is a default or not their main concern.
- There has been a temporary reduction in the prioritisation of sustainability for buyers due to the Covid crisis, but this is not expected to persist.
- The potential to differentiate certified fish in the supply chain is a positive for most but there is also some concern about the exclusion of some vessels depending on circumstances due to the restrictive nature of certifications like the MSC.
- The loss of MSC certification in Mackerel is a significant problem in markets.
- The need for the fishing industry to take more control of its own destiny, to "get ahead of the game", to be proactive so that it is in a strong position to set its own agenda was frequently stressed.
- FIPs may be a more flexible solution than restrictive standards such as MSC for some fisheries.
- The issue of humane handling of fish is rapidly growing in significance with regards to certifications.

Regulatory issues and data

- Practical difficulties with integrating regulatory data with other initiatives were described. An example of this is the necessity to install secondary location sensors in FIS032 (real-time catch app) as there were issues with accessing vessels VMS data.
- Federated learning was described as a potential tool in the analysis and integration of regulatory data.
- There are proposals to make the use of Remote Electronic Monitoring mandatory on pelagic vessels in 2021.
- There is currently a program in development to track the spatial distribution of inshore fishing vessels.

Fish Sales

- The relative benefits of fish sales through Auctions and Contracts were discussed in the context of digitalisation and business planning.
- The necessity of competing with supply from vertically integrated Icelandic companies and from other nations was stressed.
- Some data integration is already occurring at auction level including for regulatory purposes.
- Fish exports still depend at least partially on paper-based records.

Behavioural/Incentive issues

- The value proposition for digitalisation is not always clearly understood by operators across all vessel sizes and sectors so it needs to be clearly communicated.
- Fears about how data will be used are a significant disincentive for some fishers which reduces participation in data collection initiatives.
- The level of automation in digital solutions has a direct bearing on the uptake rate of tools developed.
- Product differentiation would help to tackle free rider problems associated with sustainability/responsible behaviour and would drive participation in such standards.

Spatial data

- There is a significant data gap with regards to spatial distribution of inshore fishing effort.
- This data gap can have a direct impact on the quality of decision making regarding the use of marine space.
- The siting of aquaculture operations and offshore wind farms are significant concerns in this regard.
- There is a plan to address the spatial distribution of inshore fishing effort data gap through the fitting of location data recording on all vessels under 12m.

Section Three: Digitalisation Analysis

This section analyses the outputs from the meetings and outlines the building blocks of the digitalisation strategy. Digitalisation in fisheries encompasses a wide variety of tools and uses and in this section, we examine which of these represent the most fruitful avenues for Scottish fisheries. To provide a coherent structure to the section we have broken down the issues into a series of categories although it is important to note that some issues cut across several or all categories. Under each of the categories described below we analyse issues raised during the meetings and how they may be addressed as part of the roadmap in the short and medium-term by the application of digitalisation tools.

Categories

Onboard Vessel

This is the starting point for the majority of fisheries information and represents the broadest category. There is a very wide array of data which is currently collected onboard fishing vessels including:

- Regulatory data streams in particular electronic logbook and VMS data.
- Regulatory data covers catch quantities, catch composition, gear used and spatial information.
- Scientific data collected by observers and as part of self-sampling programs.
- Data concerning crew qualifications and conditions such as hours worked etc.
- Data used for various standards and certifications such as RFVS, MSC, FIPs.
- Data collected as part of recently emerging pilot schemes such as the effort data collected under the Outer Hebrides Pilot pot limitation scheme or bycatch data collected under the BATMAP project.

There are also a wide variety of additional data streams which could be collected, or which may already be collected on a trial basis including:

- Remote monitoring of catch through the use of cameras on vessels.
- Advances in fish selectivity as covered under the Smart trawl project FIS034
- Bycatch data as covered under the BATMAP project FIS032
- Environmental data such as sea temperatures, plankton abundance recording etc.
- Humane handling of catch and catch quality

A significant opportunity exists to improve the availability of spatial data which is already collected but not always available for over 12m vessels and is largely not available for smaller vessels. The use of spatial data is an increasingly important element of fisheries management due to increasing competition for marine space and is critical to not just management of fish stocks but also in defining areas that various fleets are dependent on. A key consideration

with spatial data regards the ownership, management and use of it. We propose that improvements in how this data is collected and used represents an opportunity for industry to assume a more proactive role with greater ownership.

There are a number of issues with moving forwards with the integrated collection of vessel level data. One of the most significant is that for some fishermen existing data collected are perceived to be in response to external factors such as regulations, market demands or environmental NGOs. Additionally, there may be difficulties for vessels to use the data collected on their own vessels for new initiatives. A good example of this is the necessity for participating vessels to install a second location recording devices for the BATMAP project as it was not possible for the vessel to access its own VMS data. Another example is scientific data which is collected at vessel level but when it enters the "black box" of scientific assessment is no longer visible to the original data providers. All of this can create a buy-in problem which must be addressed for digitalised streamlining of vessel data to occur.

Our overarching proposal to create a data repository, at least partially owned and administered by the fishing industry, attempts to re-position the catching sector in a more proactive role where they can see the value of the data they are collecting and where appropriate capitalise on it. Access to individual vessels data could be granted on a specific consent basis and there may be downstream financial benefits for the data providers with the potential to charge for access to vessel collected data held in the database.

The pilot projects outlined in Section Five attempt to bridge integration gaps with vessel level data and to eliminate unnecessary duplication of effort, reduce paperwork and add value to the data collected.

A specific example of how paperwork could be reduced would be through integration of crew records (some of which are paper based) for ILO regulations, RFVS, MCA. This is described in further detail in our proposed Pilot 2 in Section Five. This integration would also have benefits in terms of validating crew information through the supply chain. Further integration with data collected for various standards including RFVS, MSC and FIPs would again reduce paperwork, promote uptake and create supply chain benefits.

Supply Chain - First Point of Sale/Processing/Retail

During fishing trips, the fishermen enter catch details each day and complete a landing declaration at the end of each trip for the full quantities onboard, catch areas, gear types etc. Once a vessel lands the catch is weighed onshore, a sales note is generated and sent to the regulatory authority by the first point of sale which is used as a check against the information that the fishermen have entered. The same information is used for the creation of a catch certificate which is required if the fish is being exported. The first point of sale or processor then starts its own traceability intake system and follows the fish through the process of grading, creating batches for orders and distribution or processing. These companies then send data to their own customers labelled using the regulatory requirements.

While fishing vessels sometimes receive feedback from further up the supply chain, such as from electronic auctions or sales agents, it is not always the case that vessels get quality and food safety information, for example, SO2 levels in Nephrops on any landings once product moves along the supply chain.

The regulatory requirements on labelling do not include data such as the sustainability credentials of the product, crew information on the vessels that caught the fish, training that the crew have undertaken in terms of food safety or whether that vessel has taken part in contributing to scientific data collation or carried observers onboard.

Retailers are seeking more supply chain verification information all the time as there are integrity concerns surrounding seafood, particularly given the internationally traded nature of seafood products. They see further verification as being highly valuable in terms of protecting their own brands by having available the data that today's consumers expect them

to have in terms of knowledge of their supply chains. Some retailers wish to develop closer relationships with their suppliers to support their marketing strategies and some also want to tell the story at shelf level. Retailers are currently using sustainability certifications and engaging NGOs to assist with the task of providing them with supply chain verification, for example MSC, Sustainable Fisheries Partnership and others.

One of the key emerging trends internationally is interest in, and early adoption of, the Global Dialogue for Seafood Traceability (GDST)[2] standard for data transfer in seafood supply chains. The underlying goal of the GDST has been to enable access to verifiable information to ensure the legal origin and responsible sourcing of seafood products.

Barriers:

The supply chain may be cautious about sharing data due to commercial sensitivities and GDPR and Freedom of Information concerns.

There are opportunities in several areas:

Additional information not currently required under labelling regulations could be captured once at the landing point and shared with supply chain participants. For example, sustainability data for specific batches could be shared along the chain.

Quality and food safety reports captured along supply chains could be shared with vessels using a cloud-based portal.

Data for catches and landings verification could be shared with retailers.

At the point of landing data could be captured using the GDST Standard Key data elements. This could be stored once, associated with a batch and updated as product moves along the supply chain.

There are many examples of highly successful vertically integrated seafood companies, (Iceland, Canada, Scotland). The reasons for the success of these companies include the fact that they have a deep understanding of the full supply chain, from catch to retail. The connectedness of their operations gives them a commercial advantage. Given the power of emerging technologies, for example Blockchain, and the power of cloud-based computing it is possible to bring the advantages of a more integrated supply chain to currently fragmented, disconnected players. This **virtual integration** would provide opportunities that are currently beyond the reach, or at least require reasonable levels of investment and strategic thinking that may not be on the radar for many fishermen and sales organisations. It is highly likely that the larger, well capitalised catching, handling and processing players will invest money themselves in digitalisation strategies. A virtual integration could bring the advantages of such a program to a wider range of stakeholders. Throughout the course of our interviews, we have learned how larger players are now coming to terms with the export requirements that proved so difficult last January and are currently investing in technologies to make this easier. A FIS strategy should look at how it can assist in the delivery of these solutions to the players currently investing but also how these solutions could be scaled out to Scottish seafood

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[2] (https://traceability-dialogue.org/)

industry players that are currently struggling to catch up with the changing landscape. Just one example of how this might work is to capture data at landing for small shellfish vessels and give them the opportunity to share this with buyers along the supply chain enabling them to tell the story of the product but based on the foundation of using data that has already been captured and sharing that under a set of permissions.

Digitalisation presents an opportunity to bring more coherence rather than fragmentation to the industry to enable smaller players to be brought along with the implementation of digitalisation. There is potential for FIS to inform the industry and guide strategic adoption of digitalisation in a manner that will benefit the most players in the Scottish seafood sector. For example, in the US the National Fisheries Institute (NFI) is currently looking at the role that Blockchain and GDST could play in seafood supply chains. The purpose of their engagement in the process is to assess the emerging technologies and trends is to arrive at a considered position and advise their members accordingly. Otherwise, the adoption of the technology throughout the industry will be in a piecemeal fashion with budgets, siloed market demands and technology companies selling themselves to the players involved setting the pace and direction of the digitalisation roll out in the US.

In section Five, we propose a number of discrete pilots, which would deliver supply chain benefits in their own right and the successful delivery of which would deliver a fully integrated, co-ordinated and digitalised Scottish seafood sector.

Sustainability and Responsible Fishing Certifications

External sources often require fisheries data for various certifications:

- MSC - for sustainability certification
- Fishery Improvement Projects – Plans to improve the sustainability of fisheries
- Sustainable Fisheries Partnership, WWF, OceanMind – collect data for supply chain validation purposes and to facilitate public reporting on sourcing caried out by retail chains
- Responsible Fishing Vessel Scheme - Becoming certified requires the provision of vessel related data such as crew information, training, hygiene records etc.

Each of these schemes have separate lists of vessel, processor and retail participants. There are opportunities to integrate the lists of what vessels and companies are joined each scheme. When supply chain traceability is back to vessels and processors it would then be possible to see exactly what a given vessel or processing company is participating in quickly and seamlessly. Storing this data in one place could provide the foundation for a new "hub" gathering together sustainability and responsible fishing initiatives and provide a forum where the catching sector could contribute to progressing new initiatives and take more control of their own destiny in terms of external entities seeking data and buy in from the sector. There is an example in the US, the Commercial Fisheries

Research Foundation (CFRF) [3] which is a collaboration between commercial fishermen and scientists with government backing. The CFRF has established an identity that promotes a positive image of the catching sector and enables the sector to put forward what it does rather than being asked to meet external standards all the time and being behind that curve. Such an entity could also assist with the provision of data to MSC, FIPs, and other external sources.

In Scotland, many of the parts of this puzzle are in place and a strategically developed set of pilot projects would lead to a smarter, more integrated sector.

Scientific data

Currently scientific data on fisheries are collected through a number of streams, primarily scientific surveys, port sampling, onboard observer and self-sampling. Our analysis is mainly focussed on the latter two elements as we feel that these are the most significant in terms of improvements which may be made through enhanced digitalisation.

There are numerous applications for digitalisation in the collection of scientific data which can assist in the addressing of several current challenges. Increasing relatively low levels of observer coverage on fishing vessels is an expensive undertaking and recently the use of observers has been difficult due to Covid issues. There has been a significant trend, very evident in Scottish fisheries, of increased involvement of fishing industry bodies in both the employment of fisheries scientists and the development of partnerships with Marine Scotland aimed at improving the supply of high-quality verified data. There is also a trend, mirrored in other countries also, of an increased emphasis on provision of industry self-sampling data. This is particularly relevant to the Scottish fleets with the UK being an independent Coastal State and potentially requiring additional fisheries data to support fisheries agreement negotiations.

We feel that there is a significant opportunity to increase the flow of robust, verified scientific data and to build on recent trends in science-industry partnerships in Scottish fisheries. Such partnerships, in addition to increasing data supply, can also build trust between scientists, fishers and potentially other stakeholders in the supply chain. Potentially improved supply of scientific data could assist with management issues such as reduction of discards by providing more timely data.

There are some barriers to the enhanced digitalisation and integration of scientific data collection. Technical issues regarding hardware and software used for data collection have in some cases led to increased rather than decreased levels of manual data collection work required. The issue of data disappearing into a "black box" is a problem from a catching sector perspective which could be contributing to a lack of buy-in from some fishers. There are ongoing issues regarding levels of trust and a crucial issue relating to self-sampling data relates to how it is validated.

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[3] http://www.cfrfoundation.org/

Our proposed Pilot 5 in Section Five covers the integration of vessel level observer and self-sampling with processor data. This pilot could also address issues with digital data collection tools used and seek to increase participation levels by vessels. In order to link with discard and bycatch issues the pilot could also seek to integrate with data from the ongoing phase of the BATMAP project.

Regulatory data

Data collection for regulatory purposes is already on a digital basis for significant elements of the fleet with all vessels over 12m recording location data automatically through the VMS system and the majority submitting daily catch data through the electronic logbook system. For inshore vessels the system is still paper-based and there is not a requirement for vessels under 12m to use VMS. Data is also required to be submitted under the ILO 188 regulation and may be digitally or paper based.

Integration of regulatory data with other data streams would present a major opportunity to improve verification, reduce duplication of effort and therefore reduce costs across a range of data streams including through the supply chain as far as the retailer and for initiatives such as sustainability and ethical labour condition certifications. There is also a significant opportunity for the fishing industry to prove compliance through such an integration.

There are practical difficulties with accessing regulatory data as for example with the BATMAP project which was unable to utilise VMS data despite having the consent of skippers. There are also fishing industry concerns regarding access to confidential and commercially sensitive information. This could be a particular issue where integrating across regulatory and commercial data is sought by private companies such as processors or retailers. Integration issues across different data formats can be a significant issue as was found to be the case in an Irish fisheries data integration project "Joined-up Thinking from Joined-up Data" carried out by the Marine Institute in 2016.[4]

There is a significant data gap for location data of inshore vessels. This also represents an opportunity and a digital solution to plugging this data gap should form part of the roadmap. This issue is currently being addressed by Marine Scotland who are examining the placement of location recording devices on Scottish inshore vessels.

Emerging Digitalisation Trends

Ensuring a digitalisation strategy is relevant and will play a role in future proofing the industry requires consideration of emerging trends:

Supply chain validation is a major driver as retailers globally seek to protect their brands particularly in light of society's growing concerns regarding environmental protection.

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[4] https://oar.marine.ie/handle/10793/1665

In recent years many companies, including major buyers of seafood, are moving from their Corporate Social Responsibility policies to implementing Environmental Social Governance frameworks as a means of measuring progress towards their sustainability and environmental goals. Crucially, much of the reporting on achieving targets will be reported on publicly, this means the relentless march of demonstrating sustainability targets are being met will become even stronger.

Consumers want to know more about the products they are purchasing for example a 2019 Forbes.com report found 93% of people reported that they are concerned about the environment, with 77% wanted to learn to live more sustainably.[5]

People are making changes to their diet in order to live more sustainably. A 2020 Galllup phone poll in the US found that 1 in 4 US adults reported eating less meat in the last year.[6]

Some companies in the seafood sector are differentiating themselves by telling the story of their products at consumer level. Mowi, the farmed salmon giant, is using blockchain traceability from "farm to fork" and making the story available to consumers through codes on pack. They have taken their product offering a step further by selling a new premium salmon product "Mowi Pure" online through Amazon and bypassing traditional retail. [7]

The Norwegian Salmon sector has also decided to differentiate itself on blockchain technology by providing farm to fork information to clients and consumers. [8]

The role of technology (across all food categories):

Consumers

People are spending longer on the internet as they adopt more devices. For example the "Digital 2019 Report" found that 6h 42 min is the average time spent online each day globally.[9] A similar trend was evidence in the 2019 Deloitte "WeAreSocial.com" report which found the average number of internet devices in US households is 11.[10]

The global blockchain in agriculture and food supply chain market size is estimated at USD 133 million in 2020; it is projected to grow at a CAGR of 48.1% to reach USD 948 million by 2025. Benefits of Blockchain in agriculture include easy and cheap food batch recalls in case of emergencies, availability of the complete history of the product status, increased customer trust and loyalty, fairer payments, approved vendors, and proper compliance management.

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[5] https://www.forbes.com/sites/jamesellsmoor/2019/07/23/77-of-people-want-to-learn-how-to-live-more-sustainably/?sh=48b76cb72b01

[6] https://news.gallup.com/poll/282779/nearly-one-four-cut-back-eating-meat.aspx

[7] https://mowisalmon.com/products/mowi-pure-fillet/

[8] https://www.bloomberg.com/news/articles/2020-06-25/blockchain-will-let-you-track-salmon-from-sea-to-dinner-plate.

[9] https://www.digitalinformationworld.com/2019/02/internet-users-spend-more-than-a-quarter-of-their-lives-online.html

[10] https://variety.com/2019/digital/news/u-s-households-have-an-average-of-11-connected-devices-and-5g-should-push-that-even-higher-1203431225/
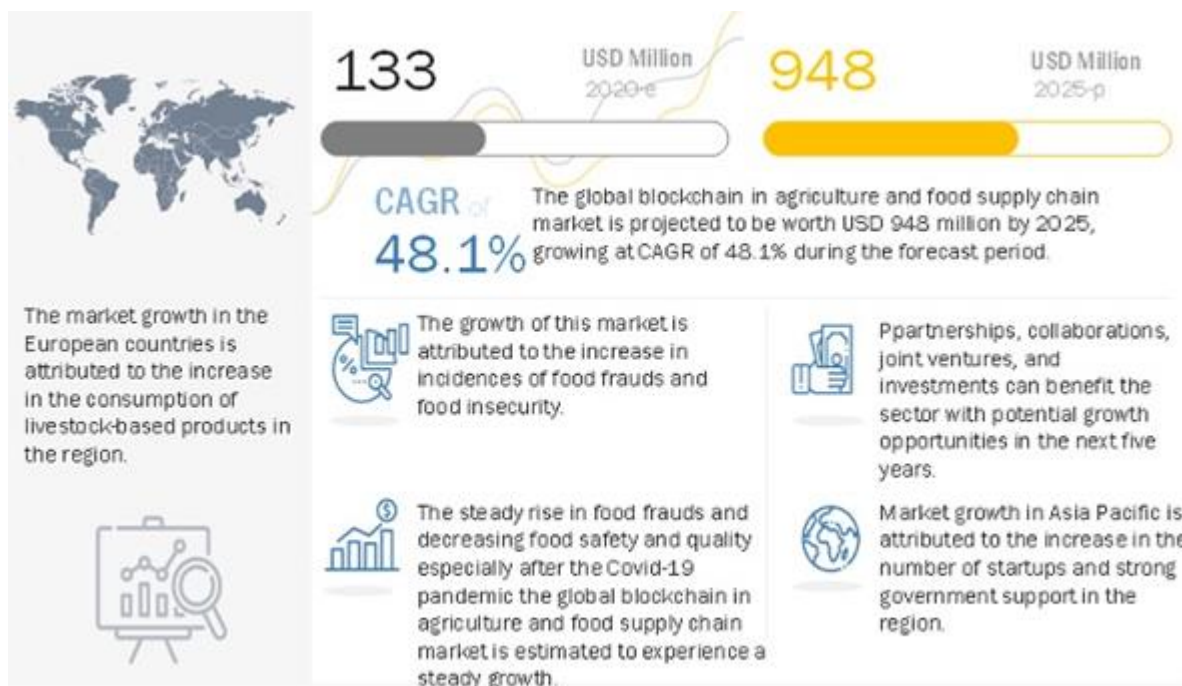
Figure 2 – Global Blockchain in Agriculture and Food Supply Chain Market Trends [11]

The increased use of emerging technologies and cloud-based systems is not driven solely by obtaining supply chain proofs but also driven by the opportunities to save costs by not replicating datasets. The principle of capturing accurate data once, storing it securely and sharing it with relevant parties has multiple applications and benefits:

- Retaining market access and gaining access to new markets
- Avoiding replication of multiple datasets and duplication of effort
- Instantaneous access to data in the event of a recall
- In a single dataset situation information from different supply chain players can be used to cross-verify other players data.
- A single dataset is a form of integration and addresses the interoperability issue of incompatible systems.

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[11] Source: https://www.marketsandmarkets.com/Market-Reports/blockchain-agriculture-market-and-food-supply-chain-55264825.html

Section Four: Consideration of the potential legal implications of collection of data

A number of interviewees raised concerns in relation to potential GDPR issues in collecting the data that would be required under some of the suggested digitalisation pilot projects. However in a number of instances GDPR is not applicable as the data either does not relate to a natural person (i.e. a living human being) or is not in fact personal data. Instead the issue may have related to commercially sensitive data or information which may be subject to a Freedom of Information Request. We have set out below some of the concerns and their legal context.

1. **Crew**

The collection of data relating to crew members raises a number of GDPR risks which must be assessed and addressed before any pilot could proceed. An example in relation to the Crew List data required on foot of ILO 188 includes the collection of "personal data" such as the crew members:
a. Name
b. Address
c. Date and place of birth
d. Nationality

The next section contains further information in relation to GDPR and how it should be addressed.

2. **GDPR**

The collection, storing and processing of this data is, post Brexit, regulated by the Data Protection Act 2018, the UK General Data Protection Regulation and The Data Protection, Privacy and Electronic Communications (Amendments etc) (EU Exit) Regulations 2019.

Personal data is defined as any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;

Under the GDPR data can only be collected and processed where the consent of the person to whom the data relates has been obtained in advance or where the processing is required under law. On first examination the collection and submission of the ILO 188 data elements of the which constitute "personal data" which a vessel owner is collecting and storing but which is owned by the individual crew member would therefore require the individual crew members consent. However as vessel owners are required to submit the data to be compliant with ILO 188 the Crew List would therefore come under the exception of where the processing is required by law and the consent of the crewmember would not be required. Notwithstanding this it vessel owners should include in their fishermen's agreement

provisions setting out the data relating to the individual crew members that will be collected by them, how same will be processed and what third parties it will be released to and obtain the crew members consent to same.

Again in relation to the List of Crew required under ILO 188 it should also be noted that the List of Crew must be made available to authorised persons including MCA surveyors, Border Force officers, Fisheries Protection Officers and those authorised by HMRC. the Royal Navy and Harbour Masters. Also for vessels 45m and over the list must be sent on an annual basis to the Registry of Shipping and Seamen. Again while the release of this information to these entities is lawful under the UK GDPR it would be advisable to obtain the crew members consent to same in advance.

To ensure GDPR compliance for any potential pilot project a data protection impact assessment[12] should be carried out during the design phase of the pilot to identify and minimise the data protection risks of that pilot.

3. Sensitive Commercial Data

As set out above GDPR only applies to personal data which relates to a natural person. Therefore where, for example, a fishing vessel, processor or retailer is owned by a company their data is not protected by GDPR. Usually companies protect what it considers to be "commercially sensitive data" by entering into legally binding agreements with those who have access to the data. These agreements usually set out not only the data the entity will have access to, but also the purpose of this access and who they may or may not disclose the data to. So called "Confidentiality" clauses are standard in all commercial agreements whether NDA's, contracts for the supply of goods and services and so on.

In relation to any pilot which might collect or access data which the participant may consider to be commercially sensitive data an agreement should be entered into with each participant prior to the commencement of the pilot identifying what data the participant considers to be commercially sensitive, establishing the purpose for its use in the pilot and the participants consent to same. Again if the data is being disclosed to a specified third party as part of the pilot the participants consent to this should be obtained and the purpose for the disclosure and limits on the use of the data set out and agreed to by all parties including the specified third party.

Going forward should the data specified as commercially sensitive data be released to any additional entities the data owners explicit consent to this should be obtained in advance of any release of data.

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[12] https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/accountability-and-governance/data-protection-impact-assessments/

4. FOI

Freedom of Information in relation to governmental/public bodies is governed by the Freedom of Information Acts in particular the Freedom of Information Act 2000 (hereinafter the Act).

Application of the Act

Section 3 and in particular Schedule I of the Act sets out to whom the Act applies. Schedule I sets out a long list of what is considered a Public Authority under the Act including any government department (other than the Competition and Markets Authority and the Office for Standards in Education, Children Services and Skills).

It includes for example under 35 B any inshore fisheries and conservation authority for a district established under section 149 of the Marine and Coastal Access Act 2009 and the Sea Fish Industry Authority.

Information which can be sought under the Act:

Section 1 of the Act sets out that every persons hall have the right to and shall on request be given access to any record held by an FOI body.

There are however a number of exemptions as set out in Part II of the Act. These include amongst others research information (section 22A), commercially sensitive information (section 43) and personal information(section 40). In relation to information from vessels and processors that might be held the only possible exemption could be that set out in Section 43 in relation to commercially sensitive information. Under Section 43 (2) Information is exempt information if its disclosure under the Act would, or would be likely to, prejudice the commercial interests of any person (including the public authority holding it). However this exemption is not automatic.

It is therefore important to consider the implications of the FOI Act should any of the proposed pilots include the collection of potentially commercially sensitive data by an entity that might come within the definition of a Public Authority under the Act. However as the Freedom of Information Act only applies to public bodies (as defined above) should the information be held by a Third Party not subject to the Freedom of Information Act (which would require that they not be holding the information on behalf of a public body) they would not be subject to a request and therefore the information owner could be confident in the security of the information. This Third Party could then be subject to audit by an independent entity to relation to the information held.

Section Five: Next Steps

This section identifies priority areas where digitalisation can have the greatest positive impact and proposes pilot projects aimed at implementation of the roadmap.

Scottish seafood could be a leader in terms of supply chain verification by implementing a digitalisation program. This could provide the basis for a new Standard for Scottish seafood which may not be as mammoth a task as it sounds. A new Standard could recognise or grant equivalency to existing Standards and then require participants to undertake a "technology based" set of criteria. For example, a processor may have existing British Retail Consortium certification in place, which would provide a robust base for the normal physical and food safety related concerns. The company could then undertake a technology-based annex, for example, join a platform where it would enter GDST level data and exchange that with its customers allowing full remote real-time verification. This could be done by exchanging pre-defined files with a third-party platform who would integrate the data between all supply chain participants. Vessels could be in MSC programs, Fishery Improvement Projects or the RFVS. A single digital traceability solution could provide a single chain of custody for any of these programs through to retail. This could be a "Scottish system" providing robust traceability back to vessels in any of the schemes depending on the market demands. This would be very cost effective with the inter-operability of systems being done externally.

In the section on trends, we mentioned the Norwegian Salmon sector and how it is differentiating itself through the use of technology. It is possible for Scottish Seafood to follow this path once it carefully considers the integration of data challenges and ensures fair and equitable access to many industry players. It is our opinion that these technology-based initiatives will form the basis for food standards of the future. Developing the pilots suggested below would provide a robust basis on which to make sustainability and provenance claims. New datasets could be used to support applications to external sustainability certifications or position to industry to consider its own identity based on solid ground. Adopting the correct digitalisation strategy would put the industry in a good position to make well informed commercial decisions in years to come.

FIS role

While this big picture is aspirational it is technologically feasible. The biggest challenge we would foresee is the necessity for a strategic view to be taken so that progress towards digitalisation is both coherent and inclusive. There is a risk that different sectors, with varying concerns and agendas, will not be sufficiently aware of global trends, including in other protein classes and the issues that different sectors in Scottish fisheries are progressing or struggling with. In this scenario only the larger players with both the sufficient resources and oversight are likely to be successful in the transition. This is potentially a key role for FIS, who have a diverse board and an overview of what is taking place on a global and National scale.

Proposed Pilots

Pilot number	Name	Rationale
Pilot 1	Virtual integration and Verification of Scottish Seafood	In line with trends of supply chain verification and consumer trends. Bring data at First Point of Sale to GDST Standard and follow along supply chain. Could look at merging of some regulatory data with supply chain data.
Pilot 2	Certification and Standards integration	Links with pilot 1 but integrates vessels in any or multiple standards into one single chain of custody. Pulls on information on sustainability of stock, MSC, FIP, RFVS. Allows for differentiation of product from any of the standards and schemes at retail or consumer level.
Pilot 3	Crew Welfare data integration	Fits under major trend of dealing with social issues and demonstrating compliance. Capture current ILO 188 reporting requirements re crew detail. Could also be used for RFVS requirements. Could use the existing Online Safety Folder initiative. Link the Seafish training database to the folder so crew training could be remotely audited in real time.
Pilot 4	Digitalised Scottish Fish Exports	Use digitalisation to streamline export requirements. Larger players are investing in this space. This pilot could assist that investment and also facilitate smaller players in groupage situations supplying small players in other countries.
Pilot 5	From Catch to Batch – integrating onboard scientific and supply chain data.	Match landings data with processing data to facilitate scientific data collection (pelagics and whitefish). Could take inputs from the planned inshore vessel tracking program and integrate with processing data to expand the economic and spatial dataset from inshore vessels.

Throughout the course of the project we have become familiar with many progressive initiatives that could fit the digitalisation agenda but have not included them as this project is focussed on new ideas and directions. For example we have not proposed pilots covering the role of tracking for inshore vessels and the use of cameras onboard vessels as we are aware of existing plans to address these issues.
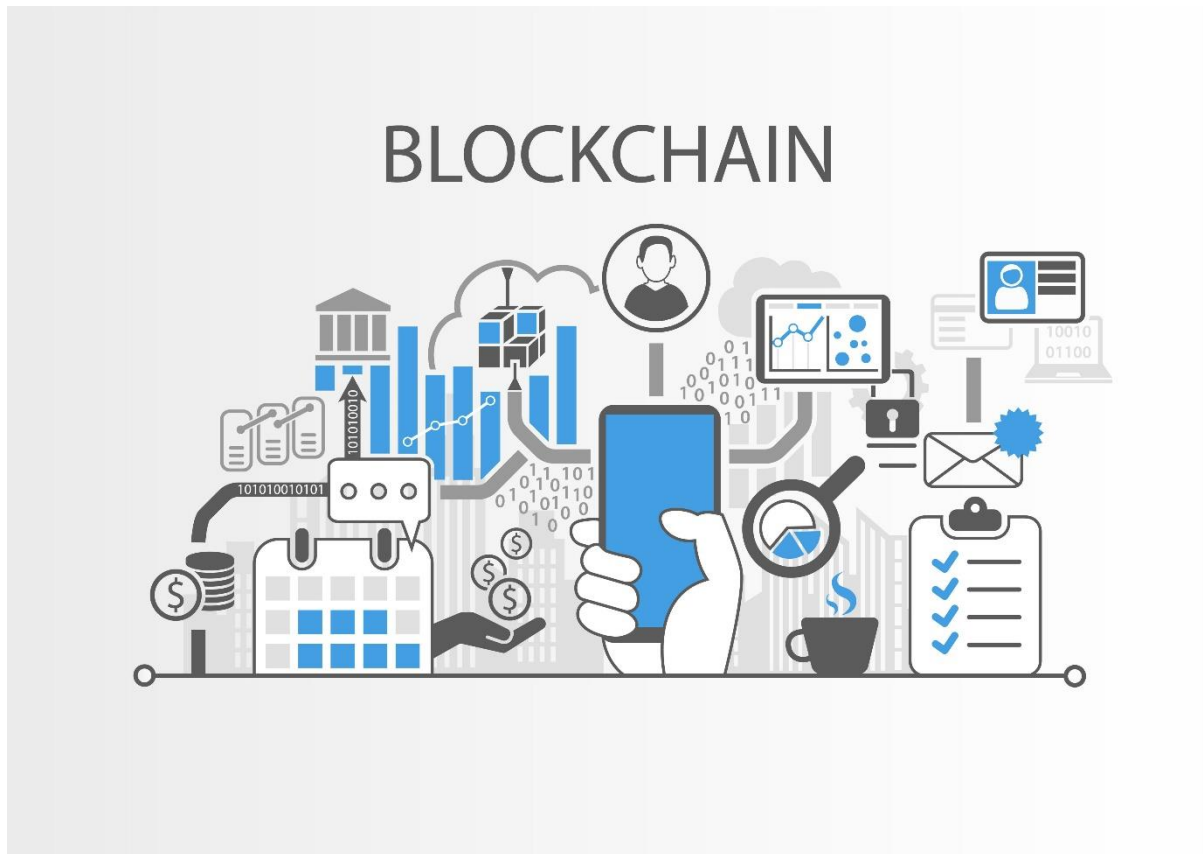
Pilot 1: Virtual integration and Verification of Scottish Seafood

This pilot project has 1 has linked objectives: firstly to ensure verification of provenance, sustainability and compliance of Scottish seafood; and secondly to provide 2 way visibility through the supply chain thereby opening up integration opportunities to all operators regardless of size. This would be done by implementing a traceability system, based on GDST, throughout the supply chain.

There would be many benefits of such a system including:
- Protecting and strengthening the Scottish seafood brand,
- Greatly increasing the ability to verify conformity under a range of criteria including sustainability, labour conditions, geographical origin etc;
- Adding value to catches,
- Two-way traceability providing both downstream visibility for producers and upstream visibility for subsequent links in the supply chain,
- Reduced paperwork,
- Time and cost savings.

For any pilot project the question has to be asked whether it needs to be done and in this case the answer is definitely yes. This solution is not currently available for the majority of operators in Scottish fisheries and as discussed in detail in the Supply Chain discussion in Section 3 there is a danger of smaller players being left behind in the move towards digitalisation without such an initiative. The necessity to tackle this issue was one of the most frequently mentioned improvements sought during the course of our meetings.

The implementation of GDST could be done on a phased basis with phase 1 starting with acquiring the key data elements (KDE) sought under the GDST standard from the first point of sale through to the retailer. Phase 2 would then look at bringing GDST back to vessel level. At the consumer level it could involve the placing of QR codes on product packs in supermarkets.

This pilot project, more than any of the others proposed, occupies a central role as it deals with fundamental fisheries data and is intrinsically linked to all of the other pilots. As such, we feel it could form the foundation of a fully integrated data repository concept, should FIS decide that is the approach they would like to take to digitalisation. It would also function perfectly well however as a stand-alone project.

There may be a possibility to include a sub-project under this focussed on inshore vessels who will have specific requirements, resources and technical capacities. This sub-project would emphasise Virtual integration over the concept of Vertical Integration increasingly evident in larger vessels and companies.

Pilot 2: Certification and Standards integration

- This pilot would aim to fully digitalise, integrate and streamline data collection under a number of different standards which currently require significant duplication of effort and in some cases paperwork.
- The vessel and processor lists from each standard would be brought into one place.
- A single technology-based chain of custody would be developed as a technology "annex" that would sit alongside existing standards in the processing sector but give real time robust traceability in a distributed ledger (blockchain) solution from vessel to plate.
- This system could be based on capturing data in line with the GDST Standard key data elements.
- This would provide very strong supply chain verification.
- The story of product could be told as and when retail see value in it.
- Social criteria now also used in FIPs and MSC and the outputs from Pilot 1 could function as an input stream in ensuring compliance with these standards.
- Steps could include an analysis of current practice and identification of where paperwork can be replaced by a digital process and where duplication can be eliminated. This would involve working with administrators of different standards to standardise data fields, to set up a portal and manage permissions.

This pilot is necessary as currently there is duplication of effort required across multiple standards. The specific benefits of the pilot would include a reduction of paperwork, time and cost saving, and the potential to develop a "Scottish system" to provide supply chain verification.

Pilot 3: Crew Welfare data integration

- Social issues are an area of growing importance where retailers are seeking supply chain assurances that the produce they are purchasing has been produced in an ethical manner.
- Currently information regarding crew on fishing vessels is held in a variety of separate databases depending on the requirement to store the data. For example safety training information is held by Seafish for individual crew members, while the Crew Lists required under the ILO Work in Fishing Convention, 2007 (No. 188) must be held by the nominated on shore entity and information on hours of work and rest, crew work visas, fishermen agreements etc is held at a vessel level sometimes on board, sometimes on shore.
- If all data relating to crew was available in a single location it would enable same to accessed and queried in a more efficient and effective manner.
- This pilot would build on the information contained in the online safety folder initiative[13], but it would expand on this concept.
- In order to address the potential GDPR issues set out in Section 4 above at the outset the data owners consent to the release of specified data to designated independent

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[13] https://www.safetyfolder.co.uk/

auditors etc would be obtained. This would allow these auditors to efficiently verify vessel compliance regarding crew welfare and training regulations without breaching individual's rights under GDPR regulations.

- This information would also assist with reducing the paperwork burden under other standards such as the Responsible Fishing Vessel Scheme.

This pilot is necessary as the data integration described currently has to be done manually for individuals. Specific benefits of the pilot include the ability to demonstrate compliance at vessel level with ethical working condition requirements, improved access to markets and added value to catches, time and cost saving and a reduction in paperwork.

Pilot 4: Digitalised Scottish Fish Exports

This pilot is strongly linked to Pilot 1 as it covers the whole supply chain from vessels through to retailers seeking to export Scottish fish products. However, it is more closely focussed on the goal of streamlining the export of Scottish fish which has become a problematic area recently. Again, we feel there is a definite necessity for this pilot as it appears to be an ongoing problem particularly for smaller operators. It may be possible to base this pilot on how some larger operators have successfully tackled the issue.

The specific benefits of the pilot are a reduction in time, costs and paperwork, reduced product waste, retaining of markets, maintaining business viability particularly for smaller operators, integration with other data streams and initiatives. This pilot would require an fuller assessment of how this would work as a viable solution.

We are aware of smaller operators in Ireland who have for many years bought fish from Scottish suppliers. They are now finding the customs clearance costs and additional paperwork difficult to contend with. The paperwork and clearance costs are exactly the same for a full load as they are for smaller lots i.e. a single pallet on a groupage load. The net result is that the smaller importers of Scottish seafood are gravitating towards the bigger players who bring in the full loads and purchasing from them. Consequently, the bigger players are in a more powerful position setting prices for the smaller operators also taking some margin at the expense of Scottish seafood. Also, it emerged at the interview stage that smaller Scottish exporters are finding it hard to win new customers as small lots (samples) are prohibitively expensive to send. A potential solution could be to look at a cloud-based platform solution where a groupage load is compiled by a Scottish entity arranging logistics and sent to a virtual (or physical) entity in an export country who would distribute the load to smaller players. This could bridge the gap between the players in both countries. While we are aware of this situation in Ireland, it is likely to be a similar scenario in other countries the Scotland exports to.

- Streamline paperwork required for seafood exports including catch cert data.
- Create, or partner with, a logistics provider who could compile a full load from smaller lots.
- Export to a single, potentially virtually based, entity who would arrange distribution in the import country side.

- Currently large operators are capable of reducing paperwork issues but smaller players lack necessary resources to follow suit.
- Impacting ability of Scottish exporters to develop new business.
- Feasibility assessment of independent clearing house idea for both export and destination sides.

Pilot 5: "From Catch to Batch"* – integrating onboard scientific and supply chain data.

Currently self-sampling and observer data is available to specific haul level particularly for pelagic species. Processors also have significant levels of data available including size grades, yield, catch composition etc.

Having the ability to integrate both data sources would add significant value from scientific, market and management perspectives for all fish categories and fleet sectors including pelagic, demersal, shellfish etc.

However, it is currently either not possible or difficult to merge these datasets and much of the potential added value of integration is lost.

This integration would increase the breadth of data sources for scientists and also serve as at least a partial verification of self-sampling initiatives. The data could also potentially have management considerations where concerns such as maximising economic yields from quota restricted or high value stocks are being considered. Decision making at vessel level could also benefit from the availability of such data.

It may be possible to incorporate a real-time element to this data source by using digital data collection and integration tools which could add further value to the data in terms of management and decision making.

It may also be possible to use inputs from the planned inshore vessel tracking program and integrate with processing data to expand the economic and spatial dataset from inshore vessels.

*Snappy title courtesy of Steve Mackinson.

A fully integrated and co-ordinated Scottish Fisheries database.

While developing the overall framework for this report we considered the concept of a central, co-ordinated data house or repository where fisheries data could be stored, integrated, interrogated and distributed in an efficient manner. This concept is essentially a fully integrated and co-ordinated system for Scottish fisheries data. It could serve, if it was implemented, as a link between all of the Pilot Projects in the roadmap. The data repository concept, in common with the pilot projects, would have a number of overarching aims and

characteristics:

- The basic premise is that the current largely *ad hoc* and disintegrated approach to data collection would be incrementally replaced with a co-ordinated approach.
- Data should be captured once but used as many times as needed.
- All data collection initiatives should be reviewed in terms of how they could be integrated with other data streams.
- The pilots commonly feature a central portal where the relevant data is captured, and a set of specific consents are established whereby specific data streams will be shared with data users. These users may include science, market, certification, marine policy and decision makers.
- A central data repository would pull the data portals from the pilots into an overarching structure and would ultimately represent a fully integrated and co-ordinated Scottish fisheries database.
- The central data repository could be owned by a cross-sectoral fisheries stakeholder group and managed by an independent third party on their behalf. As with the pilots' specific data streams will be shared with users of the data under various agreements and consents.

We canvassed all contacts about the feasibility of such an approach as part of our meetings summarised in Section 2. There was widespread support with different interviewees picking up on different applications or benefits from the concept. One of the main benefits which both we and a number of interviewees felt could arise from it is a more proactive approach to data collection by the fishing industry. Our meetings with fishing industry representatives revealed an appetite for "getting ahead of the game" by providing the necessary solid data for making the case for a sustainable fishing industry. The possibility of data collected by fishing vessels, for example environmental data, having an economic value in their own right was also discussed as a possible future benefit.

There were also legitimate questions asked during our meetings regarding how the fully integrated data repository would function. These questions included:

- Can or should regulatory and commercial data be integrated?
- What are the GDPR implications of the concept?
- Who will fund and manage the data repository?
- Will it be supported by all stakeholders?

We are fully aware of the challenges such an initiative would face and are proposing a realistic approach to them. The integration of regulatory data with other data sets is a complex issue and a stepwise approach would be required. Steps could include:

- The establishment of a working group made up of representatives of all relevant steps in the data chain including regulators, the catching sector, processors and retailers.
- Identification and description of specific barriers to integrating regulatory with other data streams including commercial data.

- Analysis of how this integration could be done without compromising individual or commercially sensitive data protections.

The potential pilot projects which we discuss in Section 5 are designed to support the overall goal of moving towards a fully integrated and co-ordinated data repository if that is an agreed approach by FIS but also to be independently beneficial in addressing specific challenges.

Section 6: Conclusions:

- This roadmap attempts to identify the key steps which may be taken to maximise the utilisation of appropriate digital technologies to enhance data collection, position the industry proactively and strengthen and protect the Scottish seafood brand.
- Many of these challenges concern the efficient collection, verification, integration and communication of data.
- There are several existing building blocks in Scottish fisheries which can be developed as pillars of a Digitalisation roadmap including: technical and human resources in industry-science partnerships; a modern offshore fleet with significant technical resources; a strong domestic market for some target species with relatively short supply chains; a cross-sectoral organisation capable of taking an overarching perspective and a strategic approach.
- There are also some significant challenges facing the sector with regards to the transition to a digital future including: export problems with an increased rather than reduced paperwork burden; barriers to integration of regulatory and other data streams; the necessity to include smaller operators and ensure that not only are they not left behind in the transition but that they flourish.
- We outline a process which we believe will build on the positives and address the negatives.
- In order to do this, we propose a series of pilot projects which can be seen as steps on the pathway towards digitalisation.
- The overall approach to the pilot projects is governed by a number of key considerations:
- The basic premise is that they should incrementally replace the current largely ad hoc and disintegrated approach to data collection with a co-ordinated approach.
- They should aim to capture data once but use it as many times as needed.
- All projects should be producing data outputs which can be integrated with other data streams.
- The pilots commonly feature a central portal where the relevant data is captured, and a set of specific consents whereby specific data streams will be shared with data users. These users may include science, market, certification, marine policy and decision makers. Some of this data may fall under the definition of "personal data" and therefore its recording and processing must be compliant with GDPR legislation. This is dealt with in further detail in Section 4 above.
- The priority or order of the pilots is not intended to be a constraint and they could be done as stand-alone projects or in some cases, for example 1 and 2 listed below, could be merged and done together.
- Pilot 1 Virtual integration and Verification of Scottish Seafood. This proof-of-concept pilot project has linked objectives: firstly to ensure verification of provenance, sustainability and compliance of Scottish seafood; and secondly to provide 2 way visibility throughout the supply chain thereby opening up integration opportunities to

all operators regardless of size. This would be done by implementing a traceability system, based on GDST, on a phased basis in a selected seafood supply chain vertical.

- Pilot 2 "Certification and Standards Integration" aims to fully digitalise, integrate and streamline data collection under a number of different standards which currently require significant duplication of effort and in some cases paperwork. It builds on Pilot 1 and goes further in allowing the differentiation of product based on adherence to various standards. Vessel and processor lists from each standard would be brought into a common database and a single technology-based chain of custody would be developed as a technology "annex" that would sit alongside existing standards in the processing sector but give real-time robust traceability in a distributed ledger (blockchain) solution from vessel to plate.

- Pilot 3: Crew Welfare Data Integration aims to efficiently integrate currently separate datasets regarding crew working conditions, safety and training. This would provide the ability to demonstrate compliance at vessel level with various regulatory and standards requirements regarding working conditions. The pilot could be done through the integration of crew data from vessels, the Seafish training register and possibly from the Online Safety folder. This could serve to add a verification layer regarding crew issues to Pilot 2.

- Pilot 4: Digitalised Scottish Fish Exports is closely focused on the goal of streamlining the export of Scottish fish which has become a problematic area recently. There appears to be a particular issue for smaller operators due to a lack of resources. It may be possible to base this pilot on how some larger operators have successfully tackled the issue. We are aware also of issues with smaller players in destination countries having similar issues with importing Scottish fish. A potential solution could be to look at a cloud-based platform solution where a groupage load is compiled by a Scottish entity arranging logistics and sent to a virtual or physical entity in an export country who would distribute the load to smaller players.

- Pilot 5: Integrating onboard scientific and supply chain data. Currently self-sampling and observer data is available to specific haul level particularly for pelagic species. Processors also have significant levels of data available including size grades, yield, catch composition etc. Having the ability to integrate both data sources would add significant value from scientific, market and management perspectives for all fish categories and fleet sectors including pelagic, demersal and shellfish. Pilot 5 could take inputs from the planned inshore vessel tracking program and integrate with processing data to expand the economic and spatial data from inshore vessels.

- A potential final step towards full digitalisation and integration could be the co-ordination of all of these pilots under a central management system or data repository where all fisheries data will be stored, integrated, queried and distributed in an efficient manner.

- This data repository would ideally be owned by a cross-sectoral stakeholder group from across Scottish fisheries and supply chain and managed by an independent third party on their behalf. Under the appropriate agreements specific data streams will be

shared with users of the data. These users would include science, market, certification, marine policy and decision makers.

- A significant advantage of the development of such a system is that it would put the fishing industry in a more proactive position with enhanced ownership of the data and would give it greater ability to get "ahead of the game" rather than reacting to an externally driven agenda.

- However, the development of a central data repository will face significant challenges and a realistic approach to this is necessary. The potential pilot projects are designed to support the overall goal of moving towards a fully integrated and co-ordinated data repository if that is an agreed approach by FIS but also to be independently beneficial in addressing specific challenges.

- There may also be currently lower priority uses such as environmental data collected by fishing vessels which may have future value well above current levels.

- We see a key role for FIS in taking a strategic overview of the transition to digitalisation so that progress is both coherent and inclusive. There is a risk that different sectors, with varying concerns and agendas, will not be sufficiently aware of global trends, including in other protein classes and the issues that different sectors in Scottish fisheries are progressing or struggling with. In this scenario only the larger players with both the sufficient resources and oversight are likely to be successful in the transition.

FIS is a unique public-private collaboration between seafood industry experts, government and scientists to champion innovation in the Scottish fishing industry. Our Member Organisations include: