Fisheries Innovation Scotland

# DESIGN, DEVELOPMENT AND DEPLOYMENT OF A SOFTWARE PLATFORM FOR REAL-TIME REPORTING IN THE WEST OF SCOTLAND DEMERSAL FLEET

## FIS032

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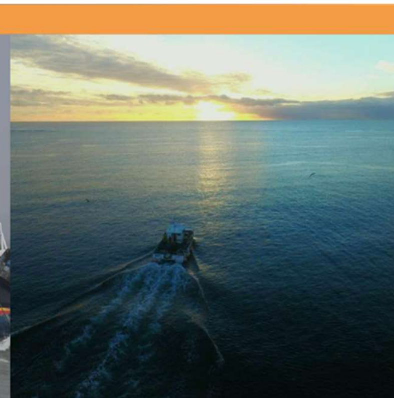


*FIS032 Design, development and deployment of a software platform for real-time reporting in the west of Scotland demersal fleet*

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# Executive Summary

In this report the term real-time reporting (RTR) refers to a semi-automated communication system used by a group of collaborating fishing vessels for the sharing of bycatch observations to identify areas having high probability of bycatch and alert fishers about the location of these areas. RTR has been used on the west coast in fisheries in Alaska and Pacific Northwest for over 20 years to successfully reduce bycatch.

FIS011B had previously outlined the use of RTR in US fisheries and evaluated the potential for its application in Scottish fisheries. Following the full implementation of the Landing Obligation in January 2019 the demersal fishery on the west of Scotland (ICES VIa) was incentivised to adopt innovations that would be effective in reducing bycatch of cod and whiting both of which were at risk of being choke species. Buy-in from several west of Scotland fishers and the producer organisations they belonged to satisfied a necessary pre-condition for trialling RTR in Scottish waters.

FIS032 was awarded to design, develop and deploy RTR software for the Scottish demersal fleet operating in the west of Scotland with co-funding from the Scottish Fishermen's Organisation, Scottish White Fish Producers Association, Seafish and the University of Aberdeen. Several key operational features were co-designed by participating fishers to reflect their tolerance for sharing information including a request for spurdog to be included, in addition to cod and whiting.

The RTR software BATmap (**B**ycatch **A**voidance **T**ool using **map**ping; https://info.batmap.co.uk/ ) was launched in June 2020 with the pilot study concluding in December 2020. At the end of the pilot study, thirteen vessels belonging to four producer organisations were using BATmap. Over 1,800 catch reports had been submitted by these vessels and bycatch alerts had been triggered for cod and spurdog on over 67 and 22 occasions, respectively.

Following the pilot study, eight participating fishers were interviewed about their experience of using BATmap. Overall, interviewees felt they had contributed to the design of the app, which they find very easy to use. The bycatch maps and automated catch entry reminders were both perceived to be very useful features. There is some evidence that the alert maps generated and disseminated by BATmap following a high bycatch elicited a tactical response (moving on), however, the pilot study was of short duration to provide conclusive evidence. Five of the interviewees indicated that they were more willing to share bycatch data because of their experience with the remainder experiencing no change. Several interviewees felt that it is important to increase confidence in the accuracy of data being shared and that the gradual experience of tangible personal benefits from their bycatch data may help to develop this confidence.

Although FIS032 has concluded, BATmap continues to be routinely used at sea by the participating fishers who are committed to building on the work done in the pilot study and eager to see BATmap develop through 2021 and onward. The Producer Organisations are also committed to the application of RTR on the west of Scotland and willing to co-fund maintenance and refinement of software, data storage and development of a data governance policy in 2021. Part of the programme of work in 2021 will include developing a five-year strategic plan for the use of RTR by the Scottish fishing industry.

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# 1 Introduction

Incidental catches of unwanted species are a signal challenge for mixed fisheries globally (Kelleher, 2005; Dunn et al., 2011). A mixed fishery exists when different species co-mingle on the fishing grounds rendering them more likely to be harvested together. Demersal trawlers are associated with the highest discarding of any fishing gear (Zeller et al., 2018). To reduce the incidence of high bycatch and eliminate discarding of fish at sea, European Union (EU) member states agreed in 2013 to the introduction of the Landing Obligation (LO) as part of the reformed Common Fishery Policy (CFP). In January 2019, the LO was fully enforced for demersal fleets fishing in EU waters and, in effect, served as a discard ban. This requirement is not expected to change substantially following the UK's exit from the CFP as bycatch reduction is a specific objective of the UK Fisheries Bill[1].

The LO requires that catches of all species regulated by Total Allowable Catches (TACs) are landed at port and counted against quota. The implementation of the LO has created the so-called 'choke' species problem (Kennelly, 2019; Uhlmann et al., 2018). 'Choke' species are fish species for which quotas are limiting relative to their local abundance but cannot easily be avoided. This can potentially result in an early tie-up of a fishing vessel if the TAC for a choke species is reached before the TACs for other commercial species are taken by that vessel.

The LO incentivises fishers to adopt fishing practices that enhance gear selectivity and/or spatial selectivity (Guillen et. al, 2018). Options for the former include increasing gear selectivity through, for example, larger mesh sizes, square mesh panels, sorting grids, escape holes and artificial lights to enable escape of untargeted species (MRAG Ltd., 2017). Gear-selectivity measures have often reduced the capture of target species and it is increasingly clear that gear selectivity alone is not sufficient for reducing bycatch (Suuronen and Gilman 2020).

A second option for fishers is to avoid fishing in areas and at times where the likelihood of encountering unwanted catch is high. Spatial approaches triggered by dynamic fishing events are viewed as a more responsive practice for the unpredictable nature of fisheries bycatch (Dunn et al. 2011). Suuronen and Gilman (2020) summarised a wide range of spatial and temporal measures that are used globally for reducing discards. These include closed areas and zoning regulations which are often used to protect juveniles and real-time fisheries closures that are established from catch data showing the current conditions on the fishing grounds.

## 1.1 Reducing bycatch through real-time reporting

Real time reporting (RTR) is a term used here to refer to the semi-automated communication system established among a group of collaborating fishing vessels for the continuous reporting of bycatch observations in near real-time (Gilman et al., 2006). RTR was first implemented in the Alaskan fishing industry in mid 1990s and over the past two decades has been successfully used to meet bycatch restrictions for salmon (Haflinger and Gruver, 2009; Marshall et al. 2017a). Spatiotemporal data, describing catch and haul locations, are combined to produce maps of high bycatch (hotspots) which are then disseminated via information and communications technology (ICT) infrastructure. For highly mobile demersal species the predictive ability of bycatch data decays over time (ca. two weeks Marshall et al. 2017a). Consequently, information must be communicated rapidly for it to be relevant to tactical decisions regarding when and where to fish.

Several US fisheries have experience using RTR for bycatch reduction (Sylvia et al., 2014; Little et al., 2014; Kauer et al., 2018; Merrifield et al., 2019). Implementing RTR in the Eastern Bering Sea pollock fishery, the largest fishery by volume in the US, enabled it to define and impose rolling hotspot closures to limit the bycatch risk of chum and chinook salmon (*Oncorhynchus keta* and *Oncorhynchus tshawytscha*), respectively (Haflinger and Gruver, 2009; Little et al., 2014). In 2010 the Atlantic sea scallop (*Placopecten magellanicus*) fisheries in eastern US implemented the use of logbook data to create a daily hotspot notification system to avoid bycatch of yellowtail flounder (*Limanda ferruginea*) (O'Keefe and DeCelles, 2013). A small segment of the western Pacific whiting (*Merluccius productus*) fishery shares bycatch data about rockfish (*Sebastes* spp) and salmon using eCatch, a web and mobile application (Merrifield et al., 2019).

[1] https://www.legislation.gov.uk/ukpga/2020/22/contents/enacted/data.htm

A common feature of these US examples was the willingness of participating fishers to share their bycatch data. This willingness was voluntary but strongly incentivised by legislation including a discard ban as well as strict bycatch limits. In Europe, there has not yet been a functional implementation of RTR. The closest analogue in Scotland has been temporary real-time closures that were used to reduce fishing mortality of spawning cod (*Gadus morhua*) in the North Sea as part of the Cod Recovery Plan (Holmes et al., 2009).

Currently, there are several ongoing initiatives in the EU and UK to develop, and deploy mobile phone apps elsewhere with the aim of avoiding unwanted catch of fish and species of conservation interest using RTR (c.f., https://www.cleancatchuk.com/) and https://www.i-fish.org/). Over the time frame of FIS032 Marine Scotland developed an option for RTR aimed at avoiding areas with high local abundances of North Sea cod (https://www.gov.scot/publications/north-sea-cod-plan/). The hesitancy of fishers to voluntarily engage with these data sharing initiatives is a common obstacle to all of these early-stage RTR initiatives.

## 1.2 Pre-conditions for the application of real-time reporting on the west coast of Scotland

The west of Scotland (WoS) is a typical mixed fishery with cod being a potential choke species. The fishing vessels operating there are equipped with modern satellite communications including VMS which is a pre-requisite for RTR. Thus, the WoS mixed demersal fishery represents a comparatively homogenous collective of fishers with the ICT required for implementing RTR.

The Fisheries Innovation Scotland (FIS) project FIS011B and Fishing Industry Science Alliance (FISA) Project (01/15) outlined how RTR could be implemented in Scotland, drawing lessons from the Alaskan and Pacific Northwest fisheries (Marshall et al., 2017a; 2017b). Early consultations with Scottish fishers showed support for using RTR for bycatch avoidance. They also identified a potential obstacle: the hesitation of fishers to sharing information beyond their already established small network of peers (Marshall et al., 2017a). The majority of fishers world-wide are reserved about sharing information because they regard fisheries information as a personal or financial asset (Palmer, 1990). Overcoming this hesitancy to trial new approaches required appropriate incentivisation to change.

In August 2018, it became apparent that WoS fishers could experience a choke problem for cod and whiting due to the zero TACs set for 2019 and the full implementation of the LO that year. This combination of circumstances served to garner industry support required for sharing bycatch information (choke species only) using RTR. This support was critical for securing industry funding for the development of a software platform and trialling that platform at sea. Sources of funding were Fisheries Innovation Scotland (FIS032), Scottish Fishermen's Organisation (SFO), Scottish White Fish Producers Association, Seafish and the University of Aberdeen.

## 1.3 Aims of FIS032

The first aim of FIS032 was to design then develop software for RTR and deploy it to the WoS fleet during a pilot study. BATmap (**B**ycatch **A**voidance **T**ool using **map**ping) is the bespoke mobile software co-designed by Scottish fishers and scientists to implement RTR for a group of trawl fishers working in ICES VIa. Participation of fishers in the pilot study was voluntary. A second aim was to study the behavioural and attitudinal changes for the fishers participating in the pilot study. To achieve both aims FIS032 had several components built into the work scope:

**Conduct consultations with WoS fishers** to establish the information needs, design features for a basic RTR system as well as establish technical features the computing facilities onboard fishing vessels.

**Survey WoS fisher attitudes to information sharing.** The participating fishers will be surveyed using a questionnaire to determine attitudes to information sharing generally and RTR specifically at the start of the project and a sub-sample of those fishers will be surveyed at the end.

**Software Development** of basic components to support data entry at sea and transmission of that data to shore-based computers, as well as development of software which would aggregate and disseminate by-catch hotspot information back to vessels at sea.

**Conduct software testing** to test the prototype RTR system with the assistance of WoS fishers. Following the end of testing, implementation of the software will have been achieved for the WoS fishery.

**Prepare final report summarising experience with** the RTR system suitable including a detailed summary of the software and its performance during testing and a summary of fisher attitudes of RTR.

### 1.4 Time frame for FIS032

FIS032 had a 12-month time frame (1/9/2019 - 31/8/2020), however, the Covid-19 situation necessitated an extension (1/9/2019 - 31/12/2020). The approximate timeline for work activities is summarised below (Table 1).

| Research objective | Activity | Month |
|---|---|---|
| Stakeholder engagement | Meet with fishers to initially to discuss their specific reporting needs | 1 |
| | Install and test position tracking units on participating vessels to identify optimal equipment | 1-2 |
| | Agree on the format and design settings | 1-2 |
| | Analysis of attitudinal surveys conducted at Skipper Expo May 2019 | 1 |
| | Present results of attitudinal surveys at ICES Annual Science Conference September 2019 | 2 |
| | Conduct follow-up interviews to assess fisher experience of using RTR | 9-11 |
| Software Development | Participate in meeting with fishers regarding specific reporting needs and relevant operating conditions | 1 |
| | Develop a design document for software based on above meetings | 1-2 |
| | Develop data model and database | 2-3 |
| | Develop shipboard software components | 2-4 |
| | Develop shore-based software components | 3-5 |
| Software Deployment and Testing | Participate in deployment and software testing | 4-10 As required, through project |
| | Review how fishers are using software, making necessary adjustments | |
| | Summarise technical performance of software (Update document dated 20/8/2020 circulated to FIS Steering Group and oral presentation given to FIS Steering Group 24/11/2020) | |
| Final report | Develop plan for future operations | 9-11 |
| | Prepare final report | 11-12 |

**Table 1** Timeline for FIS032 work activities. Preparation of final report began in this timeline but was not completed due to combined impacts of Covid-19 and Brexit.

### 1.5 FIS032 Team

Dr. C. Tara Marshall (University of Aberdeen) provided project management, supervised science-based activities, contributed writing, and oversaw website development. Dr. Paul Macdonald (SFO) provided all liaison with participating fishers, led the design process for the RTR software, maintained communications with participating fishers throughout the pilot study and undertook the interviews at the end of the pilot study. The RTR software was developed by Mr. Eric Torgerson and colleagues (Chordata LLC) based on design specifications of participating fishers. Dr. Rachel Turner (University of Exeter) assisted with the design and administering of a questionnaire at the start of the project and the interpretation of fisher interview responses after the conclusion of the pilot study. Mrs. Josephine Asare developed R-BATmap as part of her MSc thesis and assisted with the analysis and write-up of the fisher interviews conducted at the end of the pilot study. The BATmap website (https://info.batmap.co.uk/ ) was designed and developed by Mr. Mike Smith (https://smithandbrown.eu/ ).

## 2 Software Design and Development

Real-time reporting describes what the software was designed to achieve, however, a suitable name was required to refer to the software itself. Prior to the rollout of the trial version in 2020 it was decided to name the software BATmap (**B**ycatch **A**voidance **T**ool using **map**ping; https://info.batmap.co.uk/ ). This name differentiates it clearly from other similar packages that have been developed for RTR in the USA (e-catch https://www.ecatch.org/ and EcoCAST https://coastwatch.pfeg.noaa.gov/ecocast/ ) or that are currently in development in the UK (Clean catch UK https://www.cleancatchuk.com/) and Ireland (IFISH https://www.i-fish.org/ ).

## 2.1 BATmap overview

At the outset of the project, it was agreed that catch data for cod and whiting would be shared across participating vessels as these two bycatch quota species had the greatest potential to be choke species in ICES VIa. Participation was voluntary, however, maximising the participation of fishers operating in VIa was critical. Capturing as much data as possible would increase the information value of the shared maps. Therefore, BATmap had to be designed to accommodate the fisher's information requirements, their security concerns and their tolerance for sharing catch and position data. We consider the process as co-design, which distinguishes it from other initiatives whereby scientists lead the design specifications and operational features.

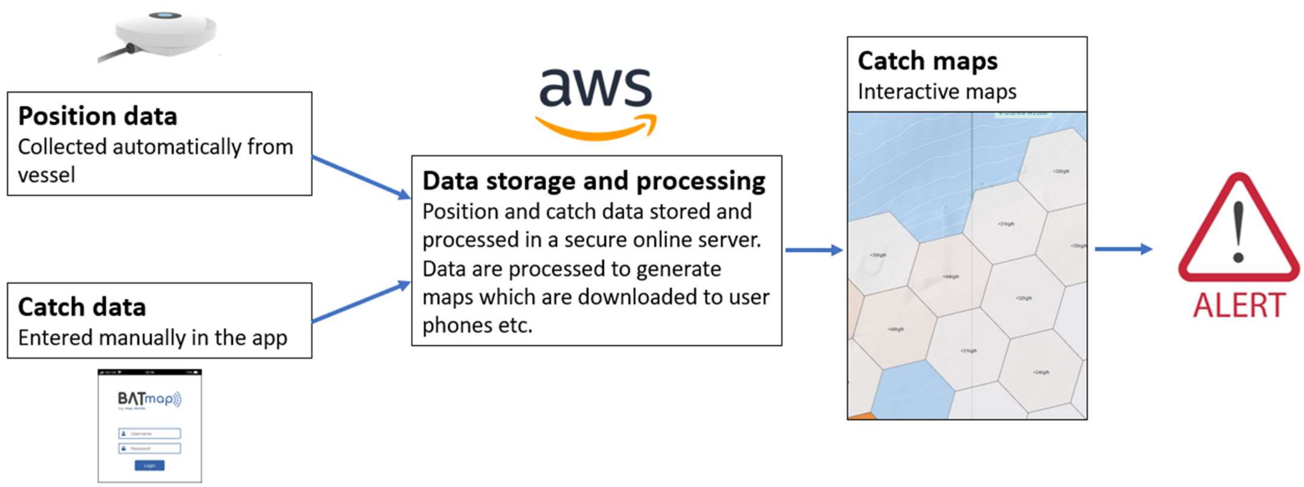


**Figure 1**: Overview of RTR as achieved by BATmap. See Figure 2 for a representation of the alerting system.

BATmap was designed for any device (mobile, laptop, tablet) having internet access, however, it was recognised that most fishers would use it as a phone app and therefore that platform was the focus of development and testing. Catch reports are automatically combined with vessel position data allowing fishers to produce a map of their vessel's data on demand (Figure 1). Fishers receive aggregate maps (i.e., maps created by combining data from other participating vessels fishing in VIa) only when the alert threshold value (ATV) is exceeded. Exceeding the ATV triggers BATmap to send a message to the mobile phone numbers of participating fishers that gives a link to the aggregate map. The aggregate map does not contain details that may identify the reporting vessel or other species information within the catch. This alert map (Figure 2) can be used to avoid areas having recent observations of high bycatch.

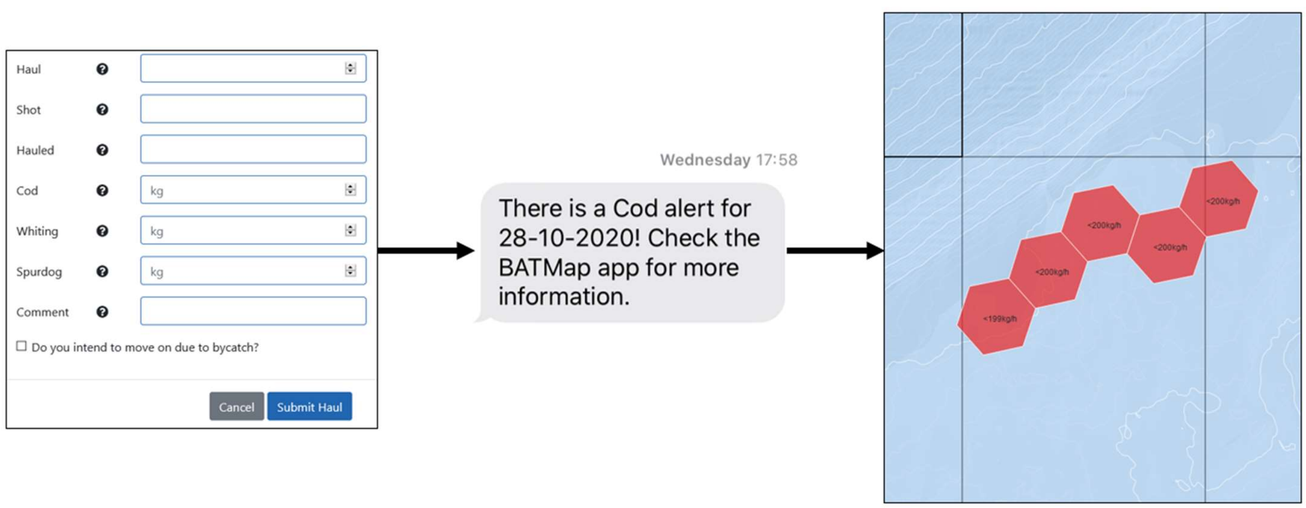


**Figure 2**: Schematic representation of the alerting system. The catch data is entered for each haul in the "Haul" tab. If the catch exceeds the ATV then it automatically triggers a SMS message to be sent. An SMS message prompts the user to open the BATmap app where the most recent alert is automatically displayed.

Early in the pilot study participating fishers indicated that RTR would be useful for trying to avoid spurdog (*Squalus acanthias*) which is a species of conservation concern and is listed by IUCN as a vulnerable species. Spurdog is seasonally present in WoS waters in large clusters. It has previously been the focus of the real-time bycatch avoidance program of Cefas (Hetherington et al., 2016). This suggestion was adopted by BATmap early in the pilot study and spurdog was added to the list of species that were being reported to BATmap along with cod and whiting.

## 2.2 Co-design process for developing BATmap

From consultations with participating fishers, the following features were incorporated into the design of BATmap.

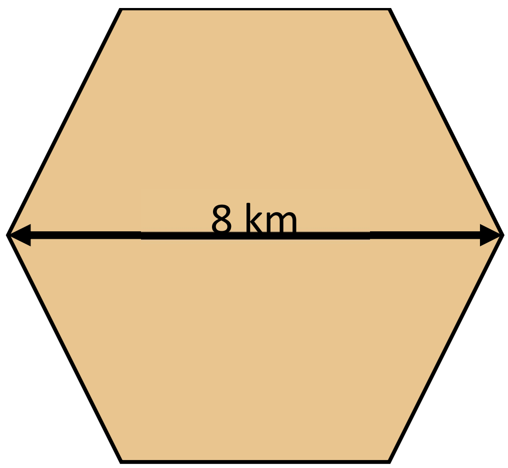


**Figure 3**: The dimensions of a hexbin showing that the internal dimension of 8 km corresponds to widest point.

**Hexbins** Rather than show exact haul tracks fishers chose to display bycatch locations using colour-graduated hexagonal bins (referred to here as hexbins). Fishers initially decided to set hexbin size to 8km between two opposite vertexes (Figure 3). The intensity of the colour assigned of the hexbin reflects the magnitude of the bycatch species (cod, whiting or spurdog). No colour indicates zero bycatch.

**Categorisation of data** Fishers entered their catch data for each species into the app as absolute values of catch in kilograms. However, the catch data is only stored in the database as ranged values. Following consultation with fishers these ranges were adjusted several times. Table 2 shows the ranges that are currently used for each species.

| Cod | Whiting | Spurdog |
|---|---|---|
| 0 | 0 | 0 |
| 1-150 | 1-250 | 1-100 |
| 151-300 | 251-500 | 101-200 |
| 301-500 | 501-750 | 201-300 |
| 501-1000 | 751-1000 | 301-400 |
| 1001-1500 | 1001-1500 | Increasing by 100 kg intervals to ≥50MT |
| 1501-2000 | ≥1501 | |
| 2001-2500 | | |
| >2500 | | |

**Table 2**: Category boundaries (kg) used for each of the BATmap species to convert raw catch values to categorical values.

**Alert Threshold Values** The ATVs are the catch values that trigger a map showing locations of high bycatch hexbins to be disseminated by BATmap to all participating fishers. The initial ATVs (in kg/hr CPUE based on an average 5.5 hour duration of towing time) were set in early 2020, following consultations with fishers, as cod: 5 tonnes, whiting: 2.5 tonnes, and spurdog: 2 tonnes. It was quickly recognized that the cod ATV was too high because no alerts were being triggered, thus, negating the collective benefits of RTR. On 8$^{th}$ July the cod ATV was reduced to 3 tonnes which resulted in 1 trigger. On 21$^{st}$ August it was reduced to 2 tonnes which resulted in 8 triggers. On 8$^{th}$ October the cod ATV reduced to 1 tonne, where it currently remains The cod and whiting alert levels were influenced to a certain degree by the levels of bycatch available for those species (the low cod bycatch quotas were more restrictive to fishing effort relative to their abundance). The sequential lowering of the cod alert levels during the pilot study was prompted by quotas becoming progressively restrictive during the fishing year. Whiting catches were relatively low in the areas where the vessels were operating and there were no issues with larger catches not being disseminated. Spurdog alert levels reflected the highly aggregated nature of these catches and were intended to alert others to these high concentrations rather than small incidental bycatches.

## 2.3 Input data

Two streams of input data are required for RTR: catch data for the three species of interest (cod, whiting, spurdog) and position data.

**Catch data**: Participating vessels are required to submit their catch data for cod and whiting to BATmap within 2 hours after every haul. Zero values must be entered to indicate absence of species of interest. Spurdog reporting is optional. BATmap presents a "Haul" tab for submitting catch reports (Figure 2) and geographically displays the catch report in "Map" tab. In the "Map" tab, each vessel can view maps of its own submitted bycatch reports with options to alter the display elements: choose date range for displaying catches (months, weeks or days) or display own-vessel tow tracks.

**Position data**: It was clear from the outset of the project that the vessel position data would need to be generated independently of the VMS data reported to the Scottish government. Costs for the hardware required to transmit position had been included in the FIS032 budget. Two types of vessel positioning hardware were tested during the development of BATmap: Rockfleet and SPOT (Table 3). One vessel was equipped with both for direct comparison. Two SPOT units failed shortly after being installed, however, the Rockfleet equipment proved to be reliable and robust enough for conditions at sea. These were subsequently installed as additional vessels were recruited to the project.

| | **Rockfleet** | **SPOT** |
|---|---|---|
| Satellite network | Irridium | Globalstar |
| Unit cost (approximate) | £600 | £130 |
| Reporting frequency | Every 30 minutes | Up to every 10 minutes |
| Total cost for each year (approximate) | £264 | £90 |

**Table 3**: Characteristics of the hardware that was evaluated as part of early at-sea trials for vessel position reporting.

When position reports indicate possible fishing activity in VIa, but no corresponding catch report is received, an SMS reminder is sent to the skipper of the boat in question asking them to confirm that they have entered all catch reports for VIa.

## 2.4 Catch Aggregation

Because the catch data are stored only as categorical values, where there are multiple observations estimating a representative catch for a given hexbin is not straightforward. For each haul there is instead a maximum amount and a minimum amount of each of the species of interest (i.e., ≥ 100kgand <200kg) unless the reported catch is above the highest range, in which case we have only a minimum (i.e., >2000kg).

The following process is used to estimate CPUE for each hexbin for a given time period. Each tow is apportioned by distance to each of the hexbins it passes through, giving a minimum and maximum catch and a total fishing time for each hexbin. This makes the assumption that towing speeds are fairly consistent for a given tow. Hexbins that are crossed by a tow with catch in the highest catch range, and therefore have an unknown maximum amount, are flagged accordingly. Based on total fishing time and the minimum and maximum catch for each hexbin, a minimum CPUE and a maximum CPUE for each is calculated and a flag is applied to those hexbins with an unknown maximum.

## 2.5 Data storage and security

This is of high importance to fishers, who recognise that they are sharing data having considerable commercial sensitivity. The catch and vessel position data are transmitted to a database server hosted in Amazon's "elastic compute" cloud. This database server stores all catch reports as well as vessel position reports. All components of the system use industry standards for encryption of catch and position data at rest and during transmission. All traffic to and from the server is encrypted using SSL/TLS.

## 2.6 Data access

All users can see the mapping of alert areas (Figure 2). For individual fishers, mapping of their own catch over arbitrary time periods is available on demand. For users that are associated with a participating producer organisation (PO), those on-demand maps will contain any, or all, of the vessels that belong to the PO.

# 3 Software Deployment

Early trials began in the autumn 2019 which sorted out a variety of small programming bugs. The rollout of BATmap began in the spring 2020 and included a FIS press release about the pilot study and the launch of the BATmap website. The rollout was specifically aimed at recruiting more fishers to the pilot study but was unfortunately interrupted by the Covid-19 crisis in the spring and the various challenges that this presented to fish sales. Once more normal fishing activities resumed in the latter half of 2020 several additional vessels were added to the pilot study which ended in December 2020. BATmap continues to be used in 2021 although the Brexit-related disruptions to European markets has meant that fishing patterns cannot be assumed to be typical. As a result of both Covid-19 and Brexit, the pilot study cannot necessarily be regarded as representing normal fishing patterns.

## 3.1 Uptake of BATmap

Initially all participating fishing vessels belonged to the SFO, however, vessels belonging to three other POs (Orkney Fish Producer's Organisation, Aberdeen Fish Producer's Organisation and North-East of Scotland Fish Producer's Organisation) were recruited during the pilot study. Currently, there are thirteen vessels participating in the pilot with these vessels collectively accounting for >70% of ICES VIa Scottish cod landings.

## 3.2 Usage of BATmap

Since the start of the project in 2019 over 1,800 catch reports had been submitted to BATmap (Table 4). As of 26/1/2021, the number of catch reports submitted by a single vessel has ranged from a minimum of 5 to a maximum of 499 with the variation across vessels reflecting the length of time the vessel has been using BATmap, the fishing activity in ICES VIa and the consistency of catch data entry.

Catch reports by months shows that there have been >100 catch reports submitted monthly in 9 out of 12 months (maximum 244). Several fishers acknowledged forgetting to enter their catch data, particularly when they had just joined the pilot. As a result, BATmap was modified to send out reminders to enter catch data when the vessel position data indicated that the vessel had been fishing. Data entry is more consistent now although there is still room for improvement in consistency and timing of reports for some vessels.

| Year | Month | Total Catch Reports |
|---|---|---|
| 2019 | 12 | 12 |
| 2020 | 1 | 114 |
| 2020 | 2 | 120 |
| 2020 | 3 | 157 |
| 2020 | 4 | 84 |
| 2020 | 5 | 101 |
| 2020 | 6 | 133 |
| 2020 | 7 | 207 |
| 2020 | 8 | 70 |
| 2020 | 9 | 79 |
| 2020 | 10 | 244 |
| 2020 | 11 | 166 |
| 2020 | 12 | 200 |
| 2021 | 1 | 205 |
| **Total** | | **1892** |

**Table 4**: Number of catch reports submitted to BATmap by month during the pilot study.

As of 26/1/2021, high bycatch alerts had been disseminated on 67 and 22 occasions for cod and spurdog, respectively. No alerts have been triggered for whiting during the pilot study. This is primarily due to the consistently relatively low catches of whiting in the areas that these vessels have been fishing during the pilot.

## 3.3 Modifications made to BATmap made during the pilot study

An advantage of the co-design process used during FIS032 is that it was highly responsive to user feedback. As noted above, fishers requested spurdog to be included early in the pilot study. Mid-way through the pilot study they also requested that the mapping capabilities of BATmap be expanded to include Rockall (ICES VIb). These requests were implemented rapidly and suggested that participating fishers were sufficiently positive about the day-to-day utility of BATmap so as to recommend expanding its use. Fishers were notified of changes to BATmap via the WhatsApp group to which project team (PM, ET, and CTM), fishers and PO data managers belong. This group was convenient for reporting bugs in the software, announcing changes to the app and soliciting feedback on any modifications that were proposed, e.g. changes to the ATVs.

# 4 Other developments

A number of initiatives were undertaken during FIS032 that were not included in the FIS032 proposal as part of the work scope but are described in this section.

## 4.1 BATmap website

Given the global interest in bycatch reduction and RTR it was decided to create a website describing the basic aims of BATmap and highlighting the unique co-design process (https://info.batmap.co.uk/ ). This online information is consistent with entries into the RTR field that have also created websites (Clean Catch UK and IFISH). It was viewed important that Scottish industry get appropriate recognition for being first in Europe to operationalise RTR for bycatch reduction. It was recognised that the target audience did not necessarily include participating fishers as they would not require basic information.

The largest spike in traffic to the BATmap website occurred during the launch of the roll out in late June 2020, coincident with a press release by FIS. Since then, the website has attracted a steady flow of traffic (>924 visits as of 11/4/2021) from a wide range of fishing nations with the top five countries being the UK, USA, Ireland, Netherlands and Spain. FIS is the top source of referrals to the website. In future, it is planned to incorporate a link to this report as well as some testimonials from participating fishers as to the merits of BATmap.

## 4.2 R-BATmap

Several operational settings impact the nature of the maps generated by BATmap, e.g., hexbin size, catagorisation of the catch data and the ATV. The BATmap software itself is not amenable to exploratory data analysis to test how varying these settings impacts the overall information value of the maps themselves. The project team recognised that it would be useful to have some capability to vary these settings for illustrative or testing purposes, e.g., using smaller (or larger) hexbins, using more (or fewer) or different categories for catch data or varying the ATV. Therefore, as part of a MSc project undertaken in the summer of 2020 (by J. Asare) a customized analytical tool “R-BATmap” was created in the programming language R to reproduce as closely as possible the maps generated by BATmap from catch and vessel position data. The coding for R-BATmap is now available as a research tool should more detailed data analytics of real or simulated data be required.

## 4.3 Seasonally aggregated maps

Feedback from participating fishers at the end of the pilot suggested that they would benefit from receiving regular updates of aggregated maps showing seasonal variation in the distribution of cod, whiting and spurdog. This is being explored as a development in 2021 but regularly releasing these requires agreement of all participating fishers. Figure 4[2] illustrates examples of seasonally aggregated maps that were generated by BATmap for cod and spurdog in Q3 and Q4 2020. Although these are for a short, pilot period that was impacted by Covid-19 and Brexit, there are some interesting observations. Fishing activity is widespread and clearly lined to depth. Cod show an aggregative pattern being concentrated in the northeast. Spurdog illustrates a distinct patchiness of distribution suggesting that sharing information in real-time would be very useful.

[2] Participating fishers have agreed to including these maps in this report.

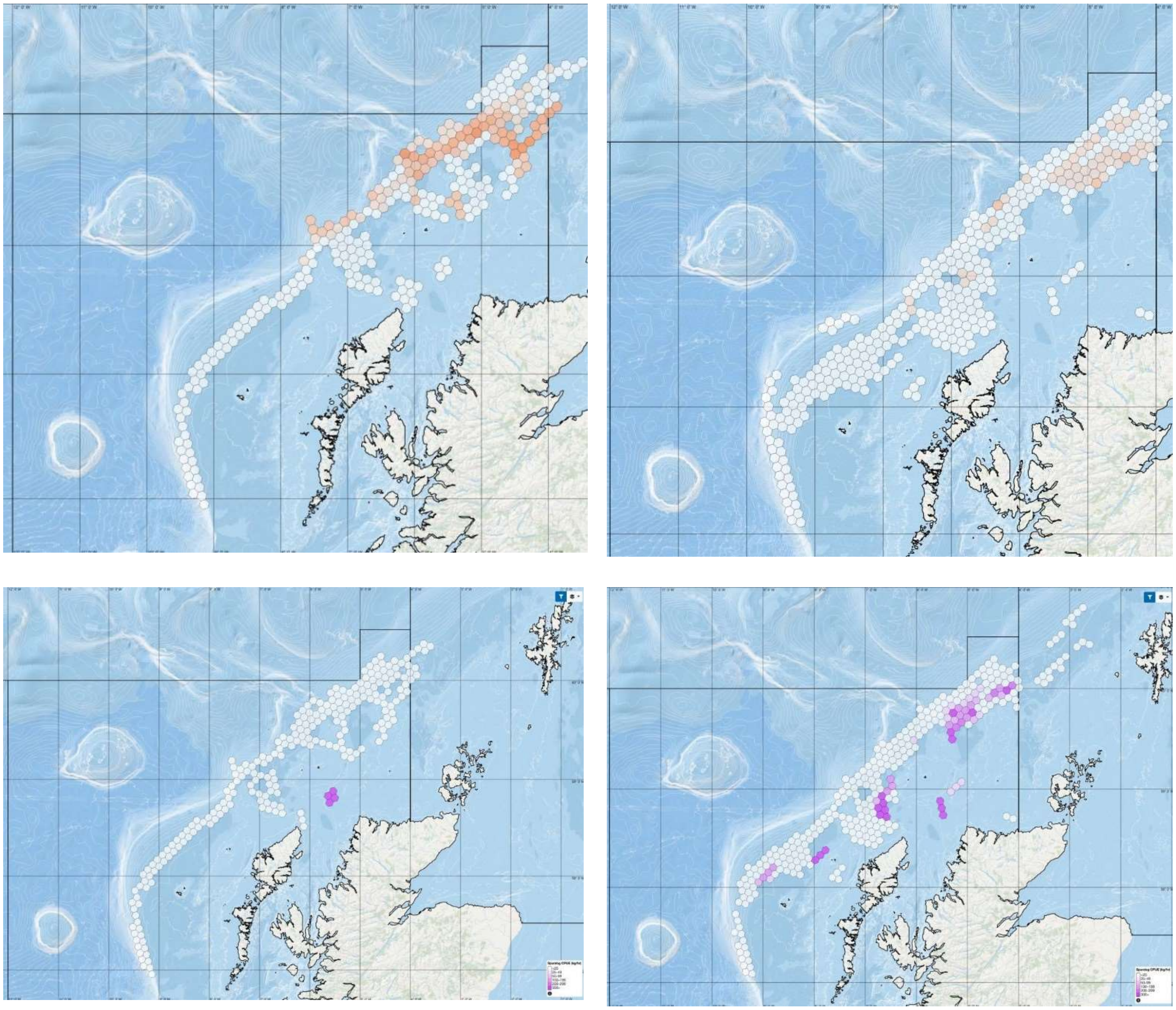

**Figure 4**: Seasonally aggregated maps for cod Q3 2020 (upper left), cod Q4 2020 (upper right), spurdog Q3 2020 (lower left) and spurdog Q4 2020 (lower right). For viewing details of the maps on larger scale versions, refer to Appendix 1.

# 5 Stakeholder engagement

The Scottish WoS demersal fishery is comprised of a relatively small number of vessels and therefore fishers. This small pool of prospective interviewees is no exception to the general rule that fishers are reluctant to be interviewed regarding topics that are sensitive (bycatch) or that they have no direct experience of (RTR). Those who voluntarily agreed to be interviewed for our study were self-selecting and may not have fully represented the diversity of viewpoints. Participants in the pre-pilot interviews were not intentionally included in the post-pilot interviews although that might have happened in some cases. Consequently, robust conclusions cannot be made about how individual attitudes shifted over the course of the pilot study. The short duration of the pilot study also limited the experience fishers had using RTR. Nevertheless, the pre- and post-pilot interviews were useful for identifying improvements that are needed for BATmap and for supplementing other forms of informal engagement, e.g. WhatsApp group comment and regular conversations with Paul Macdonald.

## 5.1 Pre-pilot study interviews

In the summer of 2019 (prior to FIS032) a MSc student at the University of Aberdeen, Mr. Cephas Asare, interviewed six WoS fishers in person to capture their views about the LO and determine their willingness to participate in a pilot RTR project. A semi-structured interview approach was used with questions covering five themes: Background, General views on the LO, Real-time reporting, and Information sharing culture (Appendix 2). At the time of the interviews the interviewees had no personal experience of RTR but had been informed about implementing RTR on the WoS through presentations, documents and emails given by Paul Macdonald.

The factors motivating their participation in the RTR pilot study showed that there was a perception of visible and direct benefits of participation (Figure 5). RTR was regarded as being important for accessing information relevant to avoiding catching cod by five of the six interviewees. The same proportion felt there would be no disincentives to participation. Industry leadership was also identified as a strong (>50%) motivator. Interestingly, improving science was not found to be a strongly motivating factor which is different to the results of the post-pilot study (Section 5.2.1) where it was found to be the strongest motivator.

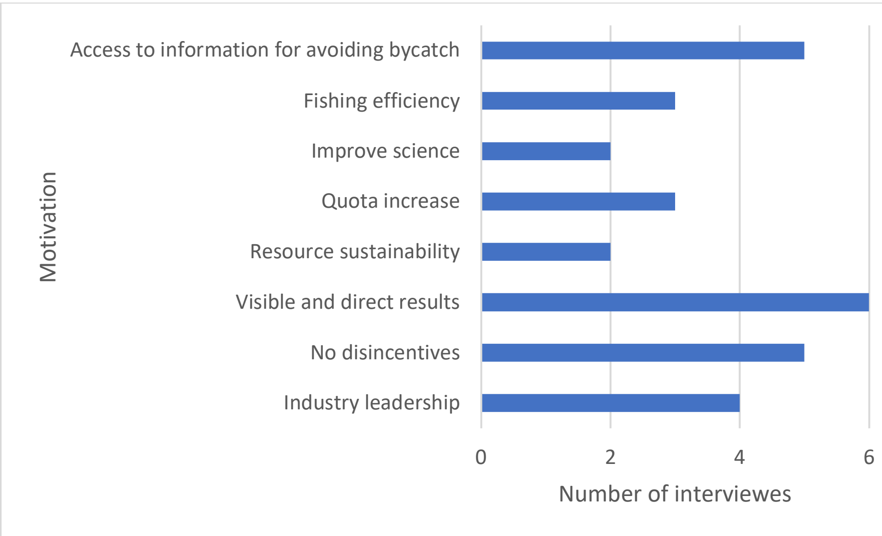


**Figure 5:** Motivation identified by fishers for participating in real-time reporting during the pre-pilot survey in 2019 (Asare, 2019)

## 5.2 Post-pilot study interviews

In December 2020, Paul Macdonald interviewed eight fishers about their experience using BATmap for all or part of the pilot study. The interviews were not recorded and the specific questions differed from the pre-pilot study interviews, covering five themes: Motivation for participation, WoS bycatch, General perception of the pilot, the BATmap app, and Sharing information (Appendix 3).

### 5.2.1 Motivation for participation in the BATmap pilot

The interviewee's motivation for using BATmap included concerns about the current status of the stocks and the desire to improve the science (Figure 6). This particular motivation is often expressed by WoS fishers, particularly in the context of cod, but differs from the actual aim of BATmap (enhance bycatch avoidance). However, their stated motivations are consistent with their broader concerns about the scientific assessments of WoS cod.

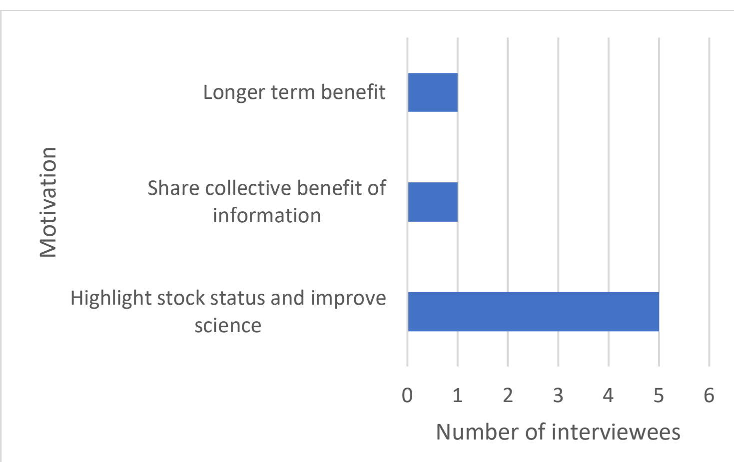


**Figure 6:** Motivation presented by fishers for participating in the sharing of data via BATmap during the post-pilot survey in 2020.

### 5.2.2 West of Scotland bycatch

The general situation in the WoS during the pilot study was characterised by poor weather during parts of it (probably "the worst" seen in a long time as noted by one fisher), lower fishing activities and a report of generally fewer fish in the area. All interviewees reported that Covid-19 impacted on the price of fish but not necessarily their fishing activity. Half of the interviewees reported that little or no change has been perceived in bycatches of WoS whiting during the pilot, compared with previously. For WoS cod, three fishers reported no change in the general bycatch situation, another three reported the bycatch to be a little lower than previously and the remainder reporting the bycatch to be a little higher. All respondents reported challenges associated with seasonal incidental bycatches of spurdog that have increased in recent years.

### 5.2.3 General perception of the pilot

All the interviewees indicated that sufficient information had been made available regarding the project's aims and its progress. The majority were unsure if they have benefitted from the pilot study at this stage but they are optimistic that RTR can mitigate the bycatch situation in the WoS. The consensus view was that it will take time to see results. Participation the pilot study was not viewed as a disadvantage in their normal fishing operations.

Interviewees felt that the app was easy and intuitive to use, unlike most reporting systems they are familiar with. The interviewees reported that consistency in their data entry has improved since the start of the pilot and is close to 100 %. The WhatsApp group has been a very useful medium of communication throughout this project but none of the interviewees had visited the project website.

### 5.2.4 The app

The interviewees felt they had made "reasonable to considerable" contributions to the development the app, which they find very easy to use. The bycatch maps, high bycatch alerts and automated catch entry reminders are perceived to be very useful. Further refinements that would be useful include having the latitude/longitude visible while zooming in or out of the maps.

### 5.2.5 Sharing information

As a result of participating in the pilot, interviewees indicated that they are now more willing to share information (Figure 7). Half of the interviewees found that the high bycatch alerts were not useful to them in avoiding unwanted catches because they were not necessarily fishing in the same areas when the alerts were generated. This insight is important when evaluating the success of any bycatch reporting tool. Any avoidance measure will require large data sets collected over long time scales so that the likelihood of the information being required and used in a tactical decision is increased given that the activity of fishing is highly mobile in both time and space and reflects net outcome of many joint decisions. The other half of the interviewees reported that, as a result of the bycatch trigger alerts, they have occasionally moved on from a fishing area, particularly where the alert indicated high bycatch of spurdog. In investigating whether the alerts have informed where they fished, one fisher out of the eight shared it had been very useful, and two each for reasonably and fairly useful. Disseminating an aggregated map to showing seasonal species information would be useful by all the respondents. Interviewees felt that the aggregated maps should not reveal any personal information that could reveal who contributed information.

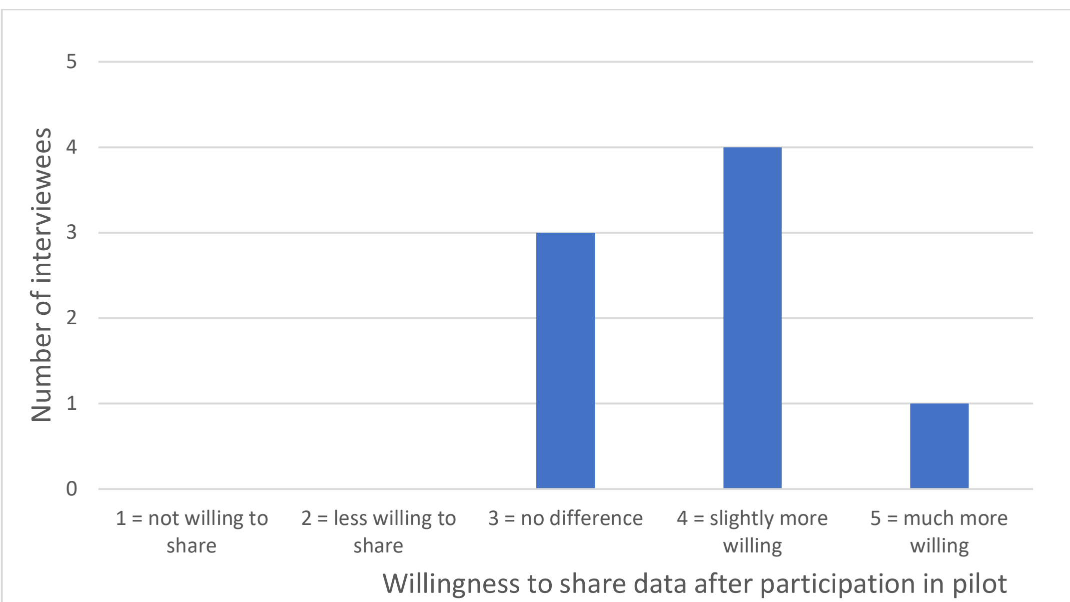


**Figure 7:** The number of interviewees reporting whether their willingness to share catch data changed as a result of their participation in the RTR pilot study in 2020. See question 22 in Appendix 3.

### 5.2.6 Can using RTR change attitudes and fishing behaviour?

Five out of eight interviewees indicated that they were more willing to share information because of having participated in this pilot (Figure 7). This attitudinal shift may partly be due to confidence that their data are being shared anonymously. Interviewees understood that the quality of data input to BATmap contributed to the quality of the output (the disseminated maps). Although the catch entries were becoming more consistent (no missed hauls) as the participants became more experienced with BATmap, over 60% of interviewees had limited confidence in the accuracy of data being entered by other vessels. The remaining interviewees indicated they had reasonable to considerable confidence in the data. Building confidence in the data entered by other participants is one aspect that needs to be developed further in future. Sustained use of BATmap over longer time scales and the gradual experience of tangible personal benefits from their bycatch data being shared will be critical to developing this confidence.

Unambiguous quantitative evidence that RTR reduces bycatch is difficult to obtain without detailed analysis of a comprehensive dataset, however, there are encouraging signs that BATmap is having a positive effect on avoidance and the sharing of high catch alerts. The seasonally aggregated map for spurdog in Q4 (Figure 4) illustrates the patchiness of this species in space. Moving on from a bycatch hotspot location as an informed response to an alert seemed to be more practical for spurdog compared to cod, possibly due to the aggregative nature of spurdog. The risk to fishing gear might make it more likely that vessels move on. Some related comments are: "*I have done so* [moved on as a result of bycatch alerts] *for spurdog. Cod is more tricky due to* [it being a] *mixed fishery*" and *"alerts will become more useful for spurdog in the new year as catches increase".* Other signs the BATmap is having an impact are:

- The responses to Questions 23, 24, and 25 (Appendix 3) were promising with 5 of 8 fishers indicating that they had moved on because of an alert being disseminated (Question 24). The interview feedback should not be overinterpreted that the fishers experience of a functional alerting system was limited given the short duration of pilot study and the cod ATV was being adjusted downward until October 2020.
- The option to report whether a vessel intended to move on due to bycatch levels was utilised by fishers on 27 occasions during the study. Table 5 provides a summary of instances when fishers reported that they intended to move on by month and by species.
- There was some evidence that vessels moved on from areas where a high catch alert was triggered. An example of this is illustrated in Figure 8. Trapping this type of response was not an aim of FIS032 and to do this accurately a larger, post-pilot data set would be required.
- Fishers who reported that they did not necessarily find the alerts useful noted that this was primarily due to them **not** fishing in the area where the alert was generated at the time it was generated. While alerts in these instances may not directly result in a vessel moving on, the information provided can be useful to help vessels as they consider where to fish in future.

| Year | Month | Total Catch Reports | Move On Marked | Cod Catch > 150 kg with Move On Marked | Whiting Catch > 150 kg with Move On Marked | Spurdog Catch > 200 kg with Move On Marked |
|---|---|---|---|---|---|---|
| 2019 | 12 | 12 | 0 | 0 | 0 | 0 |
| 2020 | 1 | 114 | 0 | 0 | 0 | 0 |
| 2020 | 2 | 120 | 1 | 0 | 1 | 0 |
| 2020 | 3 | 157 | 4 | 3 | 1 | 0 |
| 2020 | 4 | 84 | 2 | 2 | 0 | 0 |
| 2020 | 5 | 101 | 4 | 4 | 0 | 0 |
| 2020 | 6 | 133 | 1 | 1 | 0 | 0 |
| 2020 | 7 | 207 | 3 | 2 | 0 | 0 |
| 2020 | 8 | 70 | 1 | 1 | 0 | 0 |
| 2020 | 9 | 79 | 0 | 0 | 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2020 | 10 | 244 | 4 | 4 | 0 | 0 |
| 2020 | 11 | 166 | 1 | 0 | 1 | 1 |
| 2020 | 12 | 200 | 4 | 2 | 0 | 4 |
| 2021 | 1 | 205 | 2 | 1 | 0 | 2 |
| **Total** | | **1892** | **27** | **20** | **3** | **7** |

**Table 5**: Summary of instances where fishers recorded that they intended to move on due to high bycatch.

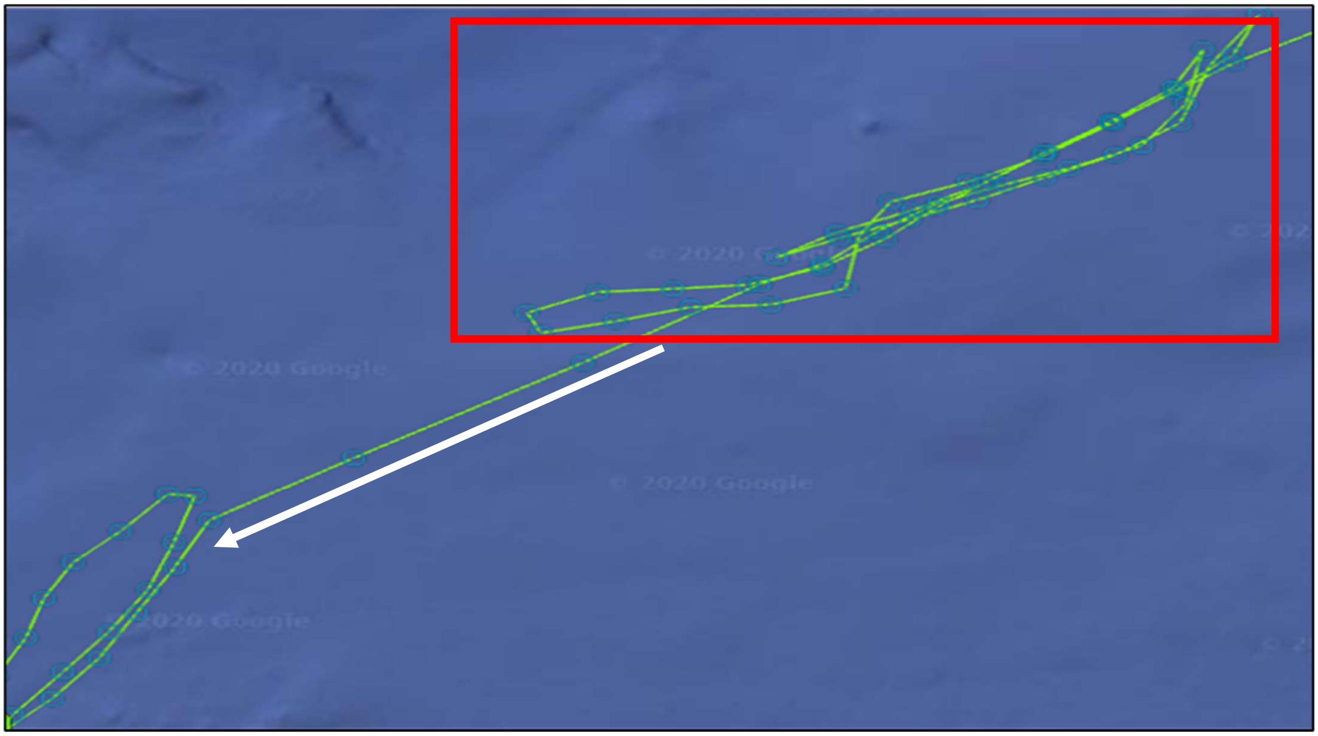


**Figure 8:** An example of a vessel moving on after generating a high catch alert for cod. The green lines illustrate the vessel's track. The red box highlights where the vessel was fishing and where the alert was generated, the white arrow indicates the direction of travel of the vessel away from the alert area to a new fishing area.

Because the ATV for cod was set too high at the beginning of the pilot this resulted in few alerts being triggered. The current ATV for cod (1 tonne) came into force on 8/10/2020 therefore the experience of the alerting system was quite limited when interviews were conducted in December. Having experience over a full fishing year will give a more complete picture of how the participating fishers view the alerting system.

## 5.3 Fishers recommendations for modifying BATmap

- Recommend an alternative communication method to SMS for sending alerts as they are not received when out of SMS range. Alternative to be explored could include Whatsapp
- It would be useful to not have to enter catches in deep water where there is no cod or whiting. It has been suggested that it is pointless to record catches there.
- Have the latitude/longitude visible on the screen when zooming in on alerts
- Consolidate hauls into trips
- Hexbins are very big, maybe could do with reducing the size, especially along the edge where the depths change very quickly

## 5.4 Expectation management

Throughout the project, a key priority was clearly communicating the aims of RTR both within the fishing industry and outside of the fishing industry. Nevertheless, misunderstandings arose across different stakeholders having differing objectives with respect to bycatch. For example, fishers sometimes expressed the hope that information collected by

BATmap could lead to improved perceptions of stock status and therefore more quota. Conversely, conservation organisations hoped that the information being shared could enter the public record. Both understandings are fundamentally incorrect. Indeed, the aim of RTR is succinctly expressed in the name of the app: *bycatch avoidance tool using mapping*. Going forward into the next phase of the project, we will continue to encourage fishers to see the intrinsic value of shared information for their own day to day operations in the hopes that data analytics will play an increasing role in operation of modern businesses.

# 6 Future plans for BATmap

As the previous section makes clear, fishers participating in the BATmap pilot study are already seeing the short-term benefits of information sharing and are supportive of the longer-term benefits of industry-led data collection and dissemination. They are committed to building on the work done to date in the pilot study and eager to see BATmap continue to develop during 2021. The POs involved are also committed to continuing the application of RTR on the WoS and willing to commit further funding to support the next phase of development.

## 6.1 Plans for 2021

The next phase of the project (from February to December 2021) will maintain and refine the catch app and associated databases while also developing additional functionality that can assist in the reporting and dissemination of information from the system such as seasonally aggregated maps (Table 6). The workplan includes modifications to BATmap that participating fishers have identified (Section 5.3) that could be easily implemented with additional IT support from Chordata. As well, the programme will aim to Increase the number of WoS fishing vessels using BATmap to maximise the quantity of information being captured.

| Task | Justification | Potential funding sources |
|---|---|---|
| Develop data governance policy | Development of a formal document that describes data sharing agreement that the PO managers and the participating fishers can use as the ‘rule book’ | Participating POs, Seafish and Scottish Fishermen’s Trust |
| Maintenance and refinement of BATmap | Routine maintenance of the system including modifications of alerts levels and further refinement of the system | |
| AWS cloud storage | Cloud data storage and messaging cost with Amazon Web Services | |
| Develop new performance monitoring capabilities for BATmap | To capture routine data such as timelines showing frequency of catch reports being submitted, frequency of alerts etc for use by PO managers | |
| Workshop(s) | Industry-wide meeting (especially with other POs) to discuss future of RTR over long-term. Chordata staff member to Scotland in November or December (depending on travel conditions) to participate in workshop. | Scottish Fishermen’s Organisation and FIS |

**Table 6**: 2021 workplan for the second stage of BATmap including the maintenance and continued development of BATmap. The potential funding sources are indicated.

The financial support required for continuing BATmap in 2021 has been sought from three sources: Seafish, the Scottish Fishermen’s Trust (SFT) and the consortium of producer organisations that are using BATmap. The participating POs and Seafish have already committed their share of the funding with an application to SFT having been submitted in April 2021. This funding ensures continued support for maintenance and development of BATmap throughout 2021.

The 2021 workplan includes the development of a data governance policy that outlines the measures taken for securing data that are contributed to the BATmap database. This will be important document for formalising the terms and conditions that fishers are signing up for when they voluntarily agree to participate in BATmap. It will, for example, describe data confidentiality arrangements and outline the steps taken to minimise the “free rider” problem that is frequently raised in informal discussions. A workshop building on the experience developing and deploying BATmap in FIS032 is tentatively planned to discuss options for expanding industry self-sampling, increasing participation and enshrining data governance.

### 6.2 Longer-term planning

In the second half of 2021 BATmap will have accumulated over a year's worth of data from all participating vessels. This is an appropriate time to evaluate the effectiveness of the system and develop a long-term strategy for RTR. Discussions with the Scottish Association of Fish Producer Organisations would be helpful for embedding the cooperative component of BATmap. These discussions could also contribute to the development of the data governance policy.

Therefore, a 5-year strategic plan (Jan 2022 to Dec 2026) will be developed in 2021 that will provide stability for the continued development of the system (hardware and software) as well as further developing the analytical capabilities of BATmap including R-BATmap. Funding will be sought via a combination of the UK replacement to EMFF and the fishing industry. Embedding the technology and data analytics capability of BATmap in the Scottish fishing industry also has considerable potential for funding from the Knowledge Transfer Partnership (https://www.ktp-uk.org/ ) which supports industry and university collaborations.

## 7 Conclusions

FIS032 has successfully delivered Europe's first and, to date, only fully operational software for RTR at sea for avoiding unwanted bycatch that is in use by commercial fisheries. The implementation plan outlined in FIS011B has therefore been realised by FIS032. Unlike many other bycatch avoidance apps currently in development, BATmap was co-designed by the fishers who are the end users of the app. This has given the Scottish fishing industry the experience of developing and applying ICT to unlock the information value of the data they routinely collect. Going forward, BATmap's features and operational settings will continue to evolve as participating fishers become more accustomed to sharing information and interpreting the maps. This experience will allow them to understand the benefits of RTR on a personal level. Over longer time scales (ca. 5-10 years) it will become possible for the industry to quantitatively evaluate the success of RTR in avoiding bycatch through analysis of the BATmap database and reviewing the multi-year experience of fishers using RTR.

## 8 Acknowledgements

We thank the co-funders (FIS, SFO, Scottish White Fish Producers Association, Seafish and the University of Aberdeen), the participating POs and the participating fishers for being willing to take a chance on RTR. Critical early support was given by D. Anderson (Aberdeen Fish Producers Organisation) and M. Park (SWFPA). K. Haflinger (Sea State Inc., Seattle, USA) generously shared valuable insights about the use of RTR on the west coast. C. Asare is thanked for his concerted efforts trying to "catch" fishers to be interviewed in 2019. C. Needle (Marine Scotland Science) kick-started interest in mapping unwanted catch of juvenile cod in the North Sea.

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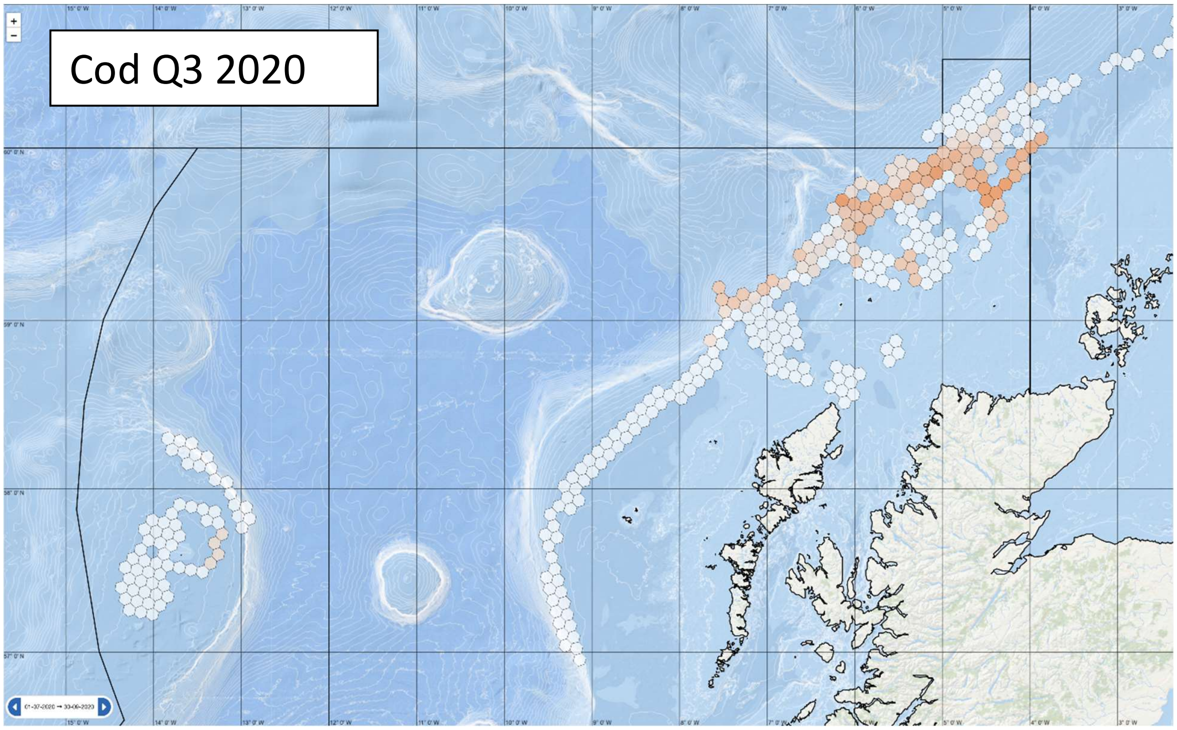
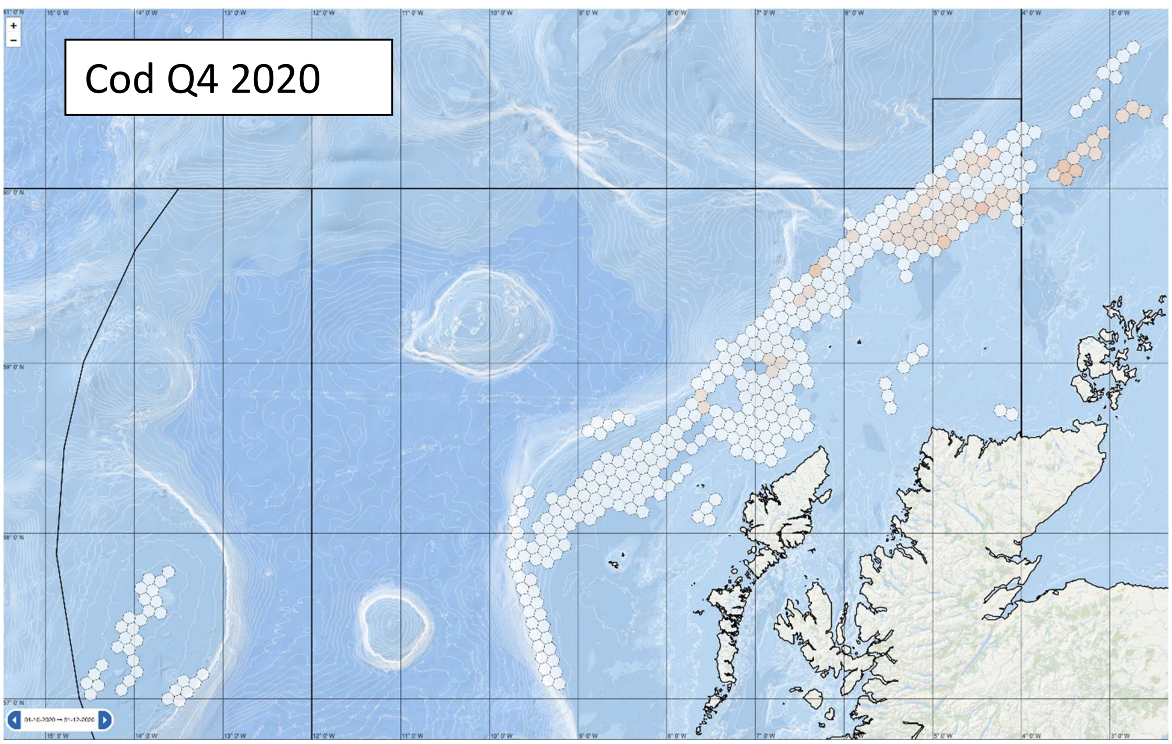
## Appendix 1



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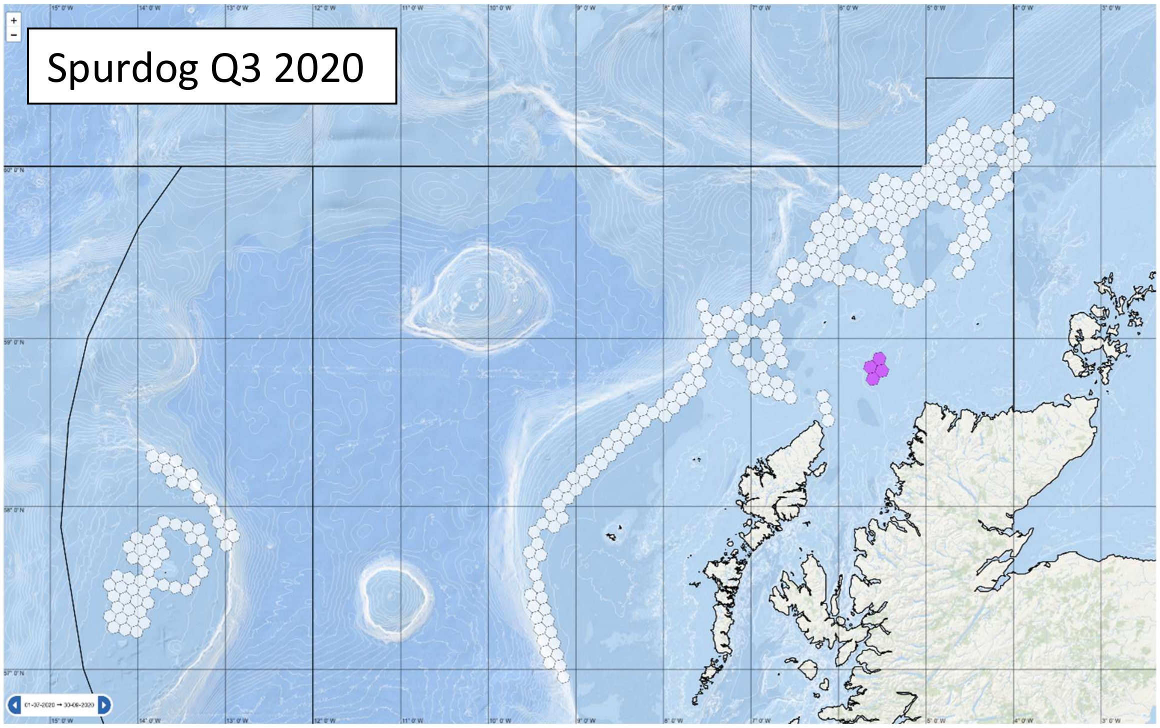
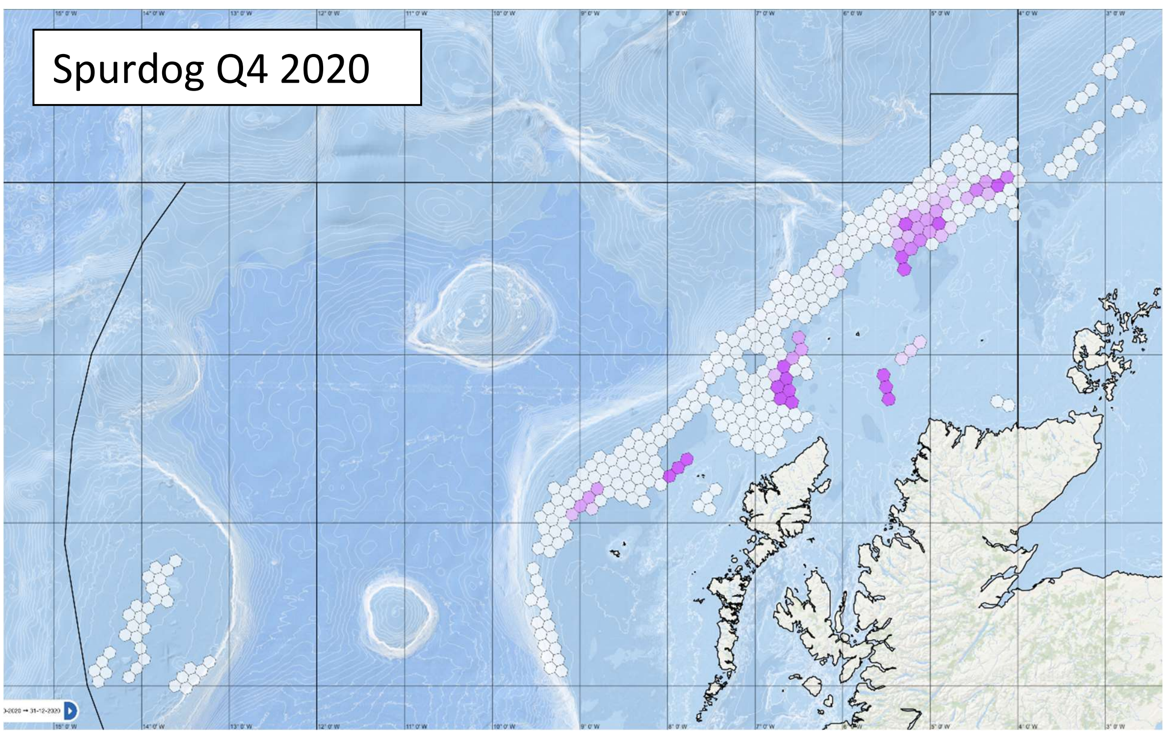


# Appendix 2

| Topic | Question |
|---|---|
| **1. Background** | Part-time or full-time<br>Fisheries involved in (species and fishing area)<br>Vessel Size (Length & HP)<br>Gear types<br>Years of experience<br>Role (skipper or owner)<br>Home Port<br>Which PO are you associated with?<br>Do you fish on the West of Scotland (WoS)?<br>What species in the WoS do you have quota for? |
| **2. General views on the Landing Obligation** | What are the difficulties associated with the LO in your experience?<br>○ Do these difficulties directly impact your work on a day-to-day basis?<br>○ If so, how do these difficulties impact your work?<br>What are the positives of the LO in your experience?<br>○ Do these positives directly affect your work on a day-to-day basis?<br>○ If so, how do these positives impact your work?<br>What could be done to improve the implementation of the LO in your opinion? |
| **3. Real-time reporting** | How familiar are you with the concept of RTR (information sharing) for avoiding unwanted catch for example chokes?<br>○ If not familiar, or uncertain, provide a quick explanation. Use graphics supplied (e.g., using handout of PowerPoint presentation).<br>○ If familiar, from your knowledge, can you explain it in your own terms? How did you come by this information?<br>Do you see yourself benefiting from taking part in a pilot RTR scheme being proposed for the WoS? If so, what are they?<br>Do you foresee costs or disadvantages to your fishing operation taking part in RTR? If so, what are they?<br>Do you think the implementation of RTR will benefit the WoS fishery?<br>What role should industry play in the design, development or operation of RTR? |

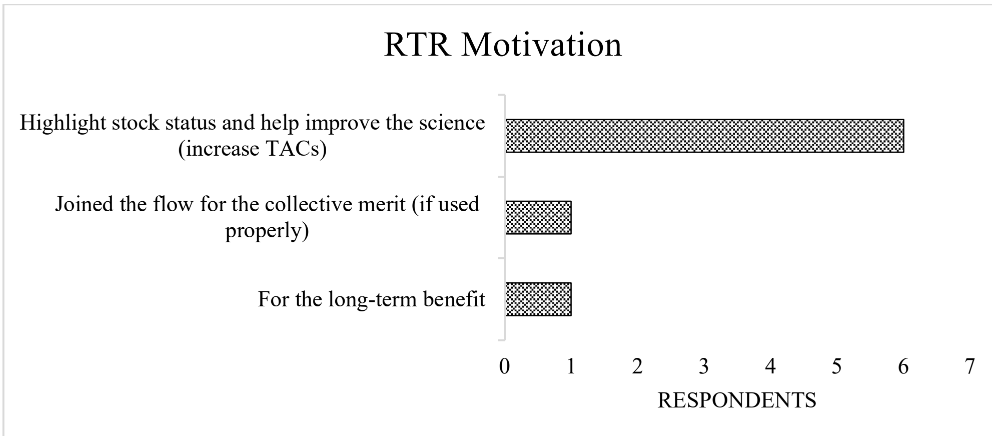
| | |
|---|---|
| **4. Information sharing culture** | What do you do when you encounter unwanted species?<br>To what extent are skippers fishing on WoS already sharing catch information with each other<br>o What do you share information about?<br>o who do you share or not share the information with?<br>How willing do you think other skippers are to participate in RTR where information about choke species will be shared with others? Why? |
| **5. Any other questions/relevant topics not covered?** | |

# Appendix 3

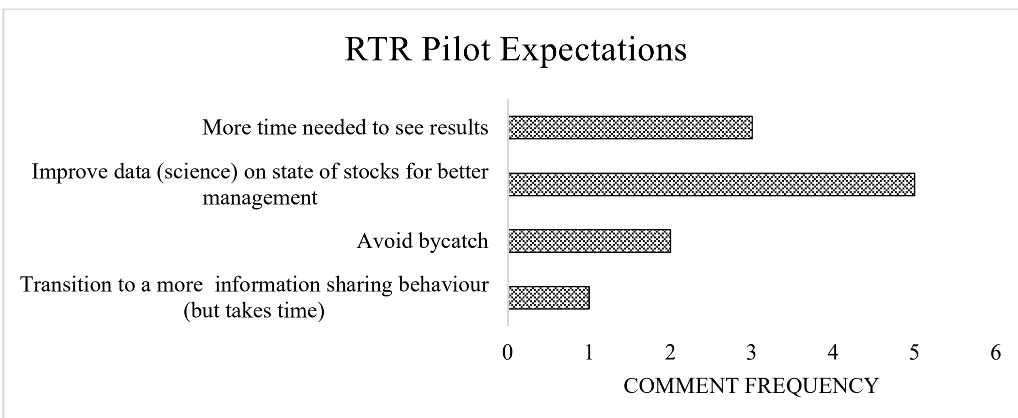
INFOGRAPHIC RESPONSES TO INTERVIEWS – Dec 2020

**Motivation for participation**

1. Why did you agree to participate in the RTR pilot?

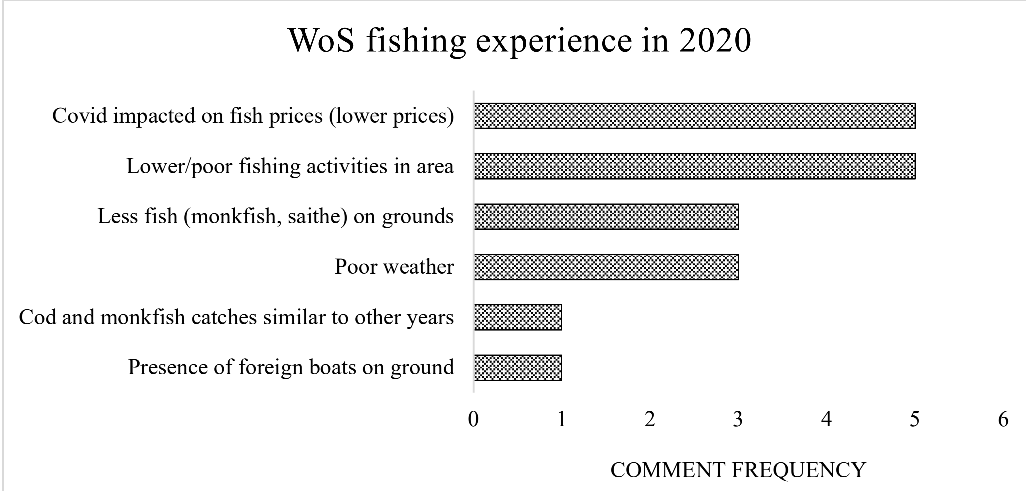



2. What did you anticipate the RTR pilot would achieve?

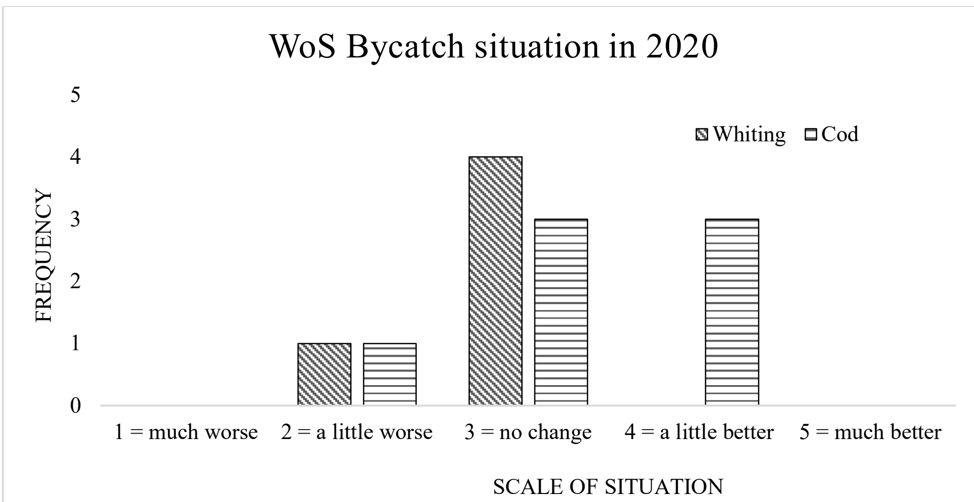



**West of Scotland situation**

3. Has your general fishing activity in 2020 on the west of Scotland been consistent with previous years? If not, why not?



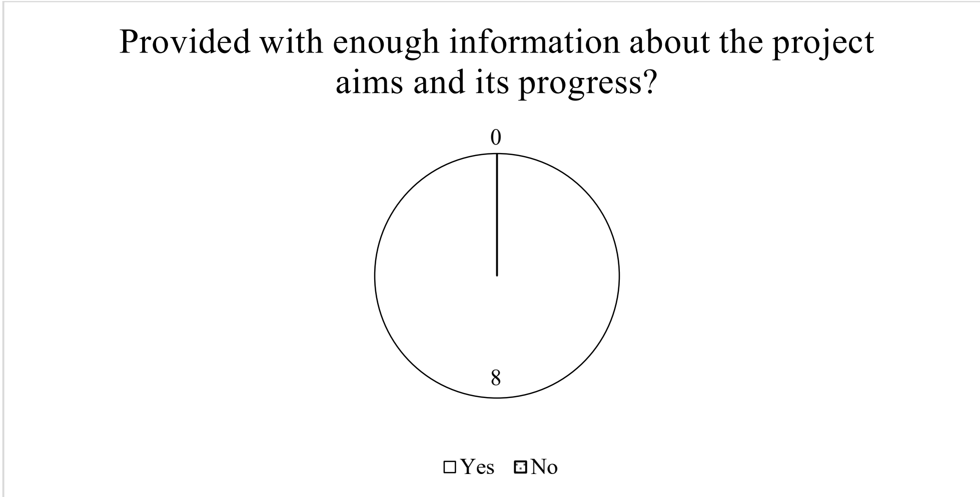

4. Has the cod and whiting bycatch situation in the west of Scotland changed since the start of 2020? (scale of 1 to 5: 1=much worse, 2=a little worse, 3=no change, 4=a little better, 5=much better)



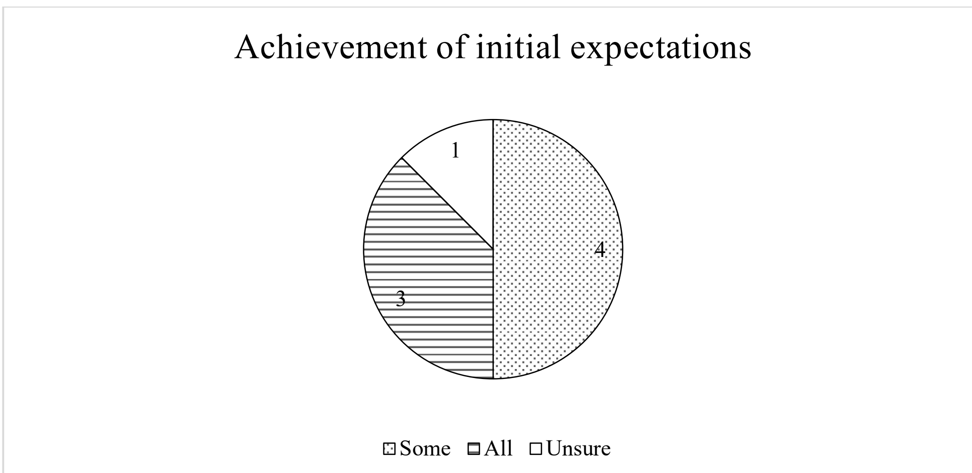

Comment: Less of really big cod hauls seen in the past. More cod seen on the west of 4° and more whiting in deeper waters (100 fathoms)

**General perception of the pilot**

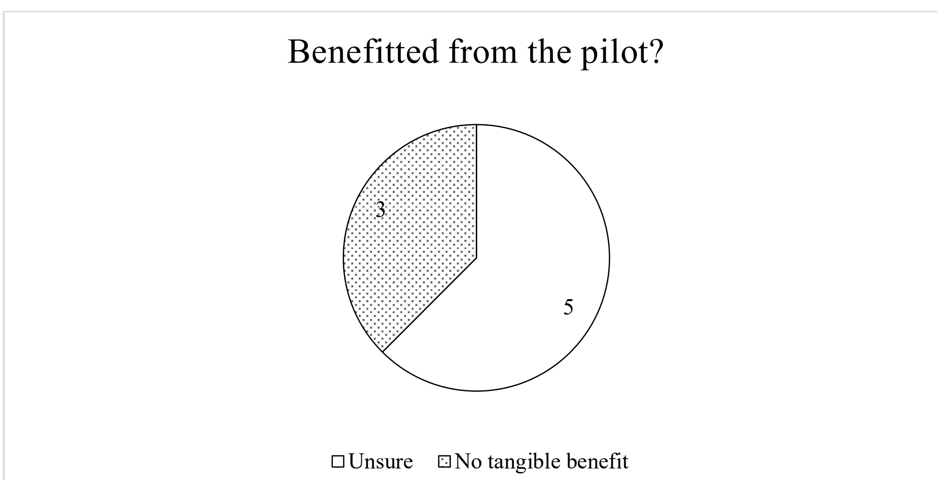
5. Do you think you have been provided with enough information about the aims of the project and how it is progressing?




6. Has the pilot achieved some or all of what you initially expected?

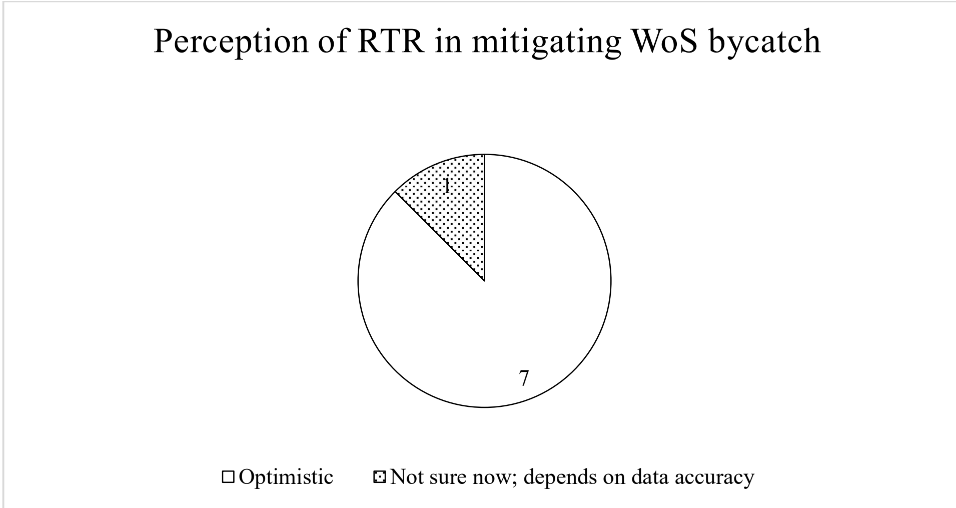



7. Have you benefitted from participation in the RTR pilot? If so, how?



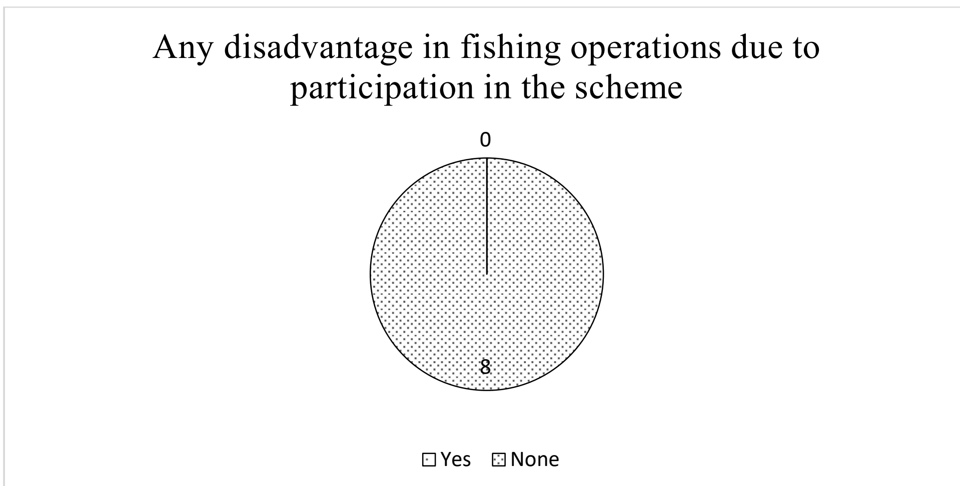

<u>Reason:</u> needs **more time** to see benefits; too early to tell

8. Having participated in the pilot, are you generally optimistic or pessimistic that RTR can help mitigating/improve the bycatch situation on the west of Scotland?

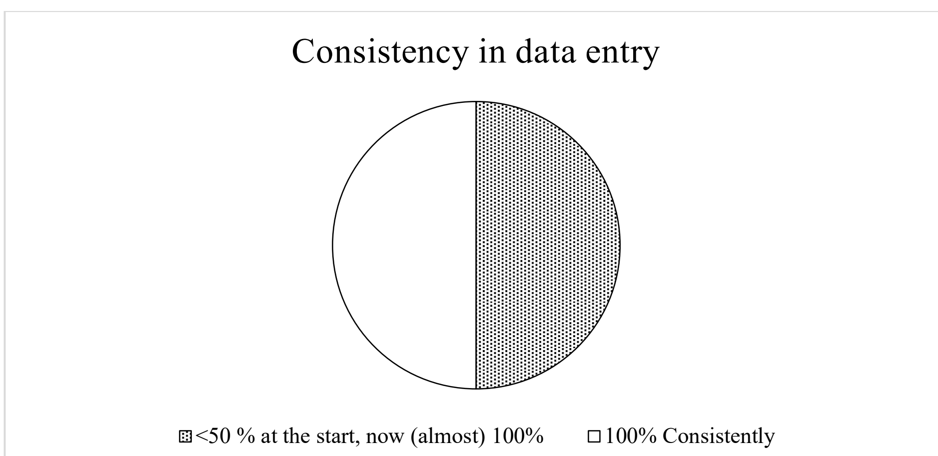



<u>Comment:</u> Needs to be **used more** to reap benefits in the long term

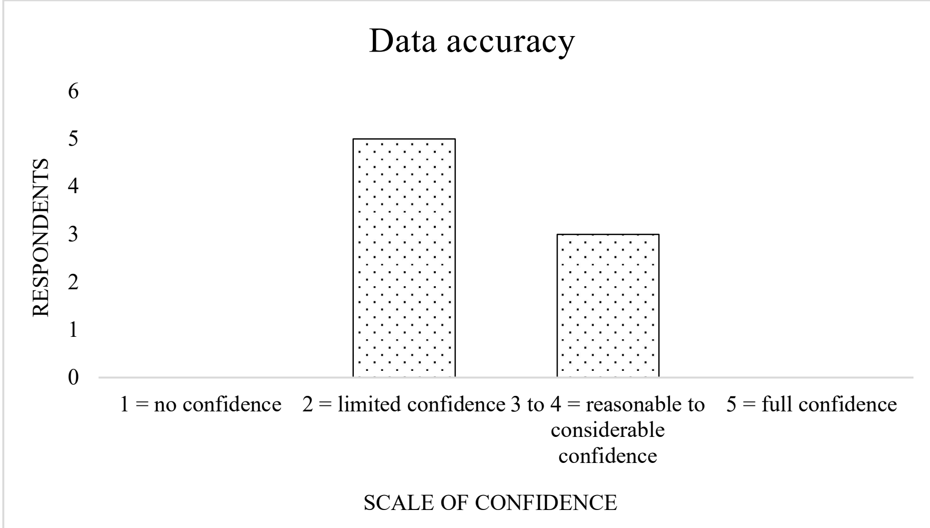
9. Has participation in the scheme disadvantaged your normal fishing operations?



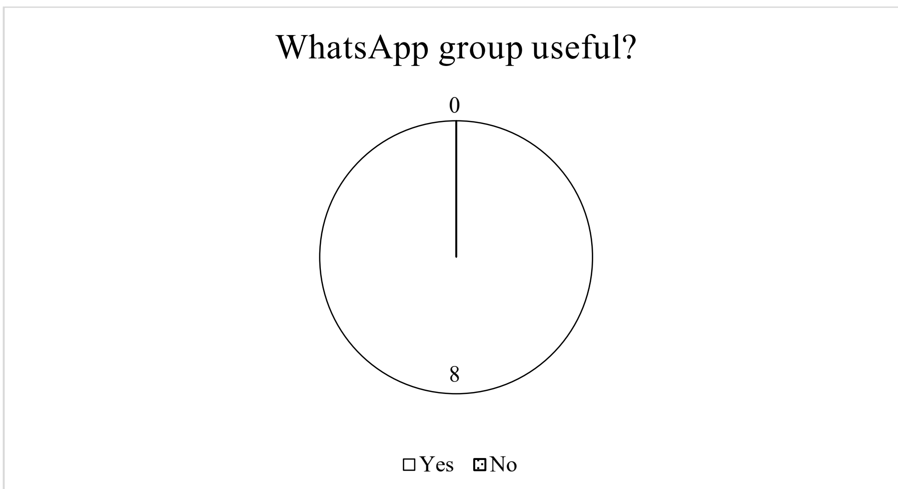

10. How consistently have you been entering your catch into the app since the pilot began? (scale of 1 being <50% to 5 being 100%)



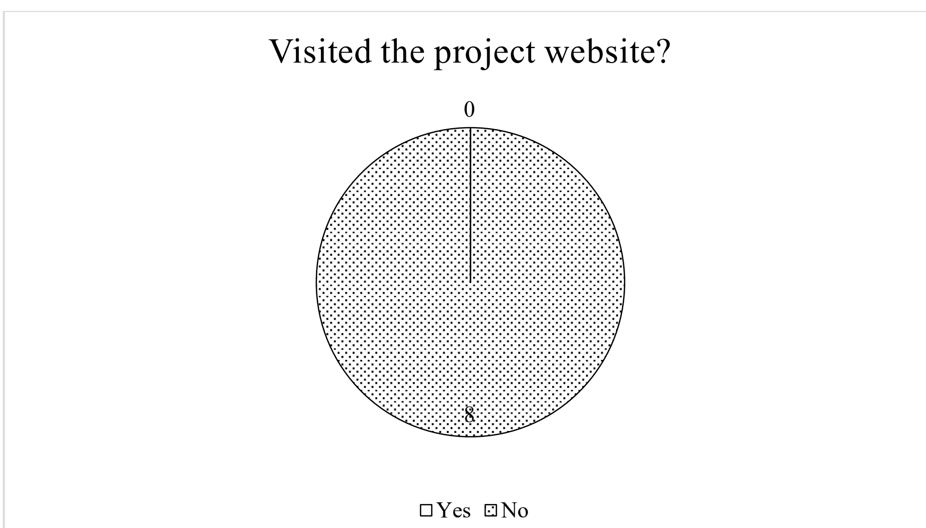

11. How much confidence do you have in the accuracy of the catch information submitted by the other pilot participants? (scale of 1 to 5: 1=no confidence, 2=limited confidence, 3=reasonable confidence, 4=considerable confidence, 5=full confidence). If not confident, why?




12. Has the WhatsApp group been a useful tool for sharing information? Would other means of communication be more useful?

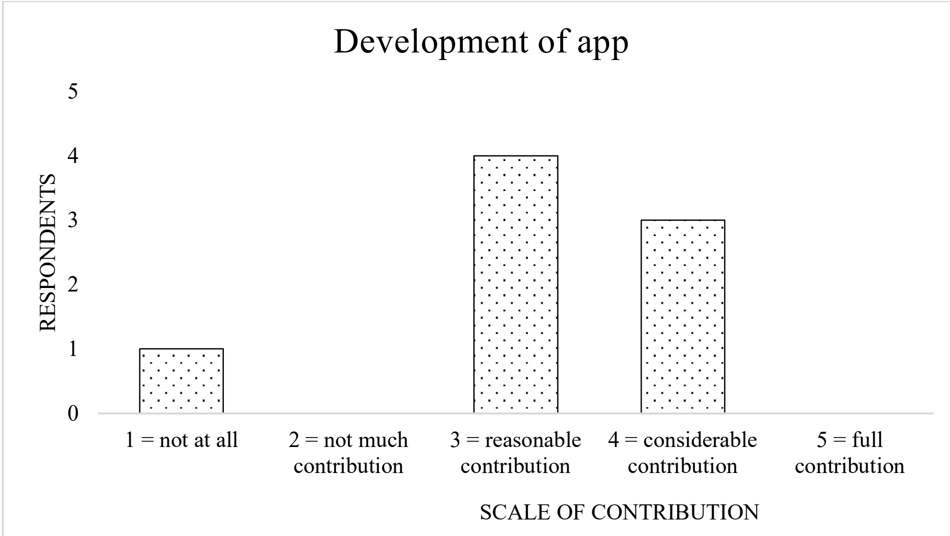



13. How often have you visited the project website? If yes, have you found it useful?

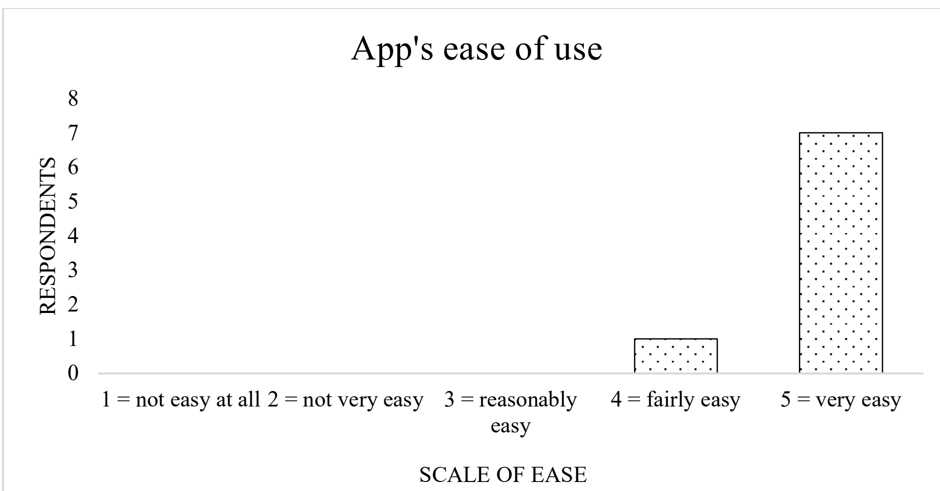


**The app**

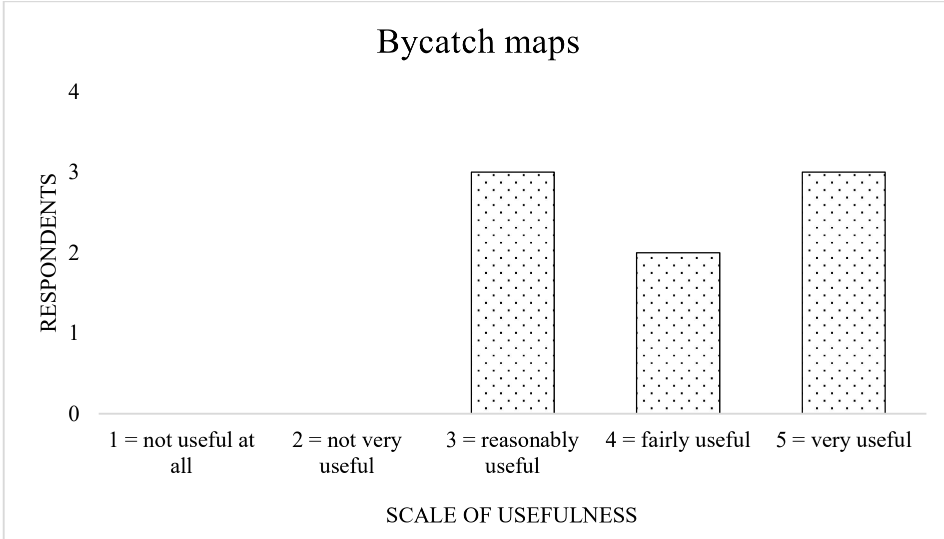
14. Do you feel you have contributed to the development and design of the mobile app? (Scale or 1 to 5: 1=not at all, 2=not very much, 3=a reasonably amount, 4=fairly extensively, 5=very extensively)




15. How intuitive and easy to use is the app? (scale of 1 to 5, 1=not useful at all, 2=not very useful, 3=reasonably useful, 4=fairly useful, 5=very useful)

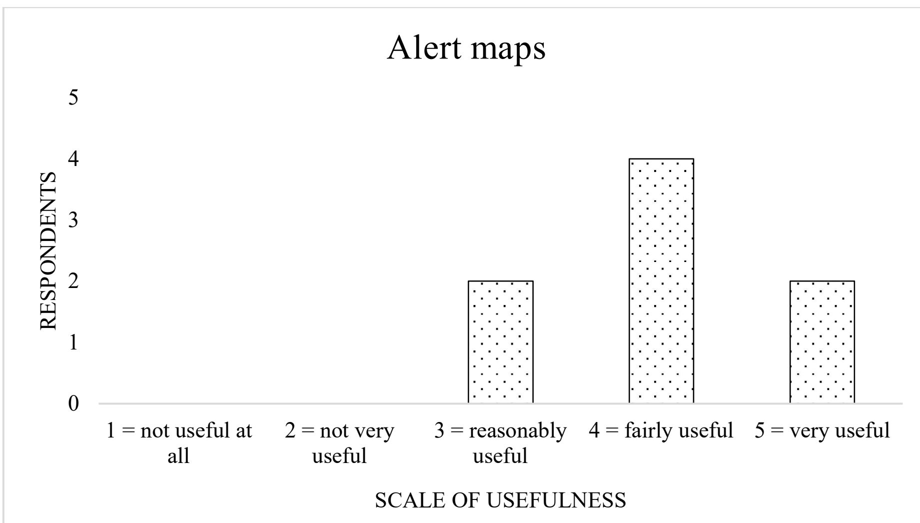



16. Are the bycatch maps for your vessel useful to you? (scale of 1 to 5, 1=not useful at all, 2=not very useful, 3=reasonably useful, 4=fairly useful, 5=very useful)

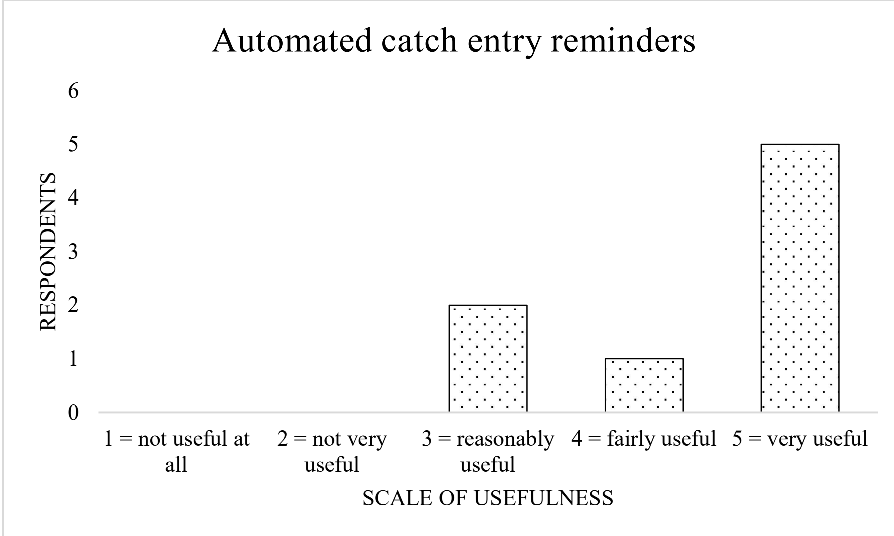



Comment: Maps are very useful for other things other than cod catches

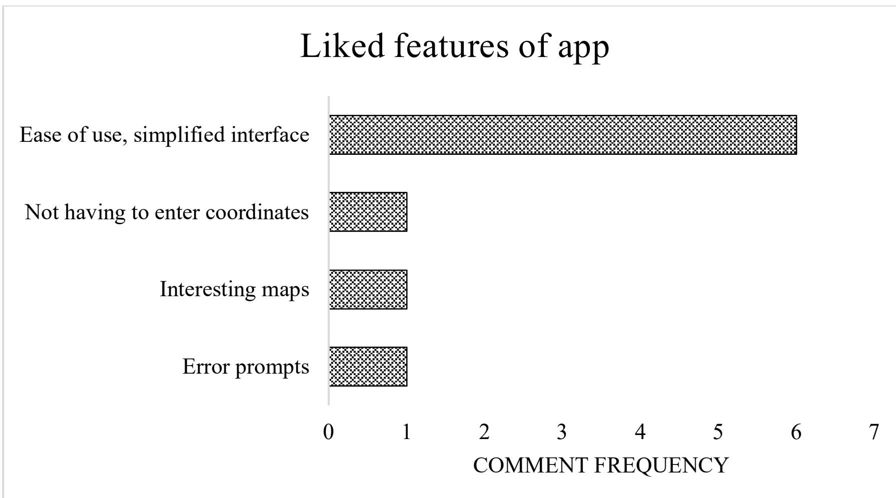
17. Are the shared alert maps useful to you? (scale of 1 to 5: 1=not useful at all, 2=not very useful, 3=reasonably useful, 4=fairly useful, 5=very useful)



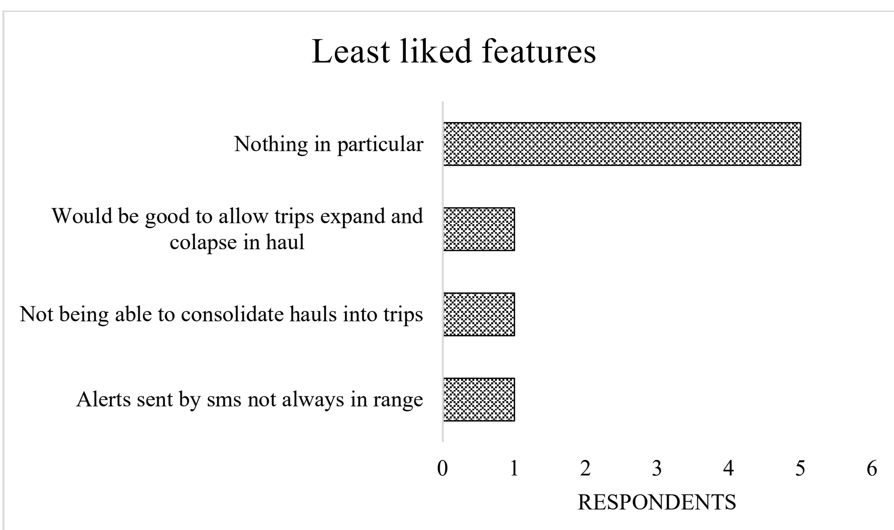

18. How useful are the automated catch entry reminders? (scale of 1 to 5: 1=not useful at all, 2=not very useful, 3=reasonably useful, 4=fairly useful, 5=very useful)



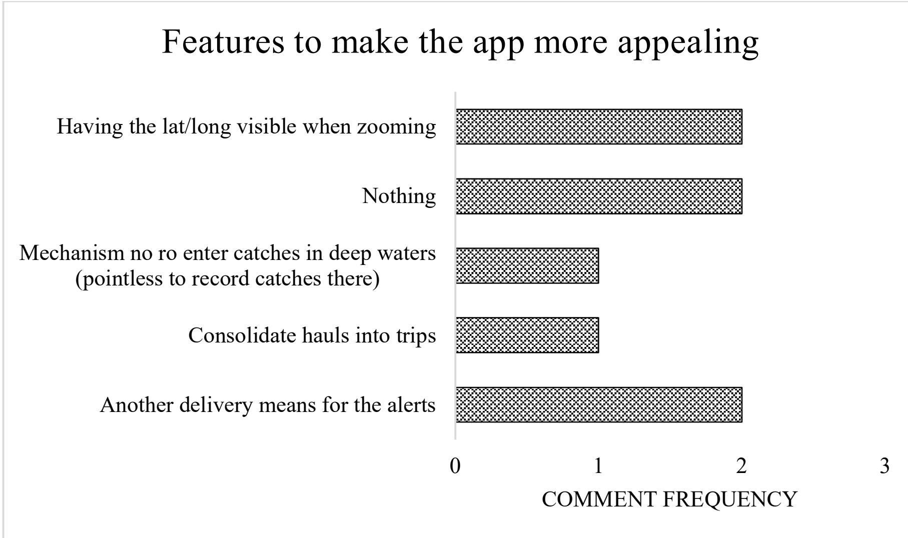

19. What features do you like the most about the app?




20. What features do you like the least about the app?

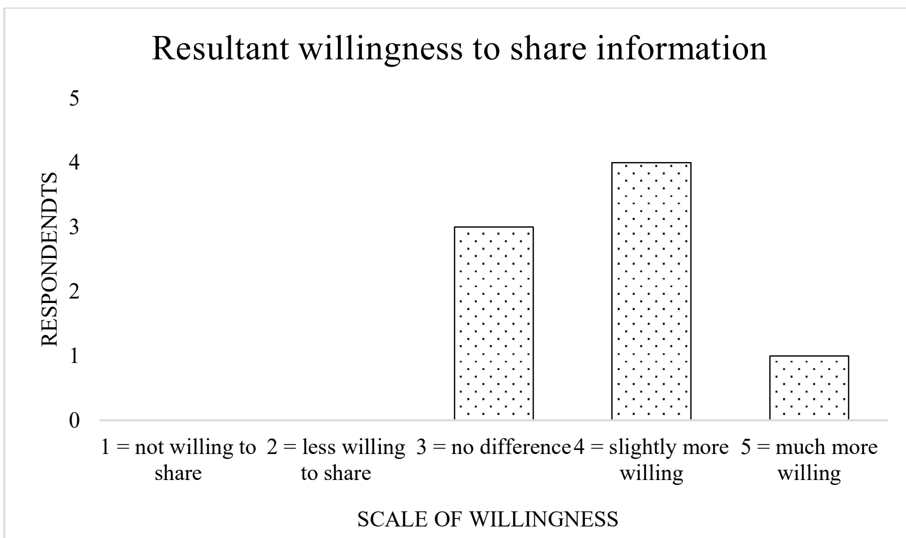



21. Are there any design improvements that would make the app more appealing or easy to use?

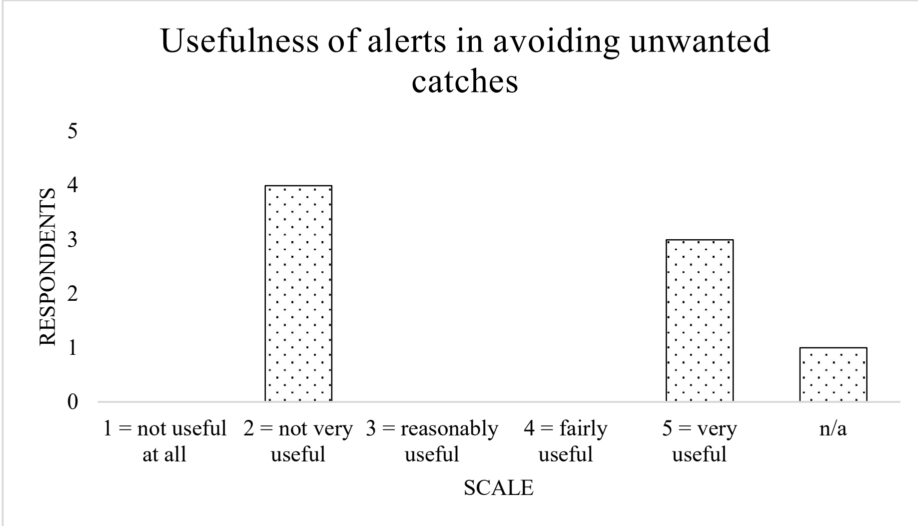



**Sharing information**

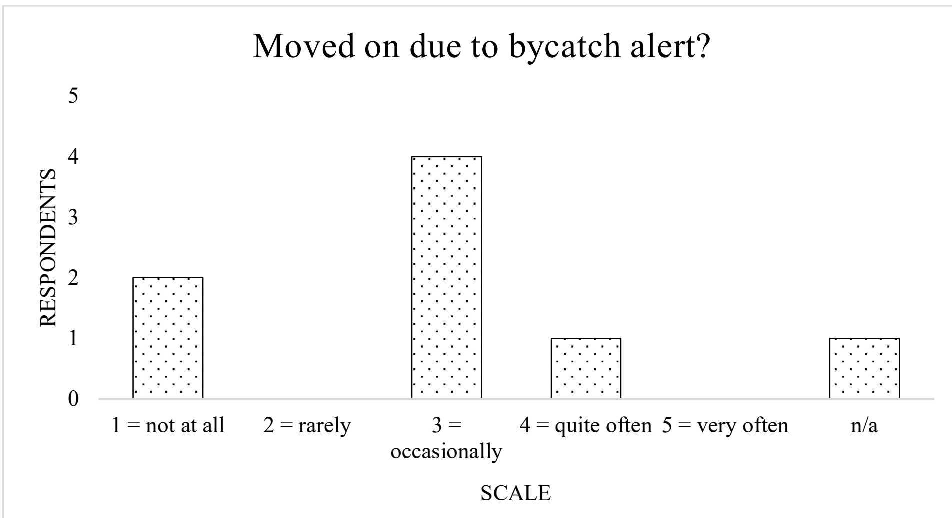
22. Are you more willing to share information as a result of participating in this pilot? (scale of 1 to 5: 1=not willing to share, 2=less willing to share, 3=no different, 4=slightly more willing to share, 5=much more willing to share)




23. How useful have the high catch alerts been for avoiding unwanted bycatch? (scale of 1 to 5: 1=not useful at all, 2=not very useful, 3=reasonably useful, 4=fairly useful, 5=very useful)

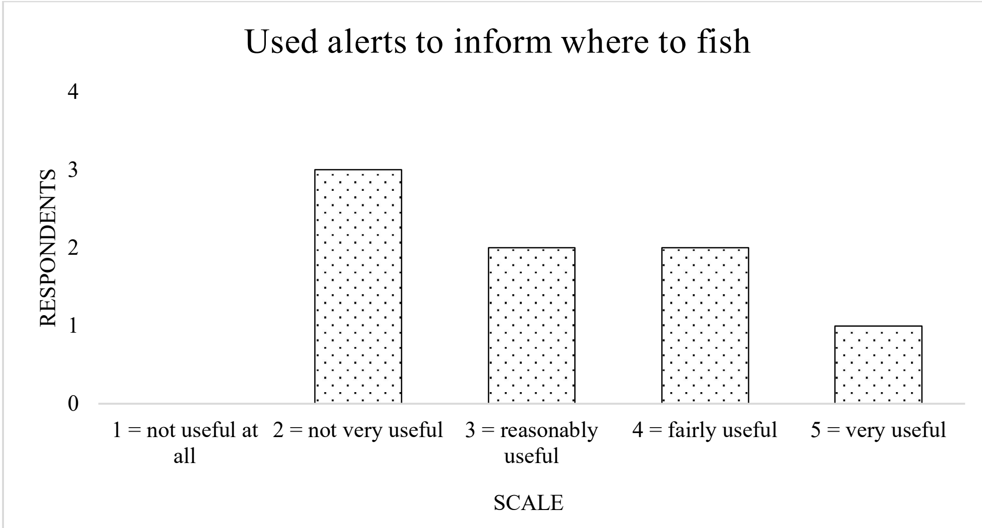



24. Have you moved on from a reported hotspot as a result of triggering or receiving a high catch alert? (Scale of 1 to 5: 1=not at all, 2=rarely, 3=occasionally, 4=quite often, 5=very often)

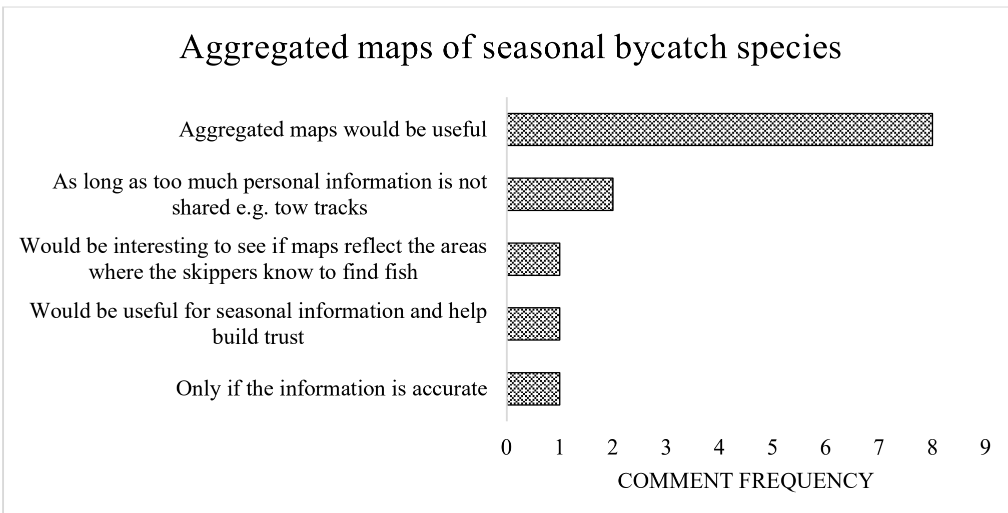



Comment: Occasionally for spurdog. Cod presents a tricky situation due to mixed fishery

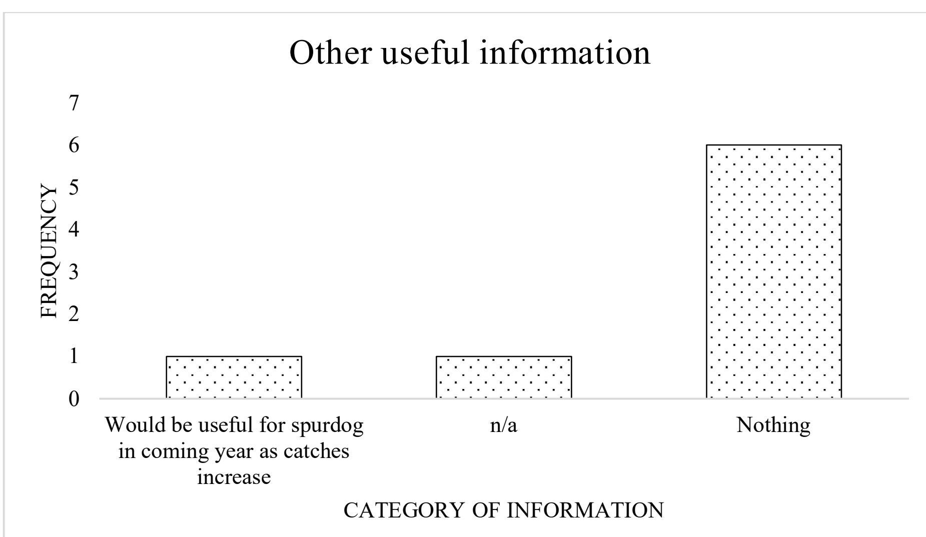
25. Have you used the high catch alerts to determine where you fish? (Scale of 1 to 5: 1=not at all, 2=rarely, 3=occasionally, 4=quite often, 5=very often)



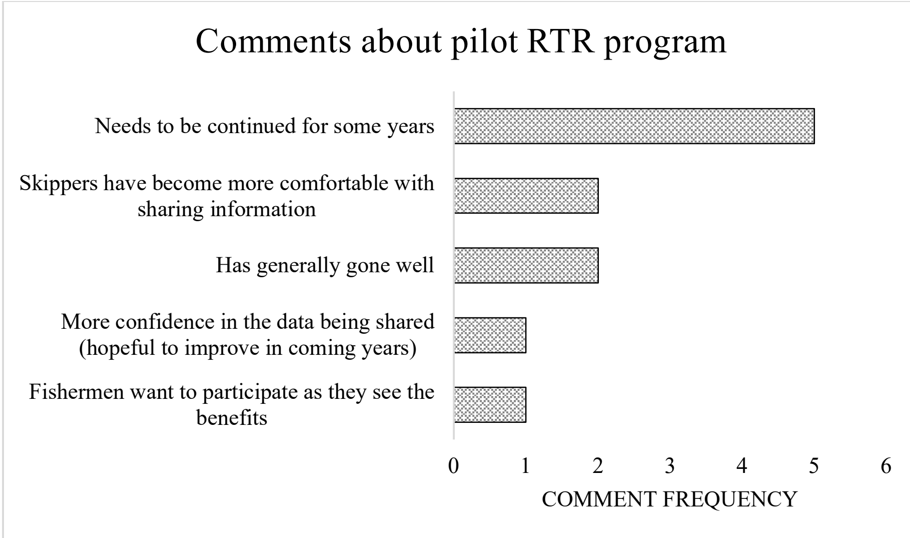

26. Do you think it would be useful to share more information on catch rates of bycatch species such as general aggregated maps showing seasonal concentrations of bycatch species? What other information might be useful to share?




27. What other information might be useful to share?



28. Do you have any further comments about the pilot that you wish to make?



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