On the merits and pitfalls of introducing a digital platform to aid conservation management: volunteer data submission and the mediating role of volunteer coordinators

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Abstract

Against a backdrop of accelerating digital innovation in nature conservation and environmental management, a real-world experiment was conducted with the research aims of assessing: 1) the effects of introducing a digital data-entry platform on volunteer data submission; and 2) the extent to which coordinators influence digital platform use by their volunteers. We focussed on a large-scale volunteer-based initiative which aims to eradicate the non-native American mink (*Neovison vison*) from northern Scotland. This geographically dispersed conservation initiative adopted a digital platform which allowed volunteers to submit records to a central database. We found that the platform had a direct and positive effect on volunteer data submission behaviour, increasing both the number and frequency of submissions. However, our analysis revealed striking differences in coordinator engagement with the platform, which in turn influenced the engagement of volunteers with this centrally introduced digital innovation. As a consequence, the intended organisation-wide rolling out of a digital platform translated into a diversely-implemented innovation, limiting the efficacy of the tool and revealing key challenges for digital innovation in geographically-dispersed conservation initiatives.

Highlights:

- Digital innovation is often enthusiastically employed but effects poorly studied
- We build a data-entry platform to assist a geographically-dispersed organisation
- The centralised platform increased data submission by volunteers
- The digital orientation of project coordinators influenced volunteer platform use
- Digital tools need be introduced with caution and attention for mediating effects

Key words: Volunteer-based management; Technological innovation; Environmental citizen science; Human-computer interaction; Invasive species control; Volunteer coordination.

1. Introduction

1.1 Data submission through a digital platform

Environmental management increasingly makes use of digital technologies (Arts et al., 2015; Bakker and Ritts, 2018; Sullivan et al., 2014). The prominent use of the internet in environmental citizen science is a clear example (Dickinson et al., 2010; Kelling et al., 2015; Kobori et al., 2016). Digital technologies provide new and often user-friendly ways of generating, handling, organising, analysing, and communicating data and information (Chapron, 2015; Stein, 2008). The promise of more data and opportunity to scale up operations has led many conservation organisations to adopt advanced digital hardware and software such as drones and apps (Galán-Díaz et al., 2015; Miller-Rushing et al., 2012). While the practical benefits may be taken for granted, they are not guaranteed (Druschke and Seltzer, 2012; Gallo and Waitt, 2011; Jordan et al., 2012). For example, the interpretation of citizen science data is often clouded by concerns regarding their accuracy, quality and reliability (Kremen et al., 2011; Wiersma, 2010). Also, without online tools that engage and are well aligned with project goals, projects may fail to acquire sufficiently large datasets over prolonged periods of time (Van der Wal et al., 2016; Wald et al., 2016). New tools may change the nature of a volunteers' engagement with conservation, and this may in turn be influenced by how coordinators of conservation volunteers (hereafter conservation coordinators) decide to introduce such tools to their volunteers. This paper engages that topic. Social processes are known to strongly influence volunteering (Asah and Blahna, 2012; Bruyere and Rappe, 2007; Pagès et al., 2018). Yet, in spite of the 'mission-driven' character of nature conservation (Mace, 2014), many digital innovations in this realm are introduced without their social impacts being studied (Arts et al., 2015). Here we

focus on a common innovation in nature conservation, namely the introduction of a new data reporting platform, and set out to address two research aims: 1) to assess whether volunteer data submission (i.e. number and frequency of submission, and number of records in a single submission, a.k.a. batch size) changes with the use of a digital platform; and 2) to determine to what extent coordinators influence the usage of a digital platform by their volunteers. The first aim was addressed by means of a randomised experimental set-up linked to a real-world nature conservation case (Section 3.1). The second aim was investigated through mixed qualitative methods (Section 3.2).

1.2 Context of study

This study revolved around the Scottish Mink Initiative (SMI), one of the world's largest volunteer-based invasive species management programmes in terms of area covered (approximately 29,500 km^2). The objective of the initiative was the detection and subsequent removal of the invasive American mink (*Neovison vison*, mink hereafter) across northern Scotland (Bryce et al., 2011; Melero et al., 2015). Volunteers were recruited by SMI to adopt and operate one or more rafts used for monitoring. The rafts are required to be checked every 10-14 days. If mink is detected, volunteers can request and operate a trap. At the time of study, volunteers were directed by four full-time employed coordinators, each operating in regions of different size and geography (Figure 1).

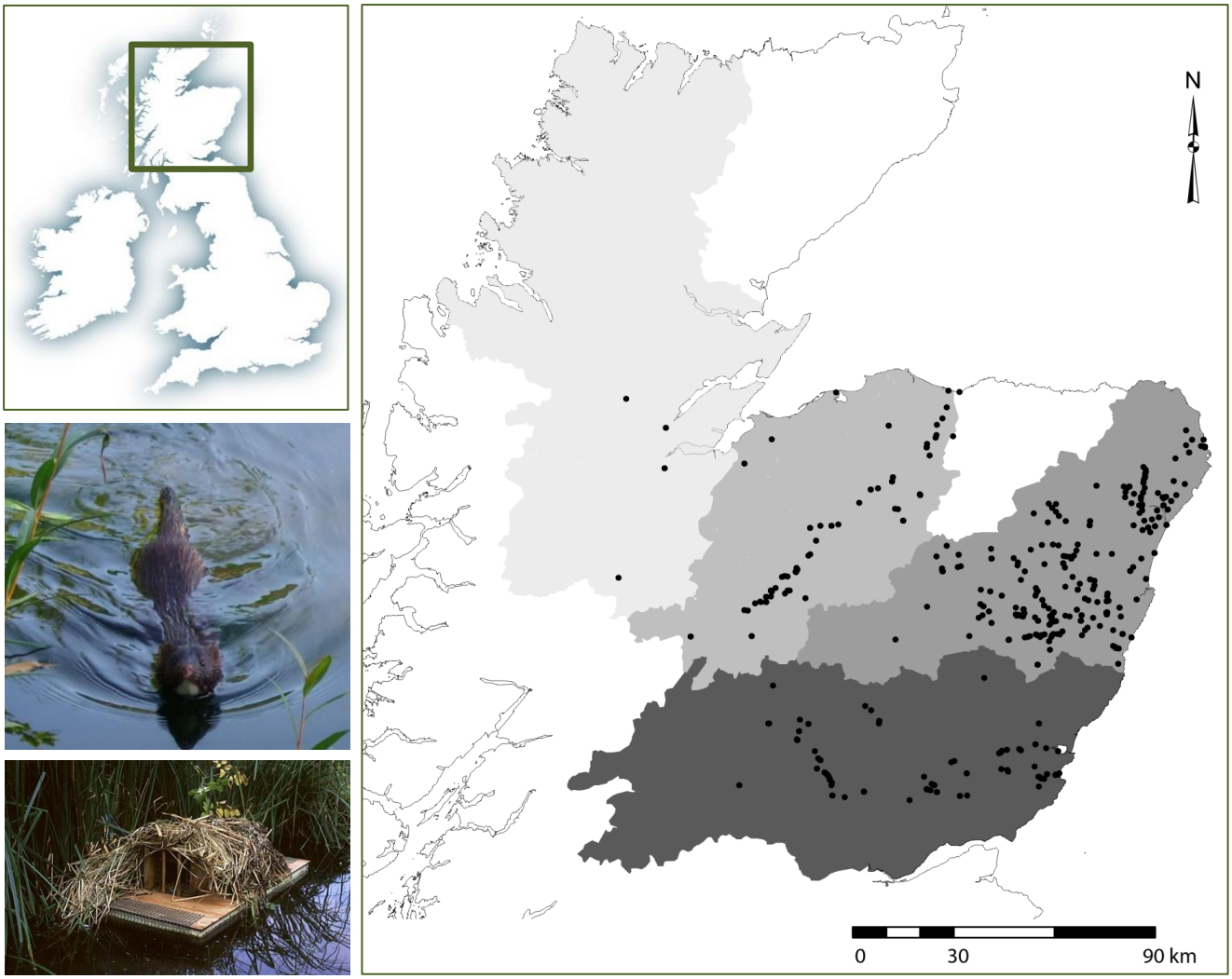


Figure 1. Images of an American mink and raft, and maps of northern Scotland with mink captures (black dots) from April 2011 to January 2013 in the four experimental focal regions of the coordinators (C), from lightest grey to darkest grey respectively: C-Highlands, C-Cairngorms, C-Aberdeenshire, and C-Tayside.

Volunteers were asked to report all mink signs recorded on their raft to their regional coordinator. Typical means for doing so included phoning, texting, emailing, and face-to-face interaction. Raft check records were either 'absence records' (no signs of mink) or 'positive records' (footprints or scats). A digital data-entry submission platform was developed with SMI that allowed volunteers to report to a central database through a web browser (on e.g. a desktop, laptop, mobile phone or tablet) (Figure 2).

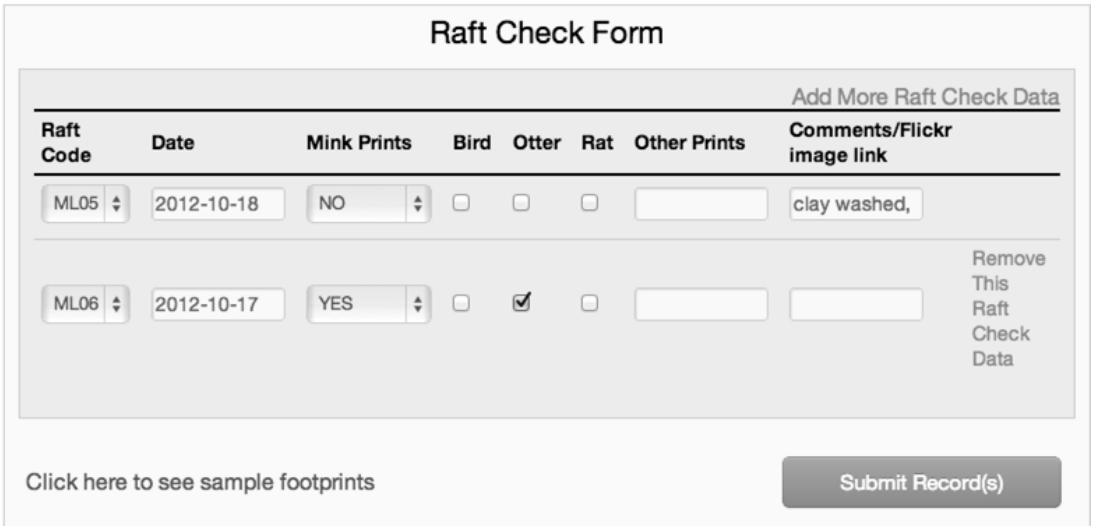


Figure 2. Screenshot of the 'raft check form' as part of the digital submission platform.

The primary goal for SMI was to improve efficiency of data collection and data processing in this geographically dispersed initiative. The platform was tested and improved upon for over a year. The experiment with the platform ran for 9.5 months; thereafter, SMI continued on a smaller funding base with a changed organisational structure, providing a natural end to us studying the digital innovation.

2. Materials and methods

2.1 Experimental approach

At the start of the experiment all volunteers conducting raft checks were randomly divided into a control group (one-third) and treatment group (two-thirds). Control volunteers were not informed about the online platform. Treatment volunteers were invited (up to 3×) to use the platform (i.e. submit raft checks online), receiving full instruction via email or hard copy letters depending on their preferred mode of communication. Coordinators were asked to take into account treatment allocation when dealing with their volunteers. Three control group volunteers became aware of the platform and requested permission to use it.

121 Some shifting was expected and permission was granted. During the experimental period,
122 60 different volunteers (15 control, 45 treatment) contributed 776 raft check submissions.
123 The experimental set-up resulted in four distinct groups:
124 A. Control group but using platform (n=3 volunteers, with in total 62 submissions);
125 B. Treatment group and using platform (n=25, 540 submissions);
126 C. Control group and not using platform (n=12, 67 submissions);
127 D. Treatment group but not using platform (n=20, 107 submissions).
128 Differences in submission behaviour were tested for by contrasting control (A+C) and
129 treatment (B+D) groups and two specific further comparisons (B vs. C and B vs. D) using
130 three indicators: 1) number of raft checks submitted per volunteer; 2) frequency of
131 submission, i.e. the number of times each volunteer logged in to submit their data, with a
132 higher frequency pointing at a more convenient and direct way for volunteers to submit
133 data; and 3) mean batch size, i.e. the number of raft checks submitted per volunteer divided
134 by their frequency of submission, with low mean batch size indicating less delay between
135 raft checks and submission of records. Differences in the number and frequency of
136 submissions were tested for using GLMs with negative binomial error distribution and log-
137 link function to model the over-dispersed count data appropriately. Differences in mean
138 batch size were also tested for with GLMs but using a gamma distribution with log-link as
139 the coefficients of variation were positive, continuous, skewed to the left and increasing
140 with the mean (Bates et al. 2015). All GLMs were run using the lme4 package of R 3.2.2. For
141 each indicator a global model containing the factors treatment, coordinator, and
142 coordinator × treatment was fitted and followed up with model simplification and selection
143 using AIC ($\Delta AIC < 2$; see Results section).
144

2.2 Qualitative social analysis

To investigate how coordinators engaged with the new digital platform, we determined how they approached their role in relation to SMI and the platform, using the concepts of respectively 'organisational orientation' and 'innovation orientation' (cf. Pruden, 1973; Tibbles et al., 2008). Three sources of data were used:

- *Semi-structured, face-to-face interviews* conducted during the platform's development phase with the coordinators and others closely involved, such as SMI's director (n=9, mean duration: 39 minutes). These interviews were aimed at understanding the methods and social structures of the organisation, SMI's relationship with its volunteers, and the perceived potential role of digital technology. For reflections on the impact of the platform and volunteer-related matters, follow-up interviews were conducted with SMI's director and coordinators at the end of the experiment period (n=5, mean duration: 37 minutes). All 14 interviews were recorded and transcribed verbatim.
- *Email communications with coordinators* concerning questions posed after the end of the experiment relating to: best volunteers, impacts of platform on e.g. volunteer retention and volunteer performance.
- *Coordinators' diaries* to capture all daily interaction with their volunteers for two months. Diary entries comprised duration, medium and initiator of contact, as well as the reason for contact. This resulted in 13 handwritten A5 pages by coordinator C-Aberdeenshire, 45 by C-Cairngorms, 4 by C-Highlands and 31 by C-Tayside.

Analysis of these sources of data consisted of qualitative classifications of the text; common themes in the data were abstracted by means of deductive coding using NVivo software (cf. discourse analysis – Hajer et al., 2006; Jørgensen and Phillips, 2002; Thomas, 2006). Subsequently, as an inductive part of the analysis (Fereday and Muir-Cochrane, 2006), these

169 themes were used to assess the coordinators' organisational and innovation orientation
170 using the following two typologies:
171 - Organisational orientation (typologies of employees – McCroskey et al., 2005; Pruden,
172 1973): *upward mobiles* (react positively to key managerial decisions [such as the
173 introduction of a digital platform] and can thrive in the new situation); *indifferents* (by
174 and large uncommitted to a key managerial decision); *ambivalents* (show signs of both
175 positivity and lack of commitment).
176 - Innovation orientation (perspectives on Information and Communications Technology
177 (ICT) – Arts et al., 2016; Bekkers et al., 2006; Siguaw et al., 2006): *technological*
178 *perspective* (ICT approached as a set of tools to achieve specific goals); *organisational*
179 *perspective* (emphasising capacities of ICT to process information, organise work and
180 improve communication); *conceptual perspective* (ICT used as a lens to understand
181 practices).
182
183
184 **3. Results**
185 ***3.1 Experimental approach***
186 Best models for all three indicators tested for (number of submissions, frequency of
187 submission and mean batch size) included 'treatment' and 'coordinator' but not their
188 interactions (all ΔAIC > 4). Treatment volunteers (group B+D) provided 1.6× more
189 submissions, and did so 1.8× more frequently than control volunteers (group A+C), though
190 neither odds-ratio was significant (Figure 3). Most prolific were control group volunteers
191 who nevertheless used the platform (group A, n=3), but their low number precluded
192 statistical testing. Treatment volunteers using the platform (group B) generated 3.9× more

193 submissions than control volunteers not using the platform (group C) and 4.0× more than
194 treatment volunteers not using the platform (group D). With regard to frequency of
195 submission, treatment volunteers using the platform (group B) scored again higher, with
196 4.4× (vs. group C) and 4.5× higher values (vs. group D). As a result, the mean batch size was
197 1.7× lower in the treatment group compared to the control group. A similar (1.6×) and
198 likewise significant difference was found when comparing batch sizes of treatment
199 volunteers using the online system (group B) with control volunteers not using the system
200 (group C). However, comparison of treatment volunteers using (group B) versus not using
201 (group D) the system revealed similarly low batch sizes.

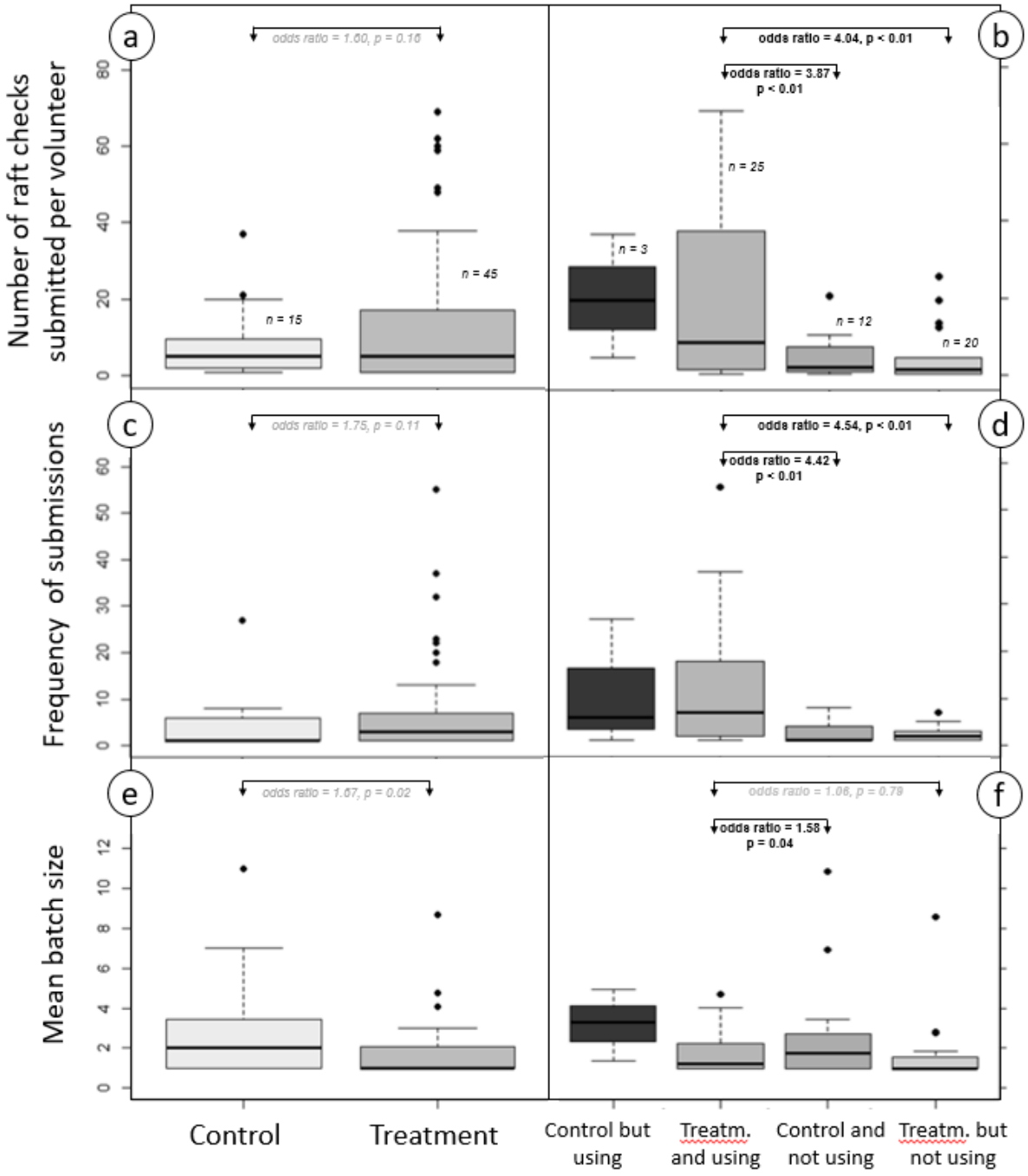
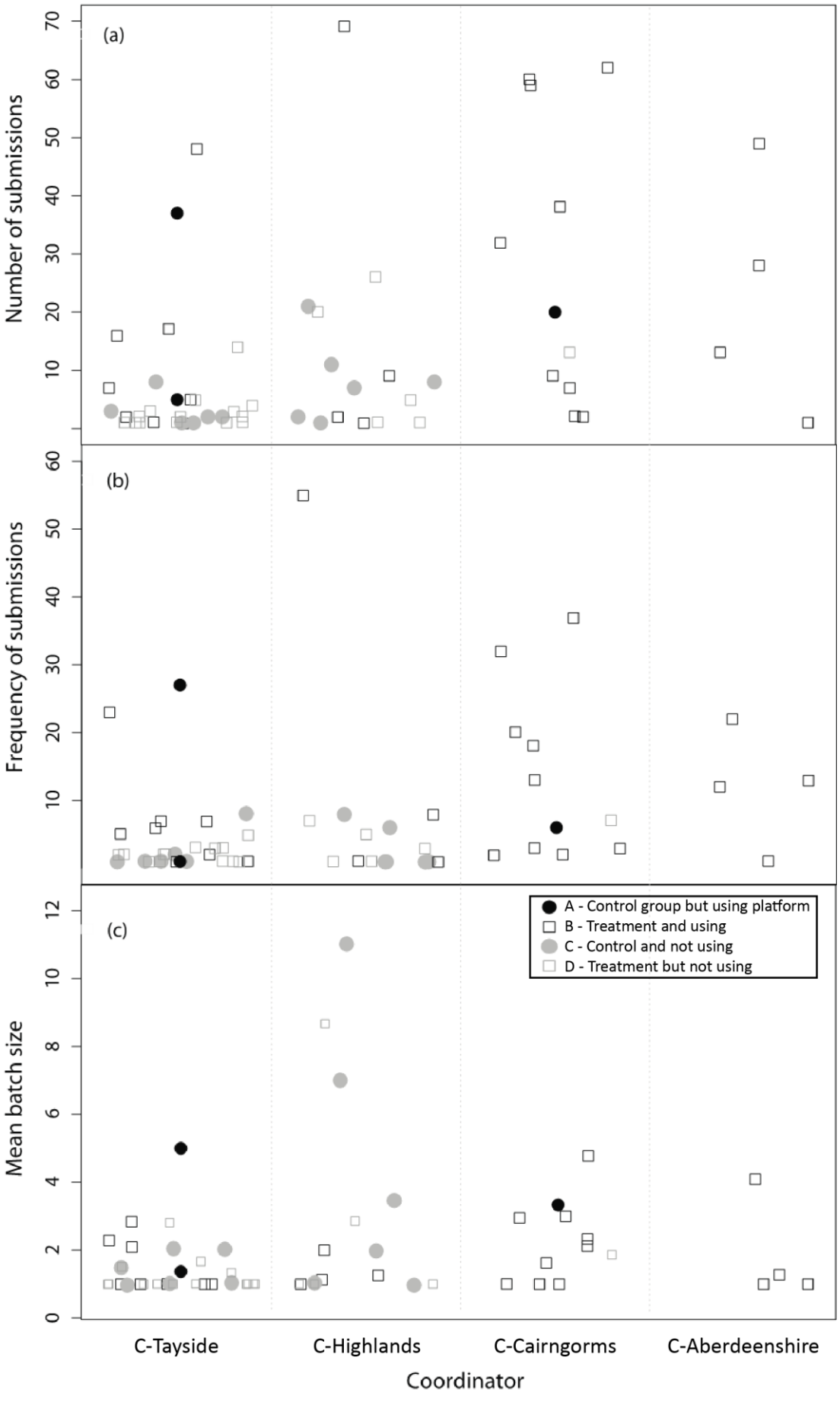


Figure 3. Boxplots of number of raft checks submitted per volunteer (a, b), frequency of submissions (c, d) and mean batch size (e, f). Panels a, c and d provide summary statistics for the two intended treatment groups (control vs. treatment) and panels b, d and f for the four realised treatment groups. Depicted are the median, 1st and 3rd quantiles, 95% confidence intervals (whiskers) and outlying points. Summary test results are given for the respective contrasts; those in black indicate statistically significant differences between groups.

211 Striking differences emerged when inspecting volunteer submissions across the four
212 coordinators (Figure 4). C-Aberdeenshire had very few associated volunteers (n=4), all of
213 which were of the treatment group (100%) and indeed using the web portal as such (group
214 B). C-Cairngorms had considerably more associated volunteers (n=11), and those were
215 primarily also from the treatment group B (90%) and none from group C, the 'offline' control
216 group. The other two coordinators (C-Highlands and C-Tayside) had both more volunteers
217 (n=15 and n=30) and fewer of them were from the treatment group (44% and 36%). This
218 included several volunteers who submitted a low number of records once or twice, which
219 significantly reduced the average number of submissions per volunteer (model deviance
220 Est=62.4, Df=3, 53, $p<0.01$) and frequency of submission (Est=61.7, Df=3, 55, $p<0.02$)
221 compared to the other two coordinators. In fact, the coordinator with the largest number of
222 volunteers had also the greatest number of volunteers from the control group, submitting
223 occasionally and via the coordinator.
224


(a)
Number of submissions
0
10
20
30
40
50
60
70
(b)
Frequency of submissions
0
10
20
30
40
50
60
(c)
Mean batch size
0
2
4
6
8
10
12
A - Control group but using platform
B - Treatment and using
C - Control and not using
D - Treatment but not using
C-Tayside
C-Highlands
C-Cairngorms
C-Aberdeenshire
Coordinator

225

Figure 4. (a) Number of volunteer submissions, (b) frequency of submissions and (c) mean batch size, by coordinator (C-Tayside, n=30; C-Highlands, n=15; C-Cairngorms n=11; and C-Aberdeenshire, n =4), and in relation to the experimental treatment categories (A=Control group but using platform, n=3; B=Treatment group and using platform, n=25; C=Control group and not using platform, n=12; and D=Treatment group but not using platform, n=20). Values on the x-axis are slightly offset to aid visualisation.

3.2 Qualitative social analysis

The intentions of SMI's director were to roll out the digital platform uniformly across northern Scotland. The director observed that "it is extremely difficult for us to be able to get data and be able to manage such large areas, especially in a strategic way". Moreover, he believed that the platform would be key to the continuity and stability of the organisation: "All the future work that we are doing (...) is going to be through the [platform]." Our qualitative analysis showed, however, that there were strong differences among coordinators in their engagement with the platform. This was underpinned by the different coordinators' organisational and innovation orientations. Five dimensions of 'organisational orientation' emerged from the qualitative data, and for each dimension, coordinators demonstrated diverging views (Table 1).

Table 1. Classification of coordinators in relation to organisational and innovation orientations.

	Coordinator			
	C-Tayside	C-Highlands	C-Cairngorms	C-Aberdeenshire
Organisational orientation	*Upward mobile:*	*Ambivalent:*	*Upward mobile:*	*Ambivalent:*
- Own role within organisation	Compliance with organisational agreements and	Catching mink	Establishing volunteer	Catching mink and using volunteers where

	rules		networks	to do this
- Importance of data	Promoting collection of records	Little emphasis on data collection	Promoting collection of records	Little emphasis on data collection
- Ideal volunteer	Complies with organisation	Catches lots of mink	Keeps in touch	Catches lots of mink
- Interaction with volunteer	Making it easy for them	No news is no mink	Putting communication onus with volunteers	No news is no mink
- Volunteer feedback about the platform	Both positive and negative responses	Possibly little used	Both positive and negative responses	Not keen on new technology
Innovation orientation	*Technological perspective:*	*Organisational perspective:*	*Organisational perspective:*	*Technological perspective:*
- Own interaction with platform	Proficient	Proficient	Proficient	Struggled to operate
- Expectations and opinion of platform	Still double-checking data but better than before	Reduced workload, stressed platform importance	Reduced workload, improvements needed but helped structuring SMI	Reduced workload, important for uniform approach to data collection

First, regarding their *own role within organisation*, C-Tayside put emphasis on compliance with the organisational agreements and rules conveyed by the director. C-Highlands was primarily focussed on catching mink himself. The same applied to C-Aberdeenshire who approached volunteers largely to help decide where to concentrate his efforts. C-Cairngorms stressed the importance of establishing self-operating volunteer networks to minimise future coordinator input.

Second, on the *importance of data*, C-Highlands and C-Aberdeenshire put relatively little emphasis on data collection by volunteers; for them data was foremost a means to catching

mink. C-Tayside and C-Cairngorms, on the other hand, kept promoting the submission of 'absence records' – deemed important to demonstrate mink absence and 'active volunteer' presence.

Third, on what comprises an *ideal volunteer,* C-Tayside described this as an eager volunteer who checks rafts frequently and communicates findings timely and accurately. Moreover, to her, ideal volunteers understand the "bigger picture" and "do things the way they are supposed to". C-Highlands said: "as far as I am concerned the best one is always the one that catches a lot of mink". For C-Cairngorms, the ideal volunteer was one that is keen and keeps in touch, while C-Aberdeenshire described the ideal volunteer as someone with a vested interest in the environment, who is "always vigilant".

Fourth, regarding *interaction with volunteer*, C-Tayside mentioned: "If you want people to do something you have got to (...) give it to them on a plate". This contrasted starkly with C-Aberdeenshire and C-Highlands who assumed that "if you do not hear anything there is nothing out there" (C-Highlands). C-Cairngorms explained that she generally speaks to "every single person in the same way", and that she tried to encourage volunteers "to contact me when they need to, rather than me having to contact [them]".

Fifth, *volunteer feedback about the platform* was the final dimension. C-Tayside and C-Cairngorms received mixed messages, with some volunteers submitting more records now than they did before, but with other volunteers who "do not want to have to sit in front of the computer" (C-Tayside). C-Highlands said he only received feedback from two volunteers about the platform, and concluded "I am not sure if [volunteers] actually use [it]". Likewise, C-Aberdeenshire noted: "The problems I have found (…) is that they are not overly keen in adopting new technology".

Two key dimensions of 'innovation orientation' were identified, and for each diverging views were demonstrated among the coordinators (Table 1). The first dimension was that of *own interaction with platform*. The data revealed that all coordinators showed proficiency from the onset except for C-Aberdeenshire, who struggled to operate the platform on his own during the experiment and needed help from another coordinator. C-Highlands and C-Cairngorms seemed to have used the data collected by the platform at face value. Yet, C-Tayside used the platform to provide feedback to volunteers and to control the quality of incoming data: "when I get a message from the [platform] saying that somebody has entered data, I double-check it". Regarding the second dimension, e*xpectations and opinion of platform*, three coordinators believed the platform led to reduced administration workload, or that it would do so in the near future. C-Tayside, however, stressed that she still had to double-check all data that came in. But she also compared it to the situation before: "we needed to do something because it was no good the way it was"; "we had excel spreadsheets and they were just on our computers (…) that is never a good plan". She also expected the platform to become central to SMI's work in the future. C-Highlands said he had little dealings with it, but also stressed the importance of the platform for the future: "[no more] Excel sheets (...) a brilliant way to go". C-Cairngorms felt that improvements around the interface were still needed, but that it had helped in structuring SMI's operations. C-Aberdeenshire stressed the value of the "uniform approach" to data collection across SMI as a result of the platform.

4. Discussion

By experimentally launching a new data submission system we were able to demonstrate the gains this digital innovation pursued: more submissions, offered in smaller batch sizes at greater frequency. Yet, our approach was bound by some limitations related to this type of participatory research, such as an experimental runtime of 9.5 months and whether this was long enough to capture 'wear-off' from curiosity about a new digital platform. In addition, the generation of four experimental groups reveals that the implementation of a digital platform acts as a selector, attracting some and repelling others, and therefore likely changing volunteer demographics (Pagès et al., 2018). This raises the question whether volunteers who use such an innovation as intended are also those who serve the organisation best otherwise (e.g. the most active and persistent). Indeed, platform development revolving around data collection, as arguably is common amongst volunteer-based conservation organisations (Arts et al., 2015; Will et al., 2015), can sit at odds with drivers of volunteer motivation and retention. Our qualitative findings provide evidence for previous suggestions in this direction (Andow et al., 2016; Asah and Blahna, 2013; Bell et al., 2008; Bruyere and Rappe, 2007).

While the innovation was introduced organisation-wide, and highly valued by the director, each coordinator moderated the platform use by volunteers. Spanning much of Scotland, the coordinators operated in starkly differing physical environments, with different mink densities and 'types' of volunteers. Hence, it is possible that the nature of the regions indirectly demanded different engagement of coordinators towards the platform. But viewing the coordinators' operations in the context of their organisational and innovation orientations made understandable the differential use of platform regardless of differences in environmental context. While we did not have enough quantitative data to identify

329 factors affecting coordinator engagement, our qualitative data points at the engagement of
330 employees with new technology what is at stake here, whist finding no evidence for region
331 specificity as additional key factor. With regard to the struggles of one coordinator with the
332 technology, there is firstly the reality of a top down innovation decision by an organisation
333 for its staff: not all employees might be able or willing to promote or use the innovation.
334 This seems a regularly overlooked element of innovation introduction in natural resource
335 management (Arts et al., 2015; Jordan et al., 2012). Secondly, conservation organisations
336 likely look for more computer-savvy staff if digital technology is to play a larger role in their
337 futures. While both aspects are important, we have also found that – in light of the financial
338 challenges that many conservation organisations or projects face (Arts et al., 2013;
339 Sauermann and Franzoni, 2015; Will et al., 2015) – a digital platform may provide a
340 backbone for continuity and stability; a central system to underpin effective data
341 governance.
342
343 Whilst our studied initiative has characteristics which may differ from other organisations
344 operating in natural resource management, such as being geographically highly dispersed
345 and possibly demanding region-specific engagement of coordinators with their volunteers,
346 we observe that the introduction of digital data submission platforms is a common
347 innovation. Many conservation organisations face similar challenges in terms of lack of
348 technical expertise, varying degrees of volunteer motivation, inefficient path-dependencies,
349 and funding limitations (Bell et al., 2008; Newman et al., 2012, Pagès et al., 2019). These
350 aspects are likely to drive leadership of conservation organisation (Dietz et al., 2004;
351 Bruyere, 2015), with managers pushing more and more for digital innovation in order “to be
352 more effective in achieving positive results” (Black et al., 2011: 329).

353 Such top-down technological innovation is usually meant to be rolled out uniformly by
354 conservation organisations. The role of the 'human layer' in between volunteers on the
355 ground and conservation organisation policies is often taken for granted; yet, it is central to
356 effective implementation of innovation (Newman et al., 2012). Our analysis has brought to
357 light striking differences in how volunteers and coordinators engage with a newly
358 introduced digital platform, collectively turning centralised innovation into new local
359 realities. Our findings show that uniform implementation of digital innovation may not be
360 achieved because of different organisational and innovation orientations of coordinators,
361 and that differential appreciation among volunteers can directly affect data submission
362 behaviour, and thus impact on a conservation organisation's goals and interests.
363

364 **5. Conclusion**

365 Following the co-development and introduction of a digital data-entry platform to aid
366 conservation management, we set out to address two research aims: 1) to assess whether
367 volunteer data submission changes with the use of a digital platform; and 2) to determine to
368 what extent coordinators influence the usage of a digital platform by their volunteers. The
369 merits of introducing a digital platform to aid conservation management resided primarily in
370 changes in volunteer data submission: the number and frequency of submissions increased
371 and batch sizes reduced. Moreover, the platform functioned as a backbone for continuity
372 and stability, an aspect of digital innovation which may be particularly valuable for
373 geographically dispersed initiatives.
374 Still, several pitfalls were identified too. Likely as a result of different organisational and
375 innovation orientations, coordinators seemed to have influenced the adoption of a
376 technology by volunteers, which was planned to be rolled out evenly across the initiative.

This uniform implementation and affected the organisation's goals and interests. In addition, the introduction of the technology acted as a selector, attracting some volunteers but deterring others. This could change the 'type' of volunteers in the longer term, which may or may not suit the organisations' direction of travel. In particular, it remains to be seen whether digitalisation serves both the volunteer and the conservation initiative alike. Volunteer-based conservation initiatives are often grounded in physical work, which requires and attracts 'hands-on' volunteers (Pages et al 2019). Computer tasks may sit at odds with this, and thus a key motivation of volunteers to become involved.

Our conclusions lead to a message of caution in relation to the introduction of digital technologies; its merits, increased efficiency and efficacy of data collection and information handling, are not without pitfalls, which are notably human factors: volunteer attraction, retention and coordination. Conservation organisations should therefore not just blindly develop or implement digital tools, but also reflect on mediating factors and mechanism that ensure uptake and continued use of those tools.

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