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Local perceptions of the QICS experimental offshore CO₂ release: Results from social science research

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2

3 Local perceptions of the QICS experimental offshore CO₂ release: results from social science
4 research

5

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13

14 Abstract: This paper explores the social dimensions of an experimental release of carbon dioxide
15 (CO₂) carried out in Ardmucknish Bay, Argyll, United Kingdom. The experiment, which aimed
16 to understand detectability and potential effects on the marine environment should there be any
17 leakage from a CO₂ storage site, provided a rare opportunity to study the social aspects of a
18 carbon dioxide capture and storage-related event taking place in a lived-in environment.

19 Qualitative research was carried out in the form of observation at public information events
20 about the release, in-depth interviews with key project staff and local stakeholders/community
21 members, and a review of online media coverage of the experiment. Focusing mainly on the
22 observation and interview data, we discuss three key findings: the role of experience and
23 analogues in learning about unfamiliar concepts like CO₂ storage; the challenge of addressing

24 questions of uncertainty in public engagement; and the issue of when to commence engagement
25 and how to frame the discussion. We conclude that whilst there are clearly slippages between a
26 small-scale experiment and full-scale CCS, the social research carried out for this project
27 demonstrates that issues of public and stakeholder perception are as relevant for offshore CO₂
28 storage as they are for onshore.

29

30 Keywords: carbon dioxide capture and storage (CCS); environmental risk; environmental
31 uncertainty; offshore energy; public engagement.

32

33 Research highlights

- 34 • Analysis of social dimensions of real-world CO₂ release event;
- 35 • Social issues as relevant for offshore CO₂ storage as onshore;
- 36 • Analogues helpful for publics in understanding CO₂ storage;
- 37 • Non-specialists can quickly grasp complex ideas and make sophisticated points;
- 38 • Ongoing challenge of when/how to engage with communities on CCS-related projects.

39

40

41 1. Introduction

42

43 1.1 Background to the study

44

45 In spring and summer 2012, an experimental release of carbon dioxide (CO₂) was carried out in
46 Ardmucknish Bay, Argyll, United Kingdom. The experiment was an integral part of the Natural
47 Environment Research Council (NERC)-funded Quantifying and Monitoring Potential
48 Ecosystem Impacts of Geological Carbon Storage (QICS) project, and sought to understand
49 detectability and potential effects on the marine environment should there be any leakage from a
50 CO₂ storage site. Over a thirty-seven day period, CO₂ was pumped into the sediments at 12
51 metres below the seabed, 350m offshore, via a horizontally-drilled pipeline connected to a
52 pumping station on land. Various monitoring devices were placed around the release site and
53 observations and samples were taken before, during and after the release (for examples of
54 research results, see Blackford and Kita (2013) and the other papers in this issue).

55

56 In addition to the physico-chemical and biological science findings, the experiment also
57 presented a rare and valuable opportunity to study the social dimensions of a real-world carbon
58 dioxide capture and storage (CCS)-related event. With the release being conducted in a lived-in
59 environment, public and stakeholder engagement was of the utmost importance in order to avoid
60 potential negative reactions that could have prevented the experiment from taking place or
61 running successfully, or at least threatened the good relationships and trust between the local
62 research laboratory - Scottish Association for Marine Science (SAMS) - and its local community.

63

64 SAMS co-ordinated the CO₂ release experiment at the top of Ardmucknish Bay close to
65 Benderloch village, including the installation and operation of the release facility and sampling
66 activities (for more details about the experiment see Taylor et al (this volume)). SAMS was also
67 responsible for acquiring the appropriate permits and consents to conduct the experiment from
68 local- (Argyll and Bute Council, Marine and Coastal Development Unit) and government
69 regulatory bodies (Marine Scotland and The Crown Estate), as well as from landowners
70 (Lochnell Estates), land users (Tralee Bay Holiday Park) and non-governmental organisations. In
71 addition to formal permissions, consent was also sought from the general public and other local
72 stakeholder groups (e.g. local fishers) through various open meetings and public outreach
73 activities.

74
75 A public information meeting was held prior to commencement of the work in Benderloch
76 Village Hall in early December 2011, at which the lead local scientist gave a forty-minute
77 presentation on the rationale behind and workflow of the experiment, followed by a forty-minute
78 question and answer session with the audience. An information stand about the project was set
79 up at a farmers' market day in the local village in March 2012. An 'open day' and a school visit
80 were held at the release site whilst the experiment was in progress, where some of the monitoring
81 equipment was displayed, a video of bubbles emitting from the seabed was shown, an
82 experiment with carbonated water and litmus paper was used to demonstrate acidity, and two
83 project scientists answered questions from visitors. Initial findings were presented at SAMS in
84 November 2012 as part of a Winter Lecture series. During the experiment, information posters
85 were displayed around the release site, and one of the responsibilities of the 'on site' scientists
86 was to answer questions about the project from the public. Articles were run in local and later

87 national print and web media, the lead local scientist gave interviews on local radio and
88 television stations, and a group was set up on social media (Facebook) giving continuous updates
89 on the project progress to members. A central webpage (www.bgs.ac.uk/qics, accessed
90 12/09/2014) was also created containing detailed information and images about the QICS project
91 as a whole.

92

93 1.2 Social science research on real-world CCS events

94

95 Low public awareness and understanding of CCS (Eurobarometer, 2011) presents a challenge for
96 social scientists seeking to understand the social dimensions of CCS. de Best-Waldhober et al
97 (2009) note that in such situations of low awareness, people's opinions are unstable and subject
98 to change. Daamen et al (2006) refer to such opinions as 'pseudo-opinions', Malone et al (2010)
99 arguing that surveying or 'polling' publics for opinions on CCS may be of limited value when
100 people have not even had the opportunity to form an opinion. Even when people do receive
101 initial information, Upham and Roberts (2011) and Howell et al (2014) find that different people
102 change their views differently in response to learning about CCS. In some cases, people's
103 perceptions towards CCS can become more negative as further information is provided, Howell
104 et al (2014) suggesting this may be because the extra information allows publics to more fully
105 think through the uncertainties associated with CCS.

106

107 One of the biggest reasons for low awareness and understanding of CCS may be the limited
108 number of full-scale integrated CCS projects currently in operation. Nonetheless, a small body of
109 empirical research has been done around 'real world' CCS, focusing mainly on pilot projects

110 trialling part of the CCS chain, or on proposals for future projects. What is widely acknowledged
111 within such studies is that publics' perceptions of CCS are highly contingent on the broader
112 social context into which specific projects are deployed. Dütschke (2011) links the successful
113 deployment of the CO₂Sink project at Ketzin in Germany to the perception of the developer as a
114 research organisation not standing to gain financially from the project, and Terwel et al (2012)
115 consider how questions of trust in the developer affected publics' responses to the Barendrecht
116 proposals in the Netherlands. Bradbury (2012) examined community responses to six CCS
117 project proposals in the USA, suggesting that the nature of previous community experience with
118 large infrastructure could affect the level of support for a project. In France, Ha-Duong et al
119 (2011) found the developer's role as a key employer in the community, and flexibility in
120 responding to early concerns over risk management and landscaping, to be an important factor in
121 the ultimately successful deployment of Total's Lacq development.

122
123 The key way in which a study of the QICS project can contribute to this work is that it stands as
124 an example of a pilot study around *offshore* CO₂ storage. The emerging preference for offshore
125 storage sites - in Europe at least - means building an understanding of the differences in public
126 perception that may exist between onshore and offshore storage is vital. Exploration of public
127 and stakeholder issues around the QICS experimental release is thus a valuable opportunity to
128 get an early indication of some of the issues that may arise with CO₂ storage in a marine
129 environment.

130

131 2. Method

132

133 Social science research around the QICS project was carried out under a wider programme of
134 work being undertaken in Scotland, north England and Italy by the public perceptions work
135 package of the EU FP7-funded ECO₂ project (www.eco2-project.eu, accessed 15/09/2014). A
136 Memorandum of Understanding between ECO₂ and QICS allowed ECO₂ researchers to observe
137 some public engagement activities being carried out around the release site, with the results
138 feeding in to the ECO₂ social science work package (for example Mabon et al, 2014; Mabon and
139 Shackley, 2014).

140
141 The research design for the QICS social science study was to a certain extent determined by the
142 nature of the project as a whole. The experimental release was inherently controversial in that it
143 could be viewed as deliberate, albeit well planned and controlled, pollution of a high-quality
144 marine environment. The experiment was both technologically risky, nothing similar having
145 been attempted previously, and involved significant expense in engineering a gas delivery
146 pipeline from shore to the release point 350m off-shore at 12m depth in the sediment. There is
147 already a precedent of environmental groups opposing open ocean iron fertilisation experiments,
148 which has contributed to the abandonment of expensive scientific projects (Mayo-Ramsay, 2012).
149 For QICS, there was thus motivation not only to minimise risk of experimental failure, but also
150 to communicate effectively and transparently so that bodies and individuals could make an
151 informed decision and/or allow the project to take account of any local issues that might require
152 some modification of the experimental plan. To this end, in addition to obtaining formal
153 permission for the CO₂ release from the relevant regulatory bodies, the project took a considered
154 and early decision to go beyond these formal legal obligations and consult with a wide range of
155 potentially affected bodies and individuals, mainly at the local level. Accordingly, QICS

156 developed a locally-centred communications strategy, consulting regional government,
157 environmental groups, marine users and the public. In order to allow any concerns among the
158 community and local stakeholders to be identified and suitably addressed before they became
159 distorted or amplified by other spatially distant actors, national publicity was deliberately left
160 until after all local issues had been considered.

161
162 Given these potential sensitivities, it was crucial (especially at the early stages of the project) not
163 to give local citizens the impression that they were being observed to study how they would react
164 to the proposals in order to trial out publicity and marketing strategies for deployment of
165 commercial CCS elsewhere, as if they too were part of an ‘experiment’. Additionally, the aim of
166 forming an in-depth understanding of why people expressed particular perceptions – and the
167 associated need to probe participants and data further on occasion - meant that a qualitative
168 approach was more suitable. Taking both of these factors into account, the first phase of social
169 research involved passive observation at two specific QICS public engagement events – the
170 public information meeting held in Benderloch village hall close to the release site in December
171 2011; and the ‘open day’ held at the release site in May 2012. ECO₂ social scientists attended
172 both these events, observed the questions publics and stakeholders asked the presenting scientists,
173 and wrote up detailed field notes based on their observations. The public information meeting
174 was also video recorded (with the camera pointing at the presenting scientists), and transcribed.

175
176 Following the completion of the main part of the experimental CO₂ release, in-depth interviews
177 were carried out with key SAMS staff involved in the project, and with local stakeholders and
178 community members aware of the experiment (see Table 1 for further details). Seven such

179 interviews were conducted, however given the aim of examining in depth the contextual factors
180 driving perceptions of offshore CO₂ storage, the quality and content of the interviews was
181 deemed more important than the size or statistical representativeness of the sample. Chase
182 (2005:667) notes that “any narrative is significant because it embodies – and gives us insight into
183 – what is possible and intelligible within a specific social context.” It was hence deemed possible
184 to get sufficient analytical purchase on the context of the QICS release by working intensively
185 with a few key locally-based respondents who had a close relationship to the experiment (see
186 Table 1), as they would be well placed to give insight into the wider social context of the QICS
187 release due to their in-depth understanding of how the project had developed over time. In any
188 case, the small local population would have made the construction of a representative sample
189 difficult. The interviews were audio-recorded and transcribed. These formal interviews were
190 supplemented with informal, unrecorded conversations held with members of the general public
191 at a farmers’ market close to the release site, at which one of the ECO₂ social researchers had a
192 stall with basic information about the experimental CO₂ release and the ECO₂ project. The aim
193 of setting the stall up was to find out people’s perceptions at an informal level, whilst continuing
194 the project’s community presence. By and large (with the exception of one member of the public
195 who expressed particular interest in energy and environmental issues, and agreed to take part in a
196 longer interview whilst visiting the stall), publics spoken to in informal conversations showed
197 some interest in but little concern over the experiment, usually admitting to low awareness of
198 CO₂ storage and CCS more widely (we discuss the implications of this at the start of Section 3.2).

199

200 Table 1: summary of interviewees

201

Interviewee	Gender	Role and relationship to project	How interviewee was selected
Communications officer (SAMS)	Female	Responsible for liaising with media and local community about all SAMS' activities.	Identified as key SAMS member – responsible for communications.
Farm manager	Female	Farm manager close to experiment site, also key figure in community sustainability group.	Identified through initial media analysis as key environmental stakeholder in area.
Journalist at local newspaper	Male	Reporting on local news, including the QICS release.	Identified through initial media analysis as key source of media information on QICS.
Informed member of public	Male	Lives close to sea, occasional sailor in experiment bay.	Opportunistic sampling at farmers' market based on expression of interest.
Professor (SAMS)	Male	Senior figure in SAMS, oversees research in institute and acts as public 'face' for activities.	Identified as key SAMS member – overarching view of institute's role in community.
Research scientist (SAMS)	Male	Working on QICS project as part of research programme.	Identified as key SAMS member – physical involvement in

			experiment.
Senior research scientist (SAMS)	Male	Chief local scientist for QICS experiment.	Initial point of contact for social scientists planning research on QICS.

202

203 Finally, articles published on online news sites about the experiment were read (both editorial
 204 content and reader comments) as a means of providing additional contextual information. These
 205 articles were used initially to help identify key stakeholders to interview, and were then reviewed
 206 after the analysis of the in-depth interviews and qualitative observations were completed as a
 207 means of checking whether the themes emerging in the small-scale data set were representative
 208 of wider thinking within the community and beyond. The key themes emerging from the
 209 interviews and observations mapped well onto the concepts raised in online articles – in
 210 particular the contextualisation of risk and the use of analogues to understand unfamiliar
 211 concepts. As these online sources were used mainly as a cross-check for the other data in the
 212 study and offered little extra in the way of thematic content, in the interests of space this paper
 213 will focus on the interview and ethnographic observations in order to explore these as fully as
 214 possible within the space available.

215

216 Topics of energy and environmental change can elicit strong and emotive responses (Cass and
 217 Walker, 2009). With this can come the risk of researchers – perhaps unconsciously – ‘cherry
 218 picking’ the most exciting or contentious quotes for further investigation (Mabon et al, 2014),
 219 even if these do not necessarily represent the views of the wider community. Data analysis was

220 therefore based on an adapted version of the Doucet and Mauthner (2008) ‘listening guide’. This
221 entailed reading the interview and meeting transcripts four times – once for the researcher’s own
222 initial responses; once for the way the speaker talks about themselves; once for identifying how
223 the speaker talks about relationships; and once for the wider themes the speaker raises. The aim
224 was to acknowledge that the researcher’s own interests and values can affect the way qualitative
225 data is processed, and to try to separate this out from what participants themselves said. The field
226 notes and online media were then read in light of the emergent themes, looking for additional
227 topics or additional nuances. The results discussed below reflect the themes that emerged most
228 clearly from the whole analysis process.

229

230 3. Results and implications for CCS

231

232 3.1 How people learn – experience and analogues

233

234 The first theme emerging from the study concerns how people learn about CO₂ storage, climate
235 change, and the environment around them. It became apparent during both the public
236 engagement sessions and interviews that whilst both publics and stakeholders can remember
237 some things well, they may remember other things in a vague, superficial or partial way:

238

239 *I was aware, certainly in Asia there were a few trials [...] And I think as well I'd heard about*
240 *earthquakes etc, I think in America if I remember correctly, and also England as well from*
241 *carbon capture experiments.* (interview with local journalist, Oban, October 2012)

242

243 *There has been experiments that you intend to carry out, there has been these done already, isn't*
244 *there? [...] in America they tested inland, there, do it there and actually contaminate fresh water*
245 *to the point that humans couldn't drink it. (participant, public meeting, December 2011)*

246
247 From the data available to the authors, it cannot be ascertained with certainty whether or not the
248 events the speakers describe above actually relate to CO₂ storage. Given the timing of the public
249 information meeting, it is likely the second speaker is referring to the leakage allegations at the
250 Weyburn-Midale project in Saskatchewan, Canada, in which a local farming couple situated on
251 the perimeter of the injection area made allegations of excessive CO₂ levels, abnormal plant
252 growth and animal mortalities on their land. Investigations subsequently found that the high CO₂
253 levels were real, but because they were seasonal, and related to rainfall in the area were most
254 likely biogenic in origin and not associated with the injected CO₂ (Beaubien et al, 2013). The
255 allegations received some headline media coverage, but the refutations did not make such
256 extensive headlines (Boyd et al, 2013). However, there is also a chance that both speakers are
257 confusing CO₂ storage with the well-documented controversies around hydraulic fracturing in
258 the USA and UK. Regardless, the fact remains that things the speakers recall seeing or hearing
259 elsewhere inform their initial perceptions of CCS, even if they cannot remember specific details.
260 In the case of the second speaker, this prior understanding pre-dispositions him to be more
261 cautious towards the whole idea of CO₂ storage, and thus towards the experimental release.
262 Whilst the second speaker explicitly refers to an 'inland' experiment in the USA (note also that
263 Weyburn-Midale is in fact situated in Canada), he carries this concern over to an offshore
264 experiment in the UK – suggesting that perceptions of risks people understand from onshore
265 ventures may transfer to their perceptions of offshore CO₂ storage.

266

267 Even when publics did fully understand the underpinning science behind the experiment,
268 personal understandings and experiences of the local environment in some cases contributed to a
269 more cautious stance towards offshore CO₂ storage – if not to the local experiment itself (we
270 explore this distinction between the experiment and CCS as a climate change mitigation
271 technology more fully in Section 4). As a farm manager with a background in biological science
272 explained:

273

274 *The full concept of the bigger, the big scale version, it would be better if we could reduce the*
275 *amount of CO₂ we were doing rather than, you know, finding unusual places to dump it! I have,*
276 *I still have my doubts about whether that's as well thought through as it could be, glad it's the*
277 *North Sea and not on the west coast but it's still a bit too close. You know, we have, we have*
278 *interesting earthquakes in this part of the world on occasions, because, well because we're at the*
279 *bottom of the Great Glen, so anything that messes about with the- Well that's the point you see,*
280 *is, geology's not just local, in fact geology's almost never local, geology does work rather, over*
281 *rather large distances, so, so yes messing about with one bit would go, can have repercussions*
282 *for the rest of us. (interview with farm manager, near Oban, October 2012)*

283

284 Here, experience of small earthquakes in the locale are used as a starting point for the
285 interviewee - who explained earlier on in the interview she had a background in biological
286 science - to think about the complexity of geology. Concepts such as tectonic plates are drawn in
287 to argue that even something happening across a great spatial distance could have localised
288 implications for communities. The use of the phrase 'messing about' perhaps also implies the

289 limitations of human knowledge (see Section 3.2), and the potential for unknown or unexpected
290 effects to arise from sub-seabed CO₂ storage. Additionally, this stands as another example of a
291 situation where experiences or understandings of activities taking place onshore can affect
292 perceptions of activities taking place ‘far away’ and offshore. Offshore activities like sub-seabed
293 CO₂ storage are not necessarily perceived as being less risky because they are taking place out at
294 sea, rather people may use more familiar ‘on land’ understandings to conceptualise what could
295 go wrong and how it could affect them.

296
297 Conversely, personal and embodied experience can help publics to understand new and complex
298 phenomena. Another attendee at the initial public information meeting rationalised the small
299 scale of the experimental release thus:

300
301 *Another parallel might be the discharge of septic tanks into Ardmucknish Bay, which has been*
302 *going on for, well, as long as we’ve been discharging urine and faeces into Ardmucknish Bay.*
303 *That presumably, I mean, I see urea mentioned there bringing down the pH [...] we’ve been able*
304 *to swim near to a sewage outcrop for many years without hitting the worst of the rubbish, so it’s*
305 *no big a problem, is it? (participant, public meeting, December 2011)*

306
307 The participant’s own understanding of the environment in which he lives helps him to
308 understand how small quantities of ‘pollutants’ released into a relatively healthy marine
309 environment need not have disastrous consequences for humans living nearby. Visitors to the
310 open afternoon at the release site made a similar point, suggesting that the environmental impacts
311 from effluent released by a nearby caravan site could be greater than those from the experimental

312 CO₂ release. In both cases, analogues are used to compare the unfamiliar concept of CO₂ storage
313 to what is known locally. There is thus the possibility that small-scale, localised ‘pollution’
314 (rather than more scientific discourses around climate change) can be used as an analogue to help
315 publics and stakeholders understand that CO₂ storage takes place against a much wider backdrop
316 of humans having effects on the marine environments around them.

317

318 A key implication of all of this for engaging with publics and stakeholders on CCS is that
319 people’s understandings and perceptions of new phenomena are based very much on their ability
320 to find appropriate analogues, primarily from direct experiences of the environments around
321 them but also from media coverage and/or wider public discussions about energy and
322 environmental change. This fits well with Gigerenzer’s (2008) advocacy for the use of analogues
323 as powerful heuristics, since they allow someone to make rapid progress in identifying and
324 characterising a ‘new thing’ by reference to something more familiar. Likewise, Riesch (2012)
325 discusses Moscovici’s work on social representations of risk, suggesting that new and abstract
326 concepts are conceptually anchored to topics that are already understood and made sense of via
327 associated reasoning. From a cognitive psychology perspective, Palmgren et al (2004) suggest a
328 ‘mental models’ approach can demonstrate how understandings of new phenomena relate to
329 people’s wider beliefs. In short, the idea of CCS being evaluated in relation to previous
330 experiences people have had fits well with thinking across a range of social theories.

331

332 People may of course come to understand things in a partial and piecemeal way, remembering
333 some things well but mis-remembering or mis-interpreting others. Equally, however, experiences
334 of processes like earthquakes and environmental pollution can help people to contextualise the

335 potential risks and benefits of an unfamiliar new technology like CO₂ storage. As such, rather
336 than ‘starting from scratch’ with a narrative of climate change and the need for CO₂ emission
337 cuts that assumes limited public knowledge, an alternative starting point for public and
338 stakeholder engagement on CCS may be to have a discussion about how people experience
339 environmental change around them more generally, and situate CO₂ storage within this much
340 larger picture of human and natural activities driving change in the marine environment. It is
341 important to register, though, that this rationale still rests upon the understanding that CO₂ is
342 somehow problematic and that carbon reduction is necessary.

343

344 3.2 Dealing with uncertainty and risk

345

346 The second emergent theme relates to how publics (and local stakeholders) evaluate questions of
347 uncertainty and risk. Carr et al (2013) argue in the context of climate engineering that the public
348 are ready for discussions of high technical, moral and ethical complexity, and can participate in
349 such discussions without a huge amount of scientific information. This certainly seemed to be
350 the case for the community members engaging with the experimental CO₂ release in
351 Ardmucknish Bay. Consider some of the questions asked by audience members at the public
352 information evening following a presentation on the experiment by the lead scientist:

353

354 *[I]n ecological terms it's impossible to ever scale up, because the reactions are all so completely*
355 *different. Is this caprock the same as what we have in Ardmucknish Bay? I mean this looks like,*
356 *what you're looking at under, you know, the North Sea is your deep sea, large empty wells or*
357 *vacant areas. What you're doing in Ardmucknish is just pumping the gas into the mud.*

358

359 *What's to stop [storage formation] water absorbing the CO₂ and then coming out? Because the*
360 *water presumably displaces when it goes somewhere, and what's to stop that water absorbing*
361 *the CO₂ and going out as it wishes?*

362

363 *[Y]our presentation appears to be maybe four or five things that are quite key to dealing with*
364 *people's perceptions, you know the small scale, short-term experiment, a minimal area being*
365 *affected, small quantities of CO₂ being released and what is the, you know, the equivalent in real*
366 *life etc.*

367

368 (participants, public meeting, December 2011)

369

370 One of course has to bear in mind the possibility that community members willing to attend a
371 public information talk – and asking questions thereafter – could well be more scientifically
372 engaged than the community at large. Indeed, members of the public spoken to informally at the
373 farmers' market appeared somewhat interested in but generally unconcerned by the experiment,
374 often professing to having low awareness of the concept of CO₂ storage. This relates to the
375 suggestion of Howell et al (2014) that as knowledge of CCS and related processes increases, so
376 too can perception of potential risks and uncertainties – hence it may be the case that those
377 attending the meeting were more engaged and informed than 'average' or lay members of the
378 public, and thus more likely to perceive shortcomings or limitations. Many of these questions
379 may also have come from those who were attending the evening in a semi-professional role as
380 stakeholders. However, these quotes still stand as a good illustration of two related issues: how

381 publics and stakeholders conceive of uncertainty in science; and how they come to interpret the
382 risks of CO₂ storage more specifically.

383

384 In terms of uncertainty in science more broadly, the first participant's questioning of the wider
385 relevance of the release reflects very well Wynne's (1992) observation on how technical risk
386 assessment is 'extended' beyond a limited context and assumed to have relevance more widely.

387 What was especially interesting about the QICS release was that, because of the experimental
388 nature of the work and the huge timescales involved with full-scale CO₂ storage, project
389 scientists were sometimes unable to give straight and unequivocal answers to questions posed by
390 the public:

391

392 *[I]n any research project you do not know one hundred percent what the outcome is going to be.*
393 *So you put something in the environment that you think is safe, that will not have a long-term*
394 *implication, what if you're wrong and you do have a long-term implication, what are you going*
395 *to do about it then? [...] So that I think was a genuine open question that we just couldn't*
396 *answer, and that nobody can, and that is a matter of research.[...] I mean we would, I think our*
397 *main, main answer was then to look at the amount of gas we were going to release and how*
398 *small it was. (interview with communications officer, SAMS, October 2012)*

399

400 Uncertainty here is conceived of as an integral and inevitable part of scientific enquiry. The
401 nature of research and experimentation is such that the outcomes cannot be determined
402 beforehand – however, through existing knowledge, understanding and experience it is possible
403 to get a sense of the parameters within which the outcome of this 'experiment' will be located.

404 Nonetheless, this conception of uncertainty in science – and an experiment as a controlled way of
405 refining existing knowledge - had potential to run up against alternative views of
406 experimentation and uncertainty. This bigger issue of uncertainty on occasion manifested itself
407 in the form of more specific concerns over the environmental risks of CO₂ storage and the
408 experimental release:

409

410 *You can't guarantee it's not going to stay within that 200 metres, the effects, what are the effects*
411 *if it does come onto the beach? [...] I happen to know three or four folk who do fish in the area*
412 *all the time, and there is a lot of people who visit, divers go to the marina etc, and I would say*
413 *that's a massive recreational area, and it's a fishing area, and basically, potentially, and you*
414 *can't answer the question is how much damage could that do in that short period of time?*

415 (participant, public meeting, December 2011)

416

417 In this case, the member of the public takes the notion of uncertainty and the need for
418 experimentation, and translates it into the possibility that absolutely anything could happen as a
419 result of CO₂ being released into Ardmucknish Bay. People thinking in this way about risks
420 specifically associated with the QICS release were in the minority, however the project scientists
421 (and some more supportive publics) responded to concerns of this type mainly by putting the size
422 and scale of the experiment into a wider context – as with the communications officer
423 emphasising the small volume of gas being released. Two scientists present at the open day at the
424 release site likewise related the controlled CO₂ release to the much larger and uncontrolled
425 'experiment' humans are doing on a daily basis by releasing vast quantities of CO₂ into the
426 environment through the consumption of fossil fuels. The scientists also used a 'Soda Stream'

427 machine to inject CO₂ into drinking water, thus creating carbonated water of the kind drunk on a
428 daily basis and illustrating that CO₂ in water was not necessarily harmful to humans.

429

430 As for what this says for CCS communication and engagement, it illustrates a much bigger issue
431 over communicating uncertainties. As some of the extracts above indicate, more than
432 reassurances that a CO₂ storage site will *not* leak (or that site operators know exactly what will
433 happen), what publics and stakeholders want is to see that researchers and developers have given
434 adequate thought to the limitations of their knowledge, and that adequate monitoring and
435 remediation procedures are in place *should* any unexpected event like a leak of CO₂ occur (Scott
436 et al, 2014). This is closely linked with the concept of ‘resilience’ in risk management, where
437 ‘success’ can be viewed as the ability of organisations, groups and individuals to anticipate the
438 complexity of the real world before failures and harm occur (Hollnagel et al, 2006). Fitting with
439 the responsible innovation agenda proposed by Stilgoe et al (2013), there is thus the importance
440 of building anticipatory capability into projects by asking and taking seriously ‘what if’
441 questions, bringing a range of knowledges and experiences into project development at as early a
442 stage as possible. By starting from the premise of what would happen were a sub-seabed CO₂
443 storage site to leak, the QICS experiment itself could even be seen as an example of building this
444 kind of anticipatory capability.

445

446 3.3 When and how to engage?

447

448 The final emergent theme concerns the timing and framing of engagement. One of the lead
449 scientists describes the dilemma that existed within the QICS project thus:

450

451 *[T]he problem is, what do you start with? It's a little bit like the chicken and the egg! Before we*
452 *knew we had a site where we actually had to get permission from the land owner, we had to do*
453 *all the surveys before and then say okay we've got a couple of sites, and then before asking the*
454 *public if, I mean some might have said that we should have gone out and asked the public first,*
455 *what do you think about this? But then we just realised this is going to take far too much time,*
456 *and there are just so many, so we thought at first it was best to just find a site, and get*
457 *permission from the landowner, and the end user, and then engaged the local community in that*
458 *area and work in that way. (interview with research scientist, QICS project, October 2012)*

459

460 The project management decided on balance that selecting one site with agreement of land
461 owners and relevant authorities, and only then engaging the wider community, was the only
462 economical and practicable approach when compared to sounding out eight or nine different
463 communities at potential sites. With necessary consents from land owners/users and regulatory
464 bodies, the public information evening thus served the purpose of informing the local community
465 about what would be happening rather than seeking their consent. This elicited surprise from
466 several (but not all) people at the information meeting:

467

468 *Is it not nice to ask folk rather than just saying by the way, coming here tonight, this thing's*
469 *happening and you're paying for this thing? You know, it's not, like, it's like me telling you that I*
470 *don't agree with totally, and I don't have all the facts about it tonight, and I just feel like you've*
471 *turned up here, and you've said this is what's happening, you can object as much as you like, but*
472 *it's a done deal. (participant, public information meeting, December 2011)*

473

474 This concern over activities being a ‘done deal’ – perhaps aided by the way in which the
475 workflow of the QICS release inevitably had to be presented as imminent and definitely going
476 ahead - is mirrored in other CCS-related social science research, where publics have expressed
477 discomfort over the way in which decisions about the environments around them are made
478 without their consultation or consent. In work carried out for the EU FP7 SiteChar project in
479 north-east Scotland, it was this perception that a decision had already been taken to proceed with
480 CO₂ storage that concerned some participants, even though the proposed storage site was far out
481 at sea and not on the land under people’s homes (Brunsting et al, 2012; Mabon and Shackley,
482 2014). This suggests that the concerns publics can have about CCS-related developments being
483 forced on them from on high may not necessarily relate to worries about exposure to immediate
484 technical and scientific risks, but rather dissatisfaction with the process through which decisions
485 about places meaningful to them are made. The value of process in reaching outcomes amenable
486 to all is likewise understood as part of the basic guidelines of consensus building and alternative
487 dispute resolution (Susskind and Cruikshank, 2006). An implication of this for governance of
488 sub-seabed CO₂ storage sites is that it should not be assumed the potential for public concern
489 will be reduced by increasing the physical distance between storage sites and centres of
490 population, as bigger questions about process, justice and ‘ownership’ of environments may arise
491 (Mackinnon and Brennan, 2012).

492

493 Nonetheless, the dilemma faced by the experiment organisers – a limited number of sites with
494 the right physical characteristics, and restrictions on time and resources to carry out public
495 engagement activities - somewhat mirrors the conditions that will affect full-scale CCS

496 deployment. Storage sites will initially be identified largely by geological suitability as opposed
497 to ‘social fit’, and the locations of existing power stations, pipelines and associated infrastructure
498 may constrain the flexibility of deployment. Further, whilst more deliberative processes bringing
499 in a range of perspectives at an early stage are certainly desirable, it may be the case that
500 decisions about renewing energy systems and mitigating climate change do ultimately have to be
501 taken, and that some people may not be happy with these. Under such conditions, strategies for
502 reducing the potential for opposition may include being clear from the outset about what can and
503 cannot be achieved through participation in engagement. The QICS experiment organisers also
504 expanded their communications strategy in response to feedback from community members,
505 taking part in a radio interview, having a presence at a farmers’ market, and feeding back initial
506 results to the community through a free public lecture organised soon after the conclusion of the
507 experiment.

508

509 Another related issue pertains to the framing of the experimental release, and of CCS more
510 generally. Many publics attending the engagement events organised by SAMS – and many
511 people posting comments to news articles – viewed the experiment as a piece of ‘science’ rather
512 than a trial of energy technology. SAMS staff involved in the experiment situated the QICS
513 release in this context of scientific endeavour:

514

515 *I think there’s a huge degree of confidence developing about our operation. People feel it’s to*
516 *their benefit so we get a lot of public support. So when we propose something we’re not seen as*
517 *coming from some distant planet and doing something terribly suspicious, we’re probably seen*

518 *as a bunch of scientists who are wanting to achieve something new, which as a starting position*
519 *is not bad!* (interview with professor, SAMS, October 2012)

520
521 *[M]ost people, whether, whether they necessarily think CCS is a good thing or a bad thing is less*
522 *relevant, they're more curious to find out what we are, what results we're going to get. I mean,*
523 *different people are approaching it from very different directions, but once we explain all we're*
524 *doing is generating the results, analysing the results, and interpreting them, then they're actually*
525 *very curious to find out what the results are going to be.* (interview with researcher, SAMS,
526 October 2012)

527
528 The primary focus on the QICS release as a piece of scientific research – with decisions about its
529 implications for the viability of CO₂ storage being made elsewhere – seemed to garner support
530 from most residents and stakeholders. The emphasis on building knowledge to allow developers
531 and policy makers to make an informed decision about CO₂ storage and CCS (the word
532 ‘evidence’ appeared frequently in interview transcripts) perhaps helped to side-step the range of
533 views within the community on whether or not full-scale CCS was a ‘good thing’. Linking back
534 to the points made in Section 3.1, additional strategies used by scientists at both the public
535 information evening and the open day to rationalise the experiment – in many cases suggested by
536 publics and stakeholders themselves – centered around the release as just one of many human
537 impacts affecting the marine ecosystem of the bay, and the very small size of the experiment
538 compared to some of these other emission sources. In particular, the samples of monitoring
539 equipment on display at the open day, and the use of experiments with carbonated water to

540 contextualise the scale of the release, seemed to keep to the fore this idea of QICS as a small-
541 scale scientific endeavour.

542
543 The QICS experimental release offers some suggestions as to how to widen out the discussion on
544 CCS. The commonly used narrative in CCS communication is one of the need for deep cuts in
545 anthropogenic CO₂ emissions to avert dangerous climate change, with CCS being the only
546 realistic way to deliver this in the time frame available (Mabon and Shackley, 2014). However,
547 this is problematic for those who may never accept the anthropogenic climate change argument,
548 and for those who may not view large-scale fossil fuel infrastructure as a fitting solution in any
549 case. The framing of CO₂ not as a greenhouse gas but more generally as a pollutant that needs to
550 be controlled is one possibility in this regard, and has already proven successful with the Decatur
551 project in the USA (Ibarolla et al, 2012). Particularly with offshore projects where the marine
552 environment is already a focus of discussion, it may be possible to couch the need to reduce the
553 amount of atmospheric CO₂ in terms of a drive to mitigate ocean acidification – indeed, a
554 discussion on water acidity formed part of the scientists’ presentations at the release site ‘open
555 day’. A focus on building the evidence base for assessing viability of storage may also prove
556 helpful with early projects, and could even be tied into reasons other than energy production for
557 why CO₂ may need to be ‘stored’, such as emissions from industrial sources.

558

559 4. Cautions – what might the QICS release *not* tell us about CCS and society?

560

561 Whilst we have aimed above to sketch out some areas in which the QICS experimental release
562 might contribute to the body of research on public perceptions of real-world CCS-related project,

563 it is important to acknowledge the limitations of our findings. Although the CO₂ release did
564 involve interaction with other activities in a populated, working marine environment, it was
565 ultimately a small-scale scientific experiment. In addition to having a long-standing reputation
566 for producing quality scientific research, SAMS is one of the biggest employers in the Argyll
567 area, especially in the communities around which the release took place. About 160 people are
568 employed locally at the organisation's Scottish Marine Institute (SAMS, 2014). Many
569 researchers themselves live in these communities (indeed, the institute director commented at the
570 end of the first public information meeting that his own house overlooked the bay in which the
571 release would take place), and the familiarity of the communities with the scientists carrying out
572 the research may have contributed to the generally high levels of support and trust. Whilst it was
573 not possible to conduct a 'baseline' analysis of public perception before the experiment due to
574 potential sensitivities within the community and the concern with not jeopardising the physical
575 science research that had been planned in advance, it is true that SAMS has conducted large-
576 scale research in the local marine environment previously. An example of this is the installation
577 of an artificial reef system (Sayer and Wilding, 2002), hence there is already precedent for
578 activities similar to the QICS release being carried out in the community to broad support.
579 Whether an external developer coming in to the area without these relationships would have been
580 able to carry out a similar piece of work is open to question.

581

582 Public support for a piece of scientific research may also not equal support for full-scale
583 commercial CCS. A number of people did make their scepticism about CCS known during the
584 engagement events and interviews, even if they could understand the need to generate a strong
585 evidence base to allow decisions to be made about CO₂ storage. The extent to which findings

586 from experimental and pilot studies like these can be transferred to projects being operated for
587 profit by private developers thus ought to be examined further. On the other hand, comments
588 from publics during the engagement events, and also on from other CCS social research projects
589 (Mabon and Shackley, 2014), suggest publics do not necessarily view science as ‘objective’ and
590 impartial and can be suspicious about the effects of science funding sources on results.

591

592 When applying the lessons of experiments like QICS to commercial CCS-related trials, it is also
593 important to note potential limitations to framing CCS as ‘pollution control’. Stressing the
594 control of pollution when the key aim is still to produce electricity could be seen as an example
595 of Schwarz and Thompson’s (1990) ‘stolen rhetoric’, which could back-fire if publics and
596 stakeholders already sceptical towards the development get a sense they are being lied to or told
597 half-truths about the real purpose of CCS. As outlined earlier, the conceptualisation of CO₂ as
598 pollution does still rely on people believing that CO₂, or pollution generally, is a problem for
599 them.

600

601 5. Conclusions

602

603 The QICS experimental CO₂ release provided a valuable opportunity to study public and
604 stakeholder responses to a CO₂ storage-related event taking place not on paper or in the
605 laboratory, but in an inhabited and working environment. Of perhaps more importance than
606 whether the local communities ultimately thought the experiment was a ‘good’ or ‘bad’ thing
607 was building an understanding of what the factors are that drive perception of sub-seabed CO₂

608 storage, and also getting a sense of where the possible gaps and slippages might lie in going from
609 a small-scale science ‘experiment’ to a large-scale commercial development.

610

611 The first main finding is that people do not enter engagement processes like these with no *a*
612 *priori* knowledge of energy or environmental change. Rather, they bring with them knowledge
613 gained from experiences of living (and sometimes working) in environments around them,
614 learning in embodied, ad hoc and occasionally piecemeal ways. As a result, things may be mis-
615 remembered or mis-understood in a way that leads to a very cautious stance to things like CO₂
616 storage, but equally these experiences can help people to contextualise and rationalise otherwise
617 obscure and opaque ideas. In any case, all of this demonstrates the value for project operators in
618 tapping in to analogues to more familiar processes as a means of opening up a discussion on a
619 new and unfamiliar concept like CO₂ storage.

620

621 The second main finding relates to dealing with uncertainty. Although awareness of CCS
622 remains low among the general public, this does not mean that people cannot quickly grasp new
623 ideas and ask complex and in-depth questions. Some of the points raised in the information
624 meetings and interviews by stakeholders and informed publics serve only to reiterate the idea
625 that people do not want to be told by researchers and developers that CO₂ storage sites will *never*
626 leak, rather that adequate procedures are in place *if* there is a leak and that sufficient attention has
627 been given to ‘worst case’ scenarios. QICS as a whole project may have a key role to play in
628 building such knowledge of what would happen should a sub-seabed storage site for whatever
629 reason leak.

630

631 The third main finding concerns how and when to engage. The dilemma around early
632 engagement for the Ardmucknish CO₂ release exemplifies well the tension between wanting to
633 have a full, fair and open deliberation process on one hand, versus the harsh reality of needing to
634 avoid paralysis and make decisions within a certain time frame and budget on the other.
635 Managing expectations from an early stage, having flexibility in governance processes, and
636 feeding back results to the community can be helpful in this regard. Although maybe excessive
637 for a project on the scale of QICS, the ‘stage gating’ approach developed by Stilgoe et al (2013)
638 might be useful for larger projects, bringing in publics and stakeholders at key decision points
639 during the project planning and execution. The QICS release has also illustrated some alternative
640 ways in which CO₂ storage can be framed (at the research and development stage at least), for
641 example the need to create an evidence base and the concept of CO₂ as a general pollutant.

642

643 We finish with an observation on perceptions of offshore versus onshore storage. There is ample
644 evidence in this study to call into question assumptions that offshore CO₂ storage will always be
645 ‘easier’ from a public acceptance perspective. The marine environment can be a major source of
646 employment and income for coastal communities like those in Argyll, so anything perceived as
647 affecting this marine environment may be viewed as exposing coastal communities to risk –
648 albeit risk to livelihood and valued biological diversity instead of the techno-scientific risk
649 usually associated with onshore storage. Furthermore, a number of participants in this study used
650 their knowledge of physical processes on land to envision what the risks of offshore storage
651 might be, and did not always see physical distance as insulating them from problems like
652 groundwater contamination or induced seismicity. Finally, concern over how decisions are taken
653 about what happens in and under waters shows that publics’ place values and attachments can

654 easily extend beyond land to include the sea and seabed. If nothing else, this social study into the
655 QICS release has illustrated that issues of public and stakeholder perception are just as relevant
656 to offshore CO₂ storage as to its onshore counterpart.

657

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659

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668

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