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Making sense of complexity in risk governance in post-disaster Fukushima fisheries: a scalar approach

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Abstract

This paper evaluates how geographical theories of scale can give a more robust understanding of the governance of complex environmental risks. We assess the case of fisheries in Iwaki City, Fukushima Prefecture in Japan following the 2011 nuclear disaster. Fisheries in Iwaki and Fukushima more widely are operating on a trial basis as understanding of the marine radiation situation becomes clearer, however questions remain over whether consumers will buy produce and to what extent full-scale fisheries will resume. Based on empirical fieldwork undertaken in Fukushima plus supporting documentary analysis, we construct a scalar account of post-disaster Iwaki fisheries. We use this to argue that framing post-disaster fisheries governance at the municipal scale rather than the prefectural scale has opened up opportunities for enacting the more two-way forms of risk governance that contemporary environmental issues may require. We also argue locally-situated 'experts' (e.g. fisheries extension officers and citizen science groups) play a key role in negotiating citizens' and fishers' relationships with larger-scale scientific discourses due to their ability to work across scales, despite having less techno-scientific expertise than their national-level counterparts. In turn, we suggest that in governance of complex environmental issues, policymakers ought to (a) consider how community-level expectations may differ from risk governance processes developed at larger scales; (b) identify key institutions or figures who can work across scales and support them accordingly; and (c) show cognisance to the social effects that may arise from spatial demarcation of environmental problems.

Keywords

environmental governance; Fukushima nuclear disaster; landscapes of risk; risk governance; social construction of scale.

Research highlights

- Evaluation of risk governance in post-disaster Fukushima fisheries;
- Focus on spaces of risk and processes across spatial scales;

- Local-level focus on understanding uncertainty instead of assuring safety outright;
- Framing at municipal scale rather than regional enhances traceability in risk;
- Actors who can work across scales key to governing complex environmental issues.

Vitae

Leslie Mabon is a Lecturer in Sociology at Robert Gordon University in Aberdeen, Scotland. He holds a PhD in Human Geography, and is especially interested in the governance of complex and ethically contentious environmental issues. Leslie's research has a particular emphasis on interdisciplinary collaboration and on working at the science-policy interface. He has been carrying out empirical research in Iwaki and Fukushima Prefecture since 2014. Regular research updates are available via his blog - energyvalues.wordpress.com - and Twitter account: @ljmabon.

Midori Kawabe is a Professor in Marine Policy at Tokyo University of Marine Science and Technology. Her research focuses on coastal and ocean management, with a particular interest in social learning of stakeholders in collaborative management. Since the 2011 nuclear accident, Midori has been closely working with the fisheries sectors of Fukushima by having participatory workshops and *café scientifique* with natural scientists, fishers and citizens to discuss ways for rehabilitation of the Fukushima coastal area.

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1. Introduction

The March 2011 Great East Japan Earthquake and Tsunami, which killed more than 15,000 people and left over 2,000 missing, profoundly affected fisheries in north-east Japan. Significant infrastructural damage was caused to ports, fisheries buildings and fishers' homes, and boats were swept away. The effects of the earthquake and tsunami were compounded in Fukushima Prefecture by the triple meltdowns at the Fukushima Dai'ichi Nuclear Power Plant (FDNPP). 70-80% of released radionuclides ended up over the north-west Pacific Ocean (Yoshida and Kanda, 2012), finding their way into sea water, sediments and marine species (Wada et al, 2013).

With over 40% of sampled fish caught in Fukushima waters exceeding regulatory limits for radioactive caesium (Buesseler, 2012), all commercial coastal fisheries in Fukushima waters were stopped after the disaster. Whilst deep-sea operations have since resumed, coastal fisheries remain closed apart from small-scale trial fisheries. These trials, running at about 10% of pre-disaster capacity, are targeted at species in which radioactive caesium has not recently been detected and aim to move towards the restart of larger-scale fisheries by monitoring the sale of Fukushima produce in markets. As of spring 2017 over 90 species had been released for trial fishing operations in this way (Fukushima Prefecture Federation of Fisheries Cooperative Associations, 2017). Yet despite monitoring regimes broadly agreed to be scientifically rigorous and reliable, consumer confidence in Fukushima produce is divided (Mabon and Kawabe, 2015).

This paper takes as its point of departure a slippage in terminology observed in interviews with post-disaster fisheries stakeholders, between 'Fukushima' fish (landed at ports in

101 Fukushima Prefecture as a single entity) and ‘Iwaki’ fish (landed in at ports in the
102 municipality of Iwaki, the further south of Fukushima’s two fishing districts (see Figure 1)) –
103 two different spatial scales for addressing what appears to be the same issue. This question of
104 scale has not gone unnoticed in environmental governance thinking. Shi et al (2012) propose
105 a consilience model to differentiate the kinds of governance required at different scales for
106 climate change, and Boyes and Elliot (2014) hold that the complexity of marine governance
107 is enhanced by the interests of different actors and institutions operating at different
108 organisational scales. Building on this, through the case of post-disaster fisheries in Iwaki we
109 suggest the scale at which the governance of an environmental risk such as marine
110 radioactive contamination is framed may open up different management options and thus
111 different societal effects. We argue that explicitly and specifically mapping out the
112 involvement of actors involved in risk governance for a particular issue offers a systematic
113 means of laying out and understanding complexity in environmental risk governance, and in
114 turn helps identify pathways for the kinds of dialogue across scales that risk governance
115 necessitates.

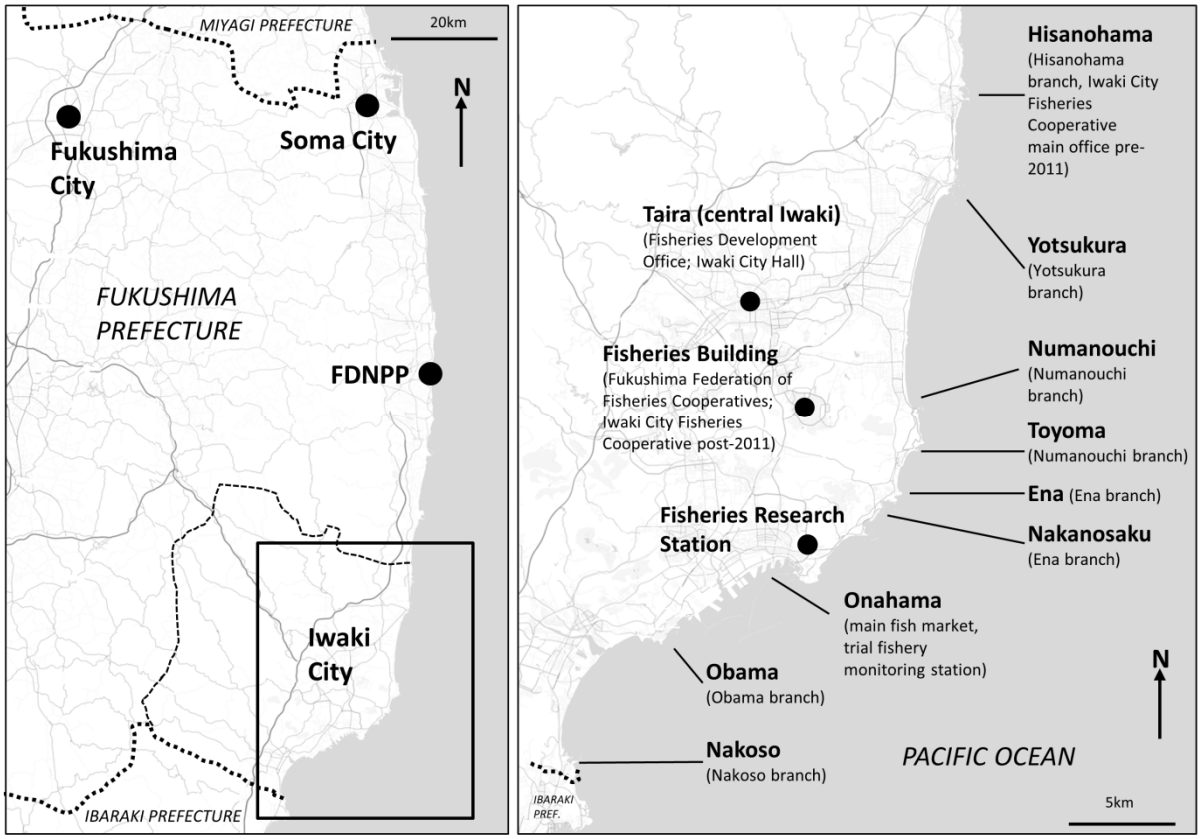

Figure 1: Fukushima Prefecture and Iwaki City. Adapted from map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL, originally published in Mabon and Kawabe (2015)

2. Spaces and scales of risk?

We set out the value of a scale-centered approach to understanding complexity in environmental risk governance, synthesising existing literature to argue that environmental risk governance happens across space, and that the spatial scale at which this governance is framed may engender particular social or political effects. Explicit attention to spatial scale, we suggest, may clarify the roles and aims of different actors within the risk governance process.

First, however, a reminder of what is meant by 'risk governance'. Pellizzoni (2003) characterises contemporary environmental issues through limitations in scientific knowledge, declining trust in 'experts' previously trusted to assess risks, and the potential for intractable conflicts to emerge. Such risks and decisions about their management nonetheless affect how people may live their lives and/or the environments and places meaningful to them, especially for energy or 'risky' large-scale environmental infrastructure (Bradbury, 1989; Wynne, 1992), hence can be seen as involving a significant value dimension. Partly because of this values-driven component, the requirement for risk governance has emerged, defined by Renn (2008) as a means of making decisions whilst balancing the range of societal perspectives on a given risk or set of risks. This does not mean 'anything' goes with regard to what may be considered a risk versus what may not (Klinke and Renn, 2002). Rather, it implies a value dimension to the underpinning knowledge (scientific or otherwise) used to inform decision-making (Duckett et al, 2015). The aim is to strive towards 'better' risk management decisions, sensitive to techno-scientific realities, but also the uncertainties inherent within these and the different value positions informing their interpretation. Rather than being one-way and top-down, effective risk governance is widely characterised as a dialogic process for evaluating different knowledge claims (Bradbury, 1989; Renn, 2008). By extension, 'risk communication' thus ought to be considered not as a one-way transfer of information from experts to citizens, but rather as the means through which discussions around these knowledge claims take place (e.g. Arvai, 2014; Kasperson, 2014).

For energy and/or environmental issues this risk governance relates to infrastructure or phenomena rooted in certain locations, hence the governance of risk will manifest itself in particular spaces or landscapes (Nadai and van der Horst, 2010). These landscapes in turn

155 engender particular social effects. Blowers (1999) discusses ‘landscapes of dependence’
156 created around sites for nuclear waste disposal as a reflection of injustices, whereas Parkhill
157 et al (2014) evaluate ‘landscapes of stigma’ associated with undesirable infrastructure and
158 note that residents may create their own alternative, more positive, narratives of place by way
159 of resistance or response. This becomes all the more pointed for radioactive contamination,
160 where the substance itself may be invisible (Pezzullo and Depoe, 2010) and yet can have
161 profound effects on humans. These impacts transcend immediate health risks to include how
162 others form opinions of places and the people within them (Edelstein, 2002), and how ability
163 to partake in economically, socially or culturally significant practices within geographically-
164 bounded locations may be constrained by the choices of decision-makers (Oughton, 2013).
165
166 Environmental risk governance necessitates specific forms of spatial organisation, which both
167 set the terms of debate on the risk in question and constrain or enable the actions of those
168 occupying the landscape of risk. Nevertheless, in keeping with Smith’s (2006: np) reminder
169 that “(i)n every phase and aspect of a disaster […] the contours of disaster and the difference
170 between who lives and who dies is to a greater or lesser extent a social calculus”, running
171 through much literature on spaces of risk but not treated explicitly is reflection on the *scale* at
172 which landscapes of risk are constructed, and what the implications for risk governance are
173 from the scale at which the debate is framed. It is of course well understood that particular
174 scales are constituted and transformed through social and spatial processes (Marston, 2000)
175 and also that there is a need to think across scales and reflect more deeply on how scale
176 specifically orders a social process (Brenner, 2001).
177
178 Fuller understanding of how contemporary environmental risks are governed, by whom and
179 to what effect thus ought to entail specific and systematic consideration of the spatial scales

over which risk governance takes place. Recurring themes in extant literature on risk and/or environmental infrastructure such as 'lay' versus expert knowledges (Wynne, 1996; McKechnie, 2003), localised narratives shaping perception (Bickerstaff, 2012; Parkhill et al, 2014) and potential for distributional injustices across space in siting decisions (Blowers, 1999) lend themselves well to the idea of different understandings of or responses to risk emerging depending on the spatial scale through which the issue is evaluated. Emerging post-disaster social research on Fukushima too carries strands of the role of scale, reflecting the influence on social production and consumption of the "small-scale social, physical, cultural and emotional infrastructure of the household" (Marston, 2000: 233). This can be seen in difficulties of Fukushima households living with the indeterminacies of radioactive contamination on a daily basis (Morris-Suzuki, 2014); differences in perception of radiation risk within households and their influence on consumption/relocation decisions (Sato, 2014); and the enactment and performance of radiation standards (Kimura, 2016). Developing such scalar dimensions in existing work and in keeping with the challenges outlined above, this paper systematically evaluates how questions of scale play out for one specific aspect of the Fukushima disaster – fisheries governance in Iwaki in the south of the prefecture.

The critical geographical thinking on scale on which we draw has emerged largely in the context of globalisation and processes of production under capitalism (e.g. Marston, 2000; Brenner, 2001; Smith, 2004). Production and consumption processes do of course influence the issue under study here, and we refer to them as and when appropriate. But to be clear, our central focus is environmental risks in a largely rural area after a major pollution event and the wider implications for understanding risk governance under conditions of high uncertainty, rather than addressing more political issues such as nuclear power as a system head-on. Nonetheless, the concerns of the 'scalar' school of thought with regard to the

construction of different scales to different purposes, and the need to think in a systematic and structured way about whether scale does make a difference, give a useful point of departure for enquiry into the scale at which environmental risk governance is enacted.

3. Methodology

Data was collected through qualitative empirical research in Iwaki City and Fukushima City between 2014 and 2017. This was supported by desk research into relevant public-facing documentation on risk governance for marine radiation in Iwaki and Fukushima.

3.1. Qualitative empirical research

In-depth interviews were conducted with forty people, encompassing fishers, fisheries cooperative staff and managers, Fukushima Prefecture Fisheries Section researchers and extension officers, local scientists, municipal government employees, municipal government politicians and academics working on Fukushima issues at the national and international level. Participants were sampled purposefully to encompass different sectors with a relationship to trial fishing operations (based on existing knowledge within the research team and initial review of policy documentation), and also to encompass people (e.g. local politicians sceptical of nuclear power, university researchers unrelated to fishing operations) who would be able to offer a more detached or critical perspective on safety post-disaster. Recruitment was undertaken via email or telephone contact, however given ethical concerns about undertaking research on a potentially sensitive topic, recruitment of fisheries and household-level interviewees was undertaken in cooperation with Fukushima Prefecture

229 Fisheries Section. Table 1 provides a breakdown of the interviewees by scale, sector and
230 rationale, with further information in the Supplementary Material.
231
232 Whilst this may seem a relatively small sample, given the complexity of the topic and the
233 specificity of the information required a focused sample of participants able to talk in-depth
234 not only about Iwaki fisheries but also about social and cultural dynamics in the area was
235 considered to offer more analytical purchase than a larger sample with less explanatory depth.
236 As Marshall (1996: 523) explains, “some informants are 'richer' than others and that these
237 people are more likely to provide insight and understanding for the researcher.” Similar
238 sample sizes have been used for qualitative research into marine governance issues elsewhere
239 (e.g. McDaniels et al, 2006; Hicks et al, 2014). The higher number of interviewees at smaller
240 scales is for three reasons. First, the majority of risk governance actions and processes for
241 fisheries in Iwaki and Fukushima such as catching fish, monitoring, screening take place at
242 the prefectural level or lower (see Section 4.1.), hence understanding how risk governance is
243 enacted in practice necessitates greater attention to these scales. Second, the majority of fish
244 landed in Iwaki post-disaster are sold *within* Fukushima Prefecture. For example, in the week
245 commencing 16 June 2014, by weight 55% of Iwaki fish were sold at market in Iwaki itself;
246 20.2% at other markets within Fukushima Prefecture (Aizu-Wakamatsu, Koriyama,
247 Fukushima); 15.1% in Tohoku (Mito, Sendai); and 9.7% in Tokyo (Iwaki City Fisheries
248 Cooperative, personal communication). For the objectives of both restarting fishers'
249 livelihoods and also ensuring consumer safety it is therefore people and processes *within* the
250 prefecture, and especially within Iwaki City, which are most significant. Third and final, at
251 smaller spatial scales textual documentation (e.g. policy briefs) to evidence risk governance
252 practices is more limited compared to the national level, hence interview-based data takes on

253 extra importance in understanding risk governance practices in a way that is not otherwise
254 readily accessible.
255
256 The interviews were loosely structured to allow naturally-occurring discussion to emerge.
257 Participants were in all cases asked how they felt the recovery of fisheries was proceeding
258 post-disaster; what they thought the key concerns around radiation in the area were; and how
259 they felt about living in Iwaki City and/or Fukushima Prefecture more generally. A
260 discussion group was also held with nine fishers covering a range of ports and catching a
261 range of fish from along the Iwaki coast. This again was loosely structured in order to allow
262 themes the fishers themselves deemed important to emerge but guided around questions of
263 how fishers saw the prognosis of Iwaki fisheries, and what they felt the main risk
264 communication and management needs were. Ethnographic observation was undertaken at
265 the landing of a catch of fish for monitoring at Onahama Fisheries Research Station, the
266 landing of catches for trial fishing operations (including radiation screening) at Onahama Fish
267 Market, and a weekly information meeting between Fukushima Prefecture fisheries
268 scientists/extension officers and fishers at the Iwaki Fisheries Building. The Supplementary
269 Material gives a fuller breakdown of the data sources and interview/focus group topic guides
270 on which this paper is based.
271
272 The interviews and discussion group were audio-recorded, with notes being written up for the
273 field observations. All interviews were undertaken in Japanese, and to avoid any slippage in
274 language analysis proceeded as far as possible on Japanese versions of the data. Analysis was
275 undertaken through a process of identifying key themes and ideas in both the interviews and
276 field notes, then grouping the main emergent ideas before re-reading to ensure the overall
277 synthesis was consistent with the themes identified in the original reading. This is derived

from the ‘grounded theory’ approach (Strauss and Corbin, 1997; Henwood and Pidgeon, 2012), where the aim is to identify themes and concepts within the data itself rather than attempting to categorise the data into pre-existing interpretative frameworks. Such iterative techniques for environmental issues have been deployed by Kempton et al (2005) and Parkhill et al (2014) among others, and are argued to be appropriate for complex environmental issues such as the issue under study here where respondents’ opinions may be contingent on local context and may not at first sight appear ‘rational’. For fuller information on the research design and execution, we direct the reader to the Supplementary Material.

3.2. Documentary analysis

The qualitative empirical data was supplemented with analysis of documentation pertaining to risk governance in Iwaki and Fukushima fisheries produced by actors operating at different spatial scales (see Table 2). The purpose of this was (a) to further refine the themes identified in the empirical research; (b) gain deeper understanding on risk governance practices and standards at different spatial scales; and (c) to understand the language, messaging and framing used to discuss risk governance for Iwaki and Fukushima fisheries at different scales.

The documents were sampled to reflect institutions with interest or involvement in risk governance for Iwaki trial fisheries, including those at smaller scales who were outside decision-making processes but could influence local consumer opinion. This was based on knowledge of the governance landscape emerging during fieldwork and prior review of policy documentation. Prior (2003) holds that documents are produced in social settings and that the context in which a document is produced is as significant as the content. Document analysis thus entailed two components – reading the documents themselves for the language

and imagery (and spatial scales) used to describe risks and uncertainties around marine radiation, and also considering how the language and imagery used related to how the reporting institution was discussed (e.g. perceived competence or trustworthiness) during the qualitative empirical research outlined above. In the following Findings section, reference to relevant sections of the above documents or related documentation is made where appropriate to support the observations from the empirical data.

3.3. Rigour

As a final note for this section, we have sought to follow as far as possible the checklist for rigour in qualitative research developed by Mays and Pope (1995). Table 3 explains the means through which we have aimed to achieve this. Note also that all translations from Japanese sources into English were undertaken by the authors – both of whom are proficient in Japanese – and checked for accuracy with an additional native speaker independent from the research team.

4. Findings

We follow the approach for an account of scalar structuration suggested by Brenner (2001). This entails laying out how/why/when the social process is subdivided into a vertical hierarchy of separate yet intertwined scales; specifying relevant spatial units within this hierarchy; delineating the specific and historically evolving roles within hierarchy; and evaluating the specific and historically evolving relations to other units within this hierarchy (Brenner, 2001). It is also important to clarify how we distinguish ‘Fukushima’ fish and ‘Iwaki’ fish, bearing in mind that how actors themselves make this distinction is a key

concern of the paper. For factual descriptions, we use *Fukushima* fish for processes relevant to whole prefecture (such as the stoppage of fisheries), and *Iwaki* fish for processes specific to Iwaki (for instance, screening by the municipal fisheries cooperative).

4.1. How/why/when the social process is subdivided into vertical hierarchy of separate yet intertwined scales; and specifying relevant spatial units within the hierarchy

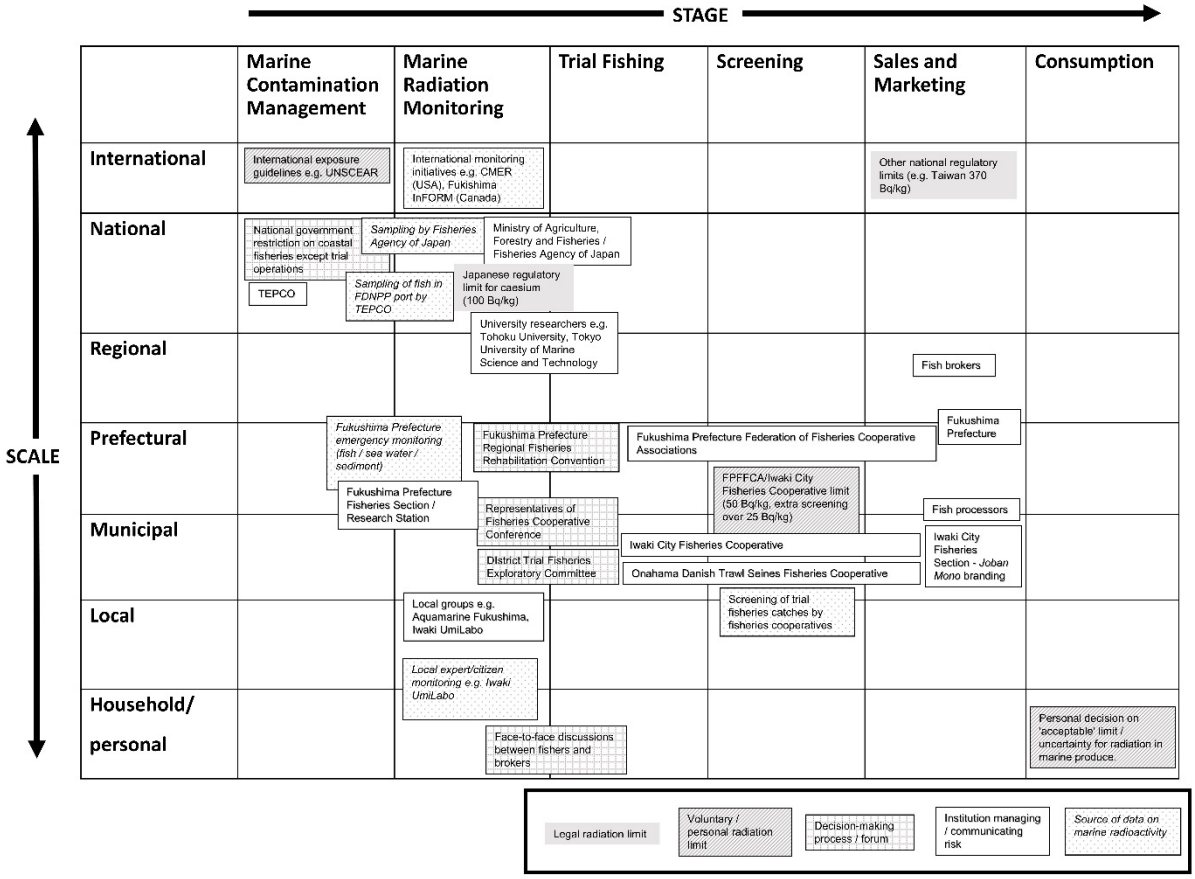

Figure 2: overview of institutions, processes, and standards involved in governance of trial fisheries in Iwaki.

Figure 2 summarises how the social process – in this case risk governance of fisheries in Iwaki after the Fukushima nuclear accident – is subdivided into a vertical hierarchy of

separate yet intertwined scales. The ‘why’ and the ‘when’ of this subdivision is as follows. This is necessarily descriptive, but sets the context for the following analysis.

The *national* scale ultimately determines whether fish can be sold and restricts commercial coastal fisheries in Fukushima, via the regulatory baseline for radioactive caesium in marine produce (100 Bq/kg). Following the March 2011 disaster, the Japanese government imposed a control directive on all fisheries off Fukushima Prefecture (Buesseler, 2012) and also for some species from nearby Ibaraki, Miyagi and Iwate Prefectures (Fisheries Agency of Japan, 2014). A national-level actor in FDNPP operator Tokyo Electric Power Company (TEPCO) is also responsible for compensating affected fishers and ensuring that the damaged plant remains under control.

The *prefectural* scale is responsible for moving fisheries towards restarts. Fukushima Prefecture’s Fisheries Section has since 2011 conducted regular (almost weekly) monitoring of fish stocks, sea water and bottom sediment, which provides baseline data for determining which species are released for trial fishing operations. For species in zones where radioactive caesium has not recently been detected during this monitoring, the potential to be released for trial operations is determined at prefectural scale via the Representatives of Fisheries Cooperative conference (Wada et al, 2013; Mabon and Kawabe, 2015).

The *municipal* scale is where trial fisheries – not only the catching of fish but also their subsequent radiation screening – are executed. Trial operations are overseen by municipal cooperatives in Soma-Futaba (north Fukushima) and Iwaki (south Fukushima), who are connected at the prefectural level through the Fukushima Prefecture Federation of Fisheries Cooperatives. Produce landed in trial fishing operations is screened within laboratories in

each municipality before going on to market – mainly within the municipality or Fukushima Prefecture, but also across north-east Japan. This process has been developing in Iwaki since 2012.

The *local* scale has a significant role in decision-making around the restart of fisheries. The actual practice of fishing is carried out by small groups of fishers who fish out of – and are members of cooperative branches within - the various ports within the municipality, who decide at the local level about participation or otherwise in trial fishing. It is also at the municipal and local scales that radiation monitoring by citizens and alternative brandings for produce have emerged, as discussed in Sections 4.2. and 4.3.

The *household* and *individual* scale is significant in that it is it is at the scale of the *household* that decisions about whether or not to consume fish caught in Fukushima waters are ultimately taken. Interpersonal face-to-face interaction between fishers, fisheries cooperative staff and brokers is also important in consensus-building around the development and expansion of trial fisheries.

Also relevant, if not involved directly in the governance of Fukushima fisheries, is the *international* context. This may be seen to influence risk governance in Fukushima fisheries via the provision of international recommendations on internal exposure to radioactivity (e.g. UNSCEAR, 2016), reputation and perception of Japanese fish (for example import bans for specific countries), and observation and research into marine radioactivity from overseas institutions who may shape international perception on the safety or otherwise of the Fukushima marine radiation situation (e.g. FukushimaInFORM, 2015).

4.2. Specific and historically evolving roles within hierarchy

Table 4 summarises specific and historically evolving roles within the scalar hierarchy. It lays out risk governance roles, processes and actions across scales based on insights from field work and documentary analysis. Especially noteworthy is that in interviews, the municipal and local scales emerge as sites for radiation monitoring perceived as more rigorous and trustworthy (interviews with fishers, Onahama/Central Iwaki; interviews with aquarium scientists/citizen monitoring group members, Onahama). We draw several explanations for this from the table. First, rather than the national standard of 100Bq/kg, the Fukushima Prefectural Federation of Fisheries Cooperative Associations (FPFFCA) upper limit for saleable produce is 50Bq/kg, with additional screening required for batches where samples exceed 25Bq/kg (Fukushima Prefecture Federation of Fisheries Cooperative Associations, 2015). Second, this screening is undertaken at fish markets within Iwaki by municipal cooperative staff trained by Fukushima Prefecture fisheries researchers, and is accompanied by calls from fishers themselves to enhance traceability of produce within trial fisheries (discussion group with fishers, Onahama). Third, separate from municipal cooperative screening, non-governmental marine research group Iwaki Sea Survey Team UmiLabo provides another means for consumers to assess the level of radioactivity in marine produce. UmiLabo allows citizens to join them to catch fish at sea for monitoring (results later being posted online at www.umilabo.jp) and holds *TabeLabo* events (literally 'checking and eating lab') in conjunction with a local aquarium at which participants view radiation monitoring of marine produce in real-time before eating freshly-prepared Iwaki seafood (UmiLabo, n.d.).

In short, *within* Iwaki City, the assessment of risks associated with restarting fisheries post-disaster is (a) governed to stricter standards than legally required, with a drive from those

who have the most to gain from restarts (i.e. fishers) for more stringent practices; (b) undertaken by institutions whose staff themselves live and work in the community; and (c) independently verifiable in terms of both process and results due to citizen science actions. Moreover, the communication aims and messaging between the national or regional scales and the local and municipal scales differ. On one hand, the national and prefectural framing of post-disaster fisheries as a 'Fukushima' issue is perhaps more closely associated with one-way, top-down risk governance. Interviewees associated with fisheries described representatives coming 'up from Kasumigaseki[1]' once a month to pass on information about marine radiation (interviews with FPFFCA and Iwaki City Fisheries Cooperative representatives, Central Iwaki). National- or regional-scale literature makes heavy reference to dispelling 'harmful rumours' via information provision (e.g. Fukushima Prefecture, 2011; Reconstruction Agency, 2013). By contrast, efforts to frame post-disaster fisheries as an 'Iwaki' issue focus not only on safety, but also on local identity and pride in the area's fisheries. This can be seen in the development of the *Joban-Mono* brand for Iwaki fish. Advertising campaigns since October 2015 focusing on the humans involved in fisheries restarts and also the geographical conditions giving Iwaki fish a distinctive taste (interview with Iwaki City Fisheries Office, Central Iwaki). The old place name for Iwaki – *Joban* – which transcends modern-day Fukushima and Ibaraki Prefectures has been evoked for this purpose (Iwaki City, 2015). Similarly, UmiLabo members spoke of their pride in the history and quality of Iwaki fish as a driving factor in commencing research, monitoring not only to check radiation but also for the social activity of eating and learning about locally-caught produce (interviews with aquarium scientists/citizen monitoring group members, Onahama).

[1] Kasumigaseki is the area of Tokyo in which the Fisheries Agency of Japan's head offices are located.

Local attempts to frame post-disaster fisheries at the municipal (i.e. Iwaki) scale thus move the aim of risk governance away from dispelling 'harmful rumours' and towards admitting where remaining uncertainties lie, making visible the processes through which these uncertainties are reduced or at least managed, and respecting informed decisions made by citizens and fishers alike. Further, framing risk governance at the municipal scale means that those undertaking the practices of risk governance – fishers, market staff, informed consumers – become risk-bearers as well as risk assessors, with a vested interest in understanding their own risk exposure and also in upholding the quality of marine produce which is key to their own local identity. It is this role of individuals within risk governance processes that we now unpackage further.

4.3. Specific and historically evolving relations to other units within hierarchy

To more fully understand why it is that municipal- or local-scale actors and institutions appear to be the most significant in moving Iwaki fisheries forwards, we look to the specific and historically evolving relations to other units within the hierarchy. Based on field work and documentary analysis, Table 5 outlines how actors and processes affect – and are effected by – processes occurring at different spatial scales.

Significant is that the extension officers and citizen science groups who were discussed as reliable sources of information in interviews with fishers, fisheries cooperatives and community groups (e.g. interviews with fishers, Onahama/Cental Iwaki; interviews with FPFFCA and Iwaki City Fisheries Cooperative representatives, Central Iwaki; interview with local politician, Central Iwaki) are those who possessed the least knowledge about radiation pre-2011 yet are able to work effectively across scales. Vital to engaging fishers in dialogue

on radiation in the marine environment are Fukushima Prefecture's Fisheries Extension Officers, and also the research scientists based at Onahama Fisheries Research Station run by Fukushima Prefecture. Whilst employed by Fukushima Prefecture – a scale and institution in which some observed citizen discomfort or distrust due to associations with 'big' and distant government (e.g. interview with sociology professor, Fukushima) – the Extension Officers enact risk governance at the local, small group or individual level. Formalised discussions between Extension Officers and Prefectural Fisheries Scientists and fishers on the results of radiation monitoring are supplemented with informal, face-to-face consultations with fishers either in their ports or before/after large group meetings. Information meetings are held in a building belonging to a prefecture-level actor - the Fukushima Federation of Fisheries Cooperative Associations building in inland Iwaki. Yet as observed during ethnographic observation, by making concessions such as allowing fishers to smoke in the entrance hall - contrary to normal convention for public buildings – or tolerating them sitting in a less formal way during the meetings (kneeling on chairs and/or putting their feet up on the tables), practices associated with the household and personal level are drawn on to build rapport. Further, the lifetime employment system of Fukushima Prefecture means many Extension Officers and senior scientists have long personal relationships with fishers and fisheries cooperative staff stretching back to well before the 2011 disaster. As such, actions at the individual and personal scale become key to putting risk governance practices regulated at the municipal level into practice, specifically by building support among fishers for progression of trial fisheries.

Similarly, at the municipal scales and lower, 'local experts' and 'citizen activists' have an important role in working across scales to connect citizens and potential consumers to scientific discourses of radioactive contamination emerging at prefectural, national and

international scales. One example of this is the *TabeLabo* event series described in Section 4.2., where marine scientists use the local aquarium – a space they feel citizens will not be intimidated entering – and the practice of eating seafood as the starting point for dialogue on the scientific process of radiation monitoring. A second example is Quebec Delta, a group led by a coastal engineering student daughter of an Iwaki fisher which undertook a programme of information provision, fisher interviews and tasting events across Fukushima and north-east Japan (Quebec Delta, n.d.). The aim of doing so was to situate the restart of Iwaki fisheries and the management of radiation risk within a wider context of local recovery and the significance of fisheries to the history and identity of Iwaki. A third example is the fact that both monitoring and trial fishery screening processes are open for public viewing, allowing consumers to discuss issues of significant scientific complexity on a one-to-one basis with staff who are simultaneously radiation 'experts' yet also local citizens (interview with prefectural fisheries scientists, Onahama).

Common to all of these practices is that the activities are undertaken within the community, and are led by people with multiple identities as scientists yet also citizens and enthusiasts. Such 'local experts' are hence an important conduit for simultaneously safeguarding local livelihoods and ensuring consumer safety. They provide a means of making visible larger-scale discourses on environmental radioactivity through open and transparent monitoring activities taking place within the confines of the local area, and thus help consumers reach informed decisions on whether or not to consume Iwaki produce. It is also worth noting that Iwaki citizens and community groups (and indeed those elsewhere in Fukushima Prefecture) can 'jump scales' (Smith, 2004) to understand and support post-disaster fisheries, using social media to directly consult with national and international environmental science 'experts' (for instance Ryugo Hayano of Tokyo University and Jay Cullen of University of Victoria) on

uncertainties, or even to directly promote local produce through hashtag campaigns such as #life_in_fukushima and #yummyfukushima. By speaking as citizens who live, work and in cases were even born in the area, these 'local experts' and 'citizen activists' are able to frame risk governance decisions not as a purely-techno scientific matter, but rather as a process taking place in a wider context of daily living and local recovery post-disaster.

5. Discussion: policy implications

What makes environmental risk governance in situations of high complexity like Fukushima fisheries especially challenging is that the livelihoods of the local communities need to be protected along with the interests of other stakeholders such as consumers. Risk governance must thus balance differing perspectives on what constitutes an appropriate course of action. The causes and immediate effects of the Fukushima nuclear disaster may be very specific, but the wider context of complex, uncertain and potentially irreversible environmental change is far from unique. As such, we conclude by drawing three policy implications from our analysis which carry wider lessons beyond fisheries in Iwaki.

1. Those setting standards and monitoring requirements (such as national-level regulatory bodies) ought to reflect on how effective risk governance processes developed at larger spatial scales may be in meeting the concerns and expectations of communities, consumers and other local-level risk-bearers such as fishers

Different 'types' of risk operate at different levels (Wynne, 1992; Riesch, 2012). For instance, specific to Fukushima Morris-Suzuki (2014) observes disconnect between large-scale government-led assessments of environmental radioactivity from air doses, versus the

539 complexities and indeterminacies of people's lived experiences. In Iwaki too, the traceability
540 of the monitoring and screening process appears more important than outright assurances of
541 safety, with fishers and citizens very aware of the heterogeneity of ecosystems and fisheries
542 within the prefecture and its districts and the indeterminacy this may engender. When
543 developing processes for marine risk governance, policymakers may thus wish to consider
544 means of allowing risk assessment processes (e.g. monitoring, decision-making meetings) to
545 proceed as far as possible within the community scale, using local institutions and people
546 where possible, so that citizens and consumers may more fully understand the grounds on
547 which risk governance decisions have been made and reach their own informed decisions on
548 what constitutes an acceptable level of uncertainty or indeterminacy.
549
550 **2. National-level regulators and operators ought to take steps to understand which**
551 **individuals and people – and why – are perceived as trustworthy and reliable sources of**
552 **information within communities.**
553
554 This is important because, as the Fukushima nuclear accident shows us, decisions about
555 operating infrastructure and about nationwide safety standards may well be taken at national
556 (or even international) scales, and yet the livelihood of the local community will be affected
557 by such decisions. However, lack of trust in those assessing or managing risks from 'on high'
558 is a major issue not only for Fukushima, but also for other pieces of environmental
559 infrastructure where citizen and stakeholder input is sought (e.g. Terwel et al (2012) on
560 carbon dioxide capture and storage, Colvin et al (2015) on coal seam gasification).
561 Understanding where the points, people and forums are to engage communities and those
562 tasked with putting risk governance into practice (e.g. fishers, municipal government
563 extension officers) is hence a crucial step in facilitating dialogue across scales on what a

scientifically appropriate yet socially acceptable course of action may be. In Iwaki, for instance, extension officers and citizen scientists are simultaneously citizens and 'insiders' (McKechnie, 2003) able to connect local consumers and fishers with complex discourses of marine environmental science. It is hence important to ensure, perhaps as part of the environmental and social impact assessment process and reviewed regularly across the lifespan of a project, that local-level actors who can work across scales, and especially who may be perceived as giving citizens or less empowered stakeholders an opportunity to engage or connect with processes operating at larger scales, are well-resourced and well-staffed to respond to any arising environmental risks. This understanding may be gleaned through, for example, collaboration with local authority environmental officials who hold rich contextual knowledge.

3. Policymakers ought to pay cognisance to fact that the spatial delineation of an environmental problem may have social effects.

Post-disaster, national government monitoring is divided into 'Fukushima Prefecture' and 'Other Prefectures' (Fisheries Agency of Japan, 2014) with restrictions on all Fukushima coastal fisheries except trial operations. Confining the risk of marine radiation to 'Fukushima' whilst simultaneously encouraging revitalisation of the same 'Fukushima' Prefecture and branding concerns over Fukushima produce as *fuhyo higai* (harmful rumours, rumour damage) may have the effect of contributing to confusion and distrust by marking a scale/space for consumption out as a landscape of risk at the same time. Morimoto (2015) sees a 'Fukushima/non-Fukushima' binary as harmful to the recovery of the area, in that it marks Fukushima produce – and only Fukushima produce – out as having the potential to be contaminated. Interviewed fishers too expressed concern and frustration that fish landed in

589 Fukushima Prefecture were subject to stricter regulation than fish which may have swum in
590 the same waters but been landed across the border in an adjacent prefecture. Clear in the
591 above is that risk governance of a complex environmental issue based on simple spatial
592 delineation may not only struggle to encompass the complexity of ecosystems, but may also
593 disproportionately expose the community concerned to risk of negative perception, delayed
594 recovery or stigmatisation. Decision-makers hence ought to be aware of the potential social
595 effects which can arise from mapping out areas of contamination, perhaps developing
596 alternative strategies such as restrictions based on species type or branding and
597 communication – as with *Joban-Mono*- which helps to break place name association.
598
599 6. Conclusion
600
601 As a final point, it is important to remember framing risk governance at a smaller spatial
602 scale does not guarantee the revival of Iwaki fisheries. Other spatial units within the
603 hierarchy render Iwaki fisheries vulnerable. As well as requiring local households willing to
604 consume fish, future recovery may depend on the support of brokers working at the regional
605 scale – engaging with buyers outwith the prefecture across north-east Japan - who believe
606 that Fukushima fish are safe *and* can be sold at an economically viable price. Likewise,
607 whilst relations of trust between TEPCO and fishers are low, the absence of full-scale
608 commercial operations also makes fishers dependent upon TEPCO. This dependence may be
609 financial through receipt of compensation payments, and also material in that decisions taken
610 by a national-scale actor like TEPCO on the management of the FDNPP site may have very
611 real consequences if, for instance, radioactively contaminated matter is purposely or
612 accidentally released into the sea with associated effects (either actual or perceived) on fish
613 stocks. Nonetheless, the case of Iwaki fisheries illustrates the challenges of risk governance

614 in a locality where not only economically, but also culturally, significant practices such as
615 fishing are under threat and where livelihoods and sense of identity may be at stake from
616 exposure to risk. In such situations, scalar accounts can help identify where the scales and in
617 turn spaces at which discussions and decisions over the most appropriate trajectory forwards
618 for a landscape of risk may be held.
619
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621
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629 References
630
631 Arvai, J. 2014. The end of risk communication as we know it. *Journal of Risk Research* 17 (10): 1245-1249.
632
633 Bickerstaff, K. 2012. "Because we've got history here": Nuclear waste, cooperative siting, and the relational
634 geography of a complex issue. *Environment and Planning A* 44(11): 2611-2628.
635
636 Blowers, A. 1999. Nuclear waste and landscapes of risk. *Landscape Research* 24(3): 241-264.
637
638 Boyes, S.J. and Elliott, M. 2014. Marine Legislation – the ultimate 'horrendogram': International Law,
639 European Directives & National Implementation. *Marine Pollution Bulletin* 86: 39-47.
640
641 Bradbury, J. 1989. The Policy Implications of Differing Concepts of Risk. *Science, Technology and Human*
642 *Values* 14 (4): 380-399.
643
644 Brenner, N. 2001. The limits to scale? Methodological reflections on scalar structuration. *Progress in Human*
645 *Geography* 25(4): 591-614.
646
647 Buesseler, K. 2012. Fishing for Answers off Fukushima. *Science* 338:480-482.
648

649 Colvin, R.M., Witt, G.B. and Lacey, J. 2015. Strange bedfellows or an aligning of values? Exploration of
650 stakeholder values in an alliance of concerned citizens against coal seam gas mining. *Land Use Policy* 42: 392-
651 399.
652
653 Duckett, D., Wynne, B., Christley, R.M., Heathwaite, A.L., Mort, M., Austin, Z., Wastling, J.M., Latham, S.M.,
654 Alcock, R.and Haygarth, P. 2015. Can policy be risk-based? The cultural theory of risk and the case of livestock
655 disease containment. *Sociologia Ruralis* 55 (4): 379-399.
656
657 Edelstein, M.R. 2002. 'Contamination: The Invisible Built Environment' in Robert B. Bechtel and Arza
658 Churchman, eds., *Handbook of Environmental Psychology* John Wiley and Sons: Chichester, 559-588.
659
660 Fisheries Agency of Japan. 2014. *The Leakage of Contaminated Water at TEPCO's Fukushima Daiichi Nuclear*
661 *Power Station and the Safety of Fishery Products (provisional translation)*. Fisheries Agency of Japan: Tokyo.
662 http://www.jfa.maff.go.jp/pdf/140305e.pdf
663
664 Fisheries Agency of Japan. 2015. Information on radioactive matter in marine produce (in Japanese).
665
666 Fukushima InForm. 2015. Fukushima Contamination Detected at Shoreline in British Columbia
667 http://fukushimainform.ca/2015/04/06/fukushima-contamination-detected-at-shoreline-in-british-columbia/
668
669 Fukushima Prefecture. 2011. 'Vision for Revitalization in Fukushima Prefecture' Fukushima Prefecture:
670 Fukushima. https://www.pref.fukushima.lg.jp/download/1/vision_for_revitalization.pdf
671
672 Fukushima Prefecture. 2017. 'Marine seafood' Fukushima Prefecture: Fukushima.
673 http://www.pref.fukushima.lg.jp/uploaded/attachment/218392.pdf
674
675 Fukushima Prefecture Federation of Fisheries Cooperative Associations. 2014. Inspection system (in Japanese),
676 FPFFCA, Iwaki. http://www.fsgyoren.jf-net.ne.jp/siso/buhin/kensa20140827.pdf
677
678 Fukushima Prefectural Federation of Fisheries Cooperative Associations. 2017. 'The undertaking of trial
679 fisheries in Fukushima Prefecture' (in Japanese). http://www.fsgyoren.jf-net.ne.jp/siso/sisotop.html
680
681 Henwood, K. and N. Pidgeon. 2012. 'Grounded theory' In *Research Methods in Psychology* edited by
682 Breakwell, G.M., Smith, J.A. and Wright, D.B. 461-484. London: Sage.
683
684 Hicks C.C., Stoeckl N., Cinner J.E. and Robinson J. 2014. 'Fishery benefits and stakeholder priorities associated
685 with a coral reef fishery and their implications for management' Environmental Science and Policy 44: 258-270.
686
687 Iwaki City Fisheries Cooperative: Hisanohama Section Youth Group. 2015. 'For fisheries in the Hisanohama
688 area in the future: area recovery events and efforts to secure support' (in Japanese). Iwaki City Fisheries
689 Cooperative: Hisanohama Section: Hisanohama.
690 https://www.zengyoren.or.jp/ninaite/kouryu/download.php?docid=1038
691
692 Iwaki City Fisheries Section. 2015. What is Joban-Mono? (in Japanese) Iwaki City: Iwaki. http://misemasu-
693 iwaki.jp/joban/item/A5guidebook-201510.pdf
694
695 Iwaki City Fisheries Section. 2016. 'Heisei 28: Fisheries in Iwaki City' (in Japanese) Iwaki City: Iwaki.
696 http://www.city.iwaki.lg.jp/www/contents/1001000000620/simple/H28iwakisinosuisan.pdf
697
698 Iwaki Sea Survey Team UmiLabo (n.d.) 'Iwaki Sea Survey Team 'UmiLabo'' (in Japanese)
699 http://www.umilabo.jp
700

Kasperson, R. 2014. Four questions for risk communication. *Journal of Risk Research* 17(10): 1233-1239.

Kempton, W., Firestone, J., Lilley, J., Rouleau, T. and Whitaker, P. 2005. The Offshore Wind Power Debate: Views from Cape Cod. *Coastal Management* 33 (2): 119-149.

Kimura, A.H. 2016. *Radiation Brain Moms and Citizen Scientists: The Gender Politics of Food Contamination after Fukushima* Duke University Press: Durham, NC.

Klinke, A. and Renn, O. 2002. A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies. *Risk Analysis* 22 (6): 1071-1094

Mabon, L. and Kawabe, M. 2015. Fisheries in Iwaki after the Fukushima Dai'ichi nuclear accident: lessons for coastal management under conditions of high uncertainty? *Coastal Management* 43 (5): 498-518.

Marshall. M.N. 1996. 'Sampling for qualitative research' *Family Practice* 13 (6): 522-525.

Marston S.A. 2000. The social construction of scale. *Progress in Human Geography* 24 (2): 219-242.

Mays, N. and Pope, C. 1995. 'Rigour and qualitative research' *British Medical Journal* 311: 109-112.

McDaniels, T., Longstaff, H. and Dowlatabadi, H. 2006. 'A value-based framework for risk management decisions involving multiple scales: a salmon aquaculture example' *Environmental Science and Policy* 9(5): 423-438.

McKechnie, R. 2003. 'Insiders and outsiders: identifying experts on home ground' in Irwin, A. and Wynne, B. (eds.) *Misunderstanding Science?: The Public Reconstruction of Science and Technology* Cambridge University Press: Cambridge pp 126-151.

Ministry of Environment. 2017. 'Progress on Off-site Cleanup and Interim Storage Facility in Japan' Ministry of Environment: Tokyo. http://josen.env.go.jp/en/pdf/progressseet_progress_on_cleanup_efforts.pdf?141022.html

Morimoto, R. 2015. 'Interpretative frameworks of disaster in society close-up' in Collins, A.E, Jones, S., Manyena, B. and Jayawickrama, J. (eds.) *Hazards, Risks, and Disasters in Society* Elsevier: Amsterdam pp 324-353.

Morris-Suzuki, T. 2014. Touching the grass: Science, uncertainty and everyday life from Chernobyl to Fukushima. *Science, Technology and Society* 19: 331-362.

Nadai, A. and van der Horst, D. 2010. Introduction: landscapes of energies. *Landscape Research* 35(2): 143-155.

Oughton, D. 2013. Social and ethical issues in environmental remediation projects. *Journal of Environmental Radioactivity* 119: 21-25.

Parkhill, K., Butler, C. and Pidgeon, N. 2014. Landscapes of Threat? Exploring Discourses of Stigma around Large Energy Developments. *Landscape Research* 39(5): 566-582.

Pellizzoni, L. 2003. Uncertainty and participatory democracy. *Environmental Values* 12 (2): 195-224.

Pezullo, P. and Depoe, S.P. 2010. 'Everyday Life and Death in a Nuclear World: Stories from Fernald' in Brouwer, D.C. and Asen, R. (eds.) *Public Modalities: Rhetoric, Culture, Media, and the Shape of Public Life*, University of Alabama Press: Tuscaloosa pp85-108.

Prior, L. 2003. *Using Documents in Social Research* Sage: Thousand Oaks, CA.

Quebec Delta (n.d.) 'QD Fukushima – Big Catch' http://quebec-delta-gyogyou.jimdo.com

Reconstruction Agency. 2013. *Towards the Creation of "New Tohoku" (The Interim Compilation of Discussions)* Reconstruction Agency: Tokyo
http://www.reconstruction.go.jp/english/topics/2013/08/20130823_Towards_the_Creation_of_New_Tohoku.pdf

Renn, O. 2008. *Risk Governance: Coping with Uncertainty in a Complex World* Earthscan: London.

Riesch, H., 2012. 'Levels of uncertainty'. In: *Essentials of Risk Theory* Roeser, S., Hillerbrand, R., Sandin, P., and Peterson M. (eds). Springer: New York pp 29-56.

Sato, A. 2014. Structure of the issues surrounding the nuclear accident evacuees: What has been seen while supporting town meetings. *Japanese Sociological Review* 64 (3): 439-459.

Shi, P., Ye, Q., Han, G., Li, N., Wang, M., Fang, W. and Liu, Y. 2012. Living with global climate diversity – suggestions on international governance for coping with climate change risk. *International Journal of Disaster Risk Science* 3(4): 177-184.

Smith, N. 2004. 'Scale Bending and the Fate of the National', in *Scale and Geographic Inquiry: Nature, Society, and Method* Sheppard, E. and McMaster, R.B. (eds). Blackwell Publishing Ltd: Malden, MA, USA. doi: 10.1002/9780470999141.ch10

Smith, N. 2006. 'There's no such thing as a natural disaster' Understanding Katrina: Perspectives from the Social Sciences (Social Science Research Council: New York) http://understandingkatrina.ssrc.org/Smith/

Strauss, A. and Corbin, J. 1997. *Grounded Theory in Practice* Sage: Thousand Oaks, CA.

Tatsuta, K. 2016. *Ichi-Efu: A Worker's Graphic Memoir of the Fukushima Nuclear Plant (Vol. 2).* Morning: Tokyo.

Terwel, B.W., ter Mors, E., Daamen, D.D.L., 2012. It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. *International Journal of Greenhouse Gas Control* 9: 41–51.

UNSCEAR. 2016. *Developments since the 2013 UNSCEAR report on the levels and effects of radiation exposure due to the nuclear accident following the great east Japan earthquake and tsunami: a 2016 white paper to guide the Scientific Committee's future programme of work.* UNSCEAR: Vienna.

Wada, T., Nemoto, Y., Shimamura, S., Fujita, T., Mizuno, T., Sohtome, T., Kamiyama, K., Morita, T. and Igarashi, S.. 2013. Effects of the nuclear disaster on marine products in Fukushima. *Journal of Environmental Radioactivity* 124:246-254.

Wynne, B., 1992 Uncertainty and environmental learning: reconceiving science and policy in the preventative paradigm. *Global Environmental Change* 2(2) 111-127.

Wynne, B. 1996. 'May the sheep safely graze? A reflexive view of the expert-lay knowledge divide' in Lash, S., Szerszynski, B. and Wynne, B. (eds) *Risk, Environment and Modernity: Towards a New Ecology* Sage: London.

804 Yoshida, N., and J. Kanda. 2012. Tracking the Fukushima Radionuclides. *Science* 336:1115-1116.
805

806 Table 1: overview of interviewees

Scale	Number of interviewees	Sectors/institutions sampled (number of persons)	Justification
National	2	Universities involved in risk research and communication around Fukushima with national/international focus (2).	Evaluate how knowledge produced at national scale feeds into risk governance, and how Fukushima marine risk is communicated nationally and internationally.
Regional/ prefectural	6	Prefectural fisheries researchers (2); prefectural radiation monitoring team (1); prefectural federation of fisheries cooperatives (2); universities involved in risk communication with regional focus (1).	Understand how radiation and risk governed in Fukushima Prefecture – the scale at which control orders on fisheries are enacted, and over which over three quarters of fish landed in trial fisheries are distributed.
Municipal	8	Municipal government fisheries office (2); municipal government environmental planning (2); municipal fisheries cooperative (2); fisheries extension officer (1); municipal politician (1).	Understand how radiation and risk governed within Iwaki fishing district – the scale at which trial fisheries are governed and at which over half of fish landed in trial fisheries are sold.
Local	15	Fishers who are members of village fisheries cooperatives (13); scientists at local aquarium/citizen monitoring group members (2).	Encompass range of ports within Iwaki landing different fish types; solicit views of scientists working and living in community.
Household/ individual	9	Administrative staff of fish markets and cooperatives (9).	Administrative staff give representation of 'informed consumers' – themselves living in community and consuming seafood.

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809 Table 2 – documents sampled for in-depth analysis

Scale	**Sampled institution / individual**	**Title of sampled document and year (in Japanese unless otherwise stated)**	**Source**
National	Japan Fisheries Agency	Information on radioactive matter in marine produce (2015)	http://www.jfa.maff.go.jp/j/press/kakou/pdf/150406-01.pdf
National	Ministry of Environment	Progress on Off-site Cleanup and Interim Storage Facility in Japan (in English) (2017)	http://josen.env.go.jp/en/pdf/progresseet_progress_on_cleanup_efforts.pdf?141022.html
Regional / prefectural	Fukushima Prefecture	Marine seafood (2017)	http://www.pref.fukushima.lg.jp/uploaded/attachment/218392.pdf
Regional / prefectural	Fukushima Prefecture Federation of Fisheries Cooperative Associations	Inspection system (2014)	http://www.fsgyoren.jf-net.ne.jp/siso/buhin/kensa20140827.pdf
Municipal	Iwaki City Fisheries Section	What is Joban-Mono? (2015)	http://misemasu-iwaki.jp/joban/item/A5guidebook-201510.pdf
Municipal	Iwaki City Fisheries Section	Heisei 28: Fisheries in Iwaki City (2016)	http://www.city.iwaki.lg.jp/www/contents/1001000000620/simple/H28iwakisinosuisan.pdf
Local	Iwaki City Fisheries Cooperative – Hisanohama Section Youth Group	For fisheries in the Hisanohama area in the future: area recovery events and efforts to secure support (2015)	https://www.zengyoren.or.jp/ninaite/kouryu/download.php?docid=1038
Local	Iwaki Sea Survey Team UmiLabo	Iwaki Sea Survey Team UmiLabo (n.d.)	http://www.umilabo.jp/
Household / individual	Tatsuta Kazuto	Ichi-Efu: A Worker's Graphic Memoir of the Fukushima Nuclear Plant (Vol. 2). (2015)	Tatsuta, K. 2015. Ichi-Efu: A Worker's Graphic Memoir of the Fukushima Nuclear Plant (Vol. 2). Morning: Tokyo.
Household / individual	Quebec Delta	QD Fukushima – Big Catch	https://quebec-delta-gyogyou.jimdo.com/

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812 Table 3: steps taken to ensure rigour in study, in line with qualitative research 'best practice'

Question(s) (from Mays and Pope, 1995)	**Response**
Did the researcher make explicit in the account the theoretical framework and methods used at every stage of the research?	Section 2 lays out the theoretical basis for the paper – namely risk governance and scale – whereas Section 3 describes methods.
Was the context clearly described?	Sections 1 and 4.1. provide an overview of the current situation in Fukushima fisheries, with as far as possible reference to peer-reviewed work.
Was the sampling strategy clearly described and justified? Was the sampling strategy theoretically comprehensive to ensure the generalisability of the conceptual analyses (diverse range of individuals and settings, for example)?	The sampling strategy is laid out in Section 3.1, and is intended to be reflective of the scales at which risk governance practices are undertaken and Iwaki fish mainly consumed. Within this, however, effort was made to interview fishers and residents from different ports, involved in catching different fish species, and also to interview participants separate from the trial fisheries process who may offer a more critical perspective.
Could the evidence (fieldwork notes, interview transcripts, recordings, documentary analysis, etc) be inspected independently by others?	Whilst the release of full interview data is not possible in this case on ethical grounds (protection of anonymity given the sensitive nature of the topic), we provide reference to publicly-available documentation supporting the observations made around risk governance.
Was sufficient of the original evidence presented systematically in the written account to satisfy the sceptical reader of the relation between the interpretation and the evidence (for example, were quotations numbered and sources given)?	Although we do not give full quotations in the interests of brevity, we explain in brackets the interviews in which the points made arose when referred to in-text. Moreover, we also refer to publicly-available documentation which demonstrates the risk governance and communication strategies described.
Was the analysis repeated by more than one researcher to ensure reliability? Did the investigator give evidence of seeking out observations that might have contradicted or modified the analysis?	Analysis was undertaken by both researchers, working together dialogically. To verify and refine the theories and concepts developed, input was sought from academic and policy peers (e.g. presentation at policy-focused conferences) and also from participants themselves (e.g. feedback session at New Onahama Fish Market, May 2015).

813 Table 4: summary of different risk communication approaches and perceptions at different scales

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Scale	Risk governance style / role / process	Communication method / style	Main theme(s) / aim(s) of risk governance actions	Perception / trustworthiness issues raised in field work	Example(s)
National	Regulation - set regulatory limit for radiactive caesium (100 Bq/kg), based on sampling in sea and in FDNPP port.	Information provision through online explanations and 'town hall' meetings.	Consumer safety.	Data produced by Fisheries Agency / TEPCO generally considered reliable, but concern over transparency around activity at FDNPP.	Ministry of Agriculture, Forestry and Fisheries 'Risk communication on food - Thinking about how to inspect radioactive materials in food' town hall meeting series (http://www.maff.go.jp/j/press/syouan/hyoji/170106.html)
Regional / prefectural	Refinement - undertake monitoring to review suspensions. Self-regulation - voluntary suspension by fisheries cooperatives, stricter 50 Bq/kg radioactive caesium limit (with additional screening over 25 Bq/kg).	Information provision through online explanations, consultation with citizens/stakeholders on monitoring needs.	Dispelling 'harmful rumours', regional revitalisation.	Fukushima Prefecture as an entity seen as difficult for citizens to trust, but individuals working within Fukushima Prefecture (e.g. fisheries scientists and extension officers) viewed as trustworthy by fishers.	Fukushima Prefecture 'Situation of trial fisheries' website (http://www.pref.fukushima.lg.jp/site/portal/list274-860.html)
Municipal	Enactment - catch fish for monitoring/trial fisheries operations; undertake screening of trial fisheries catches (as above, additional screening for catches over 25 Bq/kg).	Branding campaign within area (posters, stickers, leaflets), television adverts, open viewing of screening, data provision.	Transparency, local identity, quality of produce.	Municipal scale – Iwaki City Government and Iwaki City Fisheries Cooperative – viewed positively due to attempts to promote transparency in screening and develop 'Joban-Mono- branding. Municipal cooperative building in Central Iwaki acts as site for fishers to meet and discuss trial fisheries progress.	Iwaki City Fisheries Section *Joban-Mono* campaign (http://misemasu-iwaki.jp/joban/) FPFFCA trial fisheries screening data portal (http://www.fsgyoren.jf-net.ne.jp/siso/sisotop.html)
Local	Verification - collect data to verify government/cooperative results, no influence on policy.	Co-creation of data – citizen science and monitoring in collaboration with 'local experts'.	Enjoyment of food, pride in local produce, building social relations.	Importance of monitoring of marine produce seen as independent / distinct from national government and prefecture.	Iwaki Sea Survey Team UmiLabo / Aquamarine Fukushima *TabeLabo* events (http://www.umilabo.jp/archives/category/tabelabo)
Household / individual	Engagement - decision to consume local fish (or not) based on evaluation of risk	Use of social media – including English language – to engage with academics,	Pride in local identity, personal motivation to counter negative images	Value of individuals living within the community but also carrying scientific knowledge in explaining and translating	'#life_in_fukushima' and '#yummyfukushima' Twitter hashtags

	governance process; engagement with knowledge and other citizens to inform (and influence) decision-making.	share understanding of radiation and project imagery of locality.	of Fukushima, motivation to better understand radiation as citizens.	risk assessment processes. Also citizens as 'champions' for Iwaki produce.	https://www.fukushimatrip.com/en citizen-run website encouraging consumption of prefectural produce Featuring of Iwaki seafood quality in 'Ichi-Efu' manga series.

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816 Table 5: cross-scale relations in risk governance from interviews (read horizontally)

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Affected > Effecting V	**National**	**Regional/prefectural**	**Municipal**	**Local**	**Household/individual**
National		National-level expertise (both government and academia) supports prefecture rehabilitation committees.	Continued recovery of Iwaki fisheries contingent on competence (both real and perceived) of TEPCO and related companies to keep FDNPP under control.	Fishers remain dependent on TEPCO (via national government) for compensation payments in absence of full-scale fisheries.	National government standards play fundamental role in setting maximum level of consumer exposure.
Regional / prefectural	*Not raised in data.*		Prefectural scientists crucial in providing and communicating evidence base for fisheries restarts to municipal cooperatives.	Face-to-face contact in ports between fishers and prefectural extension officers builds support for trial fishing operations.	Move towards direct consultation with individuals/households on monitoring data requirements.
Municipal	Remaining suspicion among fisheries cooperatives of trustworthiness and competence of TEPCO to release timely information about FDNPP.	Emphasis on 'Iwaki' fisheries (e.g. *Joban-Mono*) and local environmental characteristics breaks name association with Fukushima		*Not raised in data.*	Fisheries cooperatives in Iwaki screen to stricter standards (50 Bq/kg) than national (100 Bq/kg).
Local	*Not raised in data.*	Fishers/groups of fishers operating out of individual ports collect monitoring data which feeds into Fukushima Prefecture monitoring data prior to trial operations.	Decisions on nature and extent of fishing operations within Iwaki made by fishing cooperatives in individual ports.		'Local experts' (e.g. UmiLabo, Aquamarine Fukushima, Quebec Delta) engaging with citizens on collaborative monitoring or education activities to build understanding
Household / individual	Individual actions by 'citizen activists' (especially via social media) facilitate engagement with national-level actors on radiation data, and transmit nuanced image of Fukushima/Iwaki.	Value of Fukushima Prefecture produce and environment contingent on decisions taken at household level as to safety or otherwise.	Perception of prefectural scientists/cooperative staff as 'citizens' (hence exposed to any risk) as well as employees may help trust-building with fishers and consumers. Also invocation of household scale activities (e.g. smoking) to build dialogue in consultation with fishers.	Motivation/pride/identity of individual citizens as Iwaki consumers led to formation of local groups e.g. UmiLabo.	

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SUPPLEMENTARY MATERIAL

Making sense of complexity in risk governance in post-disaster Fukushima fisheries: a scalar approach: supplementary material

1. Interviews

(a) List of interviewees

Sampling: interviewees sampled through combination of drawing on existing contacts the research team had through previous research; 'snowball' sampling based on contacts given during interviews; and search of online media/news outlets to ensure key sectors related to Iwaki and Fukushima fisheries covered. Recruitment of fishers and cooperative staff through trusted intermediary (Fukushima Prefecture Fisheries Section). Caution exercised to avoid bias by independently setting up interviews with local politicians sceptical of nuclear power and academics at nearby university, in order to solicit opinions of those more distant from the restart of Iwaki fisheries.

Role	**Place of interview (place lived if known)**	**Gender**	**Date**
Fisheries Resources Manager, Fukushima Prefecture	Fukushima Prefecture Fisheries Research Station	Male	July 2014
Senior Researcher, Fukushima Prefecture	Fukushima Prefecture Fisheries Research Station	Male	July 2014
Fisheries Extension Officer, Fukushima Prefecture	Iwaki Coast	Male	July 2014
Market Staff, Iwaki City Fisheries Cooperative	Onahama Fish Market (Yotsukura)	Male	July 2014
Market Staff, Iwaki City Fisheries Cooperative	Onahama Fish Market (Nakanosaku)	Male	July 2014
Fisher (crab)	Onahama Fish Market (Hisanohama)	Male	July 2014
Fisher (crab)	Onahama Fish Market (Yotsukura)	Male	July 2014
Fisher (crab, surf clam, whitebait)	Onahama Fish Market (Hisanohama)	Male	July 2014
Board Member, Iwaki City Fisheries Cooperative	Iwaki Fisheries Building	Male	July 2014
Project Manager, Fukushima Prefecture Federation of Fisheries Cooperative Associations/Onahama Danish Trawl Seines Fisheries Cooperative	Iwaki Fisheries Building	Male	July 2014
Market Staff, Iwaki City Fisheries Cooperative	Fukushima Prefecture Fisheries Research Station (Onahama)	Male	July 2014
Market Staff, Iwaki	Fukushima Prefecture	Male	July 2014

City Fisheries Cooperative	Fisheries Research Station (Onahama)		
Office Staff, Onahama Danish Trawl Seines Fisheries Cooperative	Onahama Fish Market (Onahama)	Female	July 2014
Office Staff, Onahama Danish Trawl Seines Fisheries Cooperative	Onahama Fish Market (Onahama)	Female	July 2014
Office Staff, Iwaki City Fisheries Cooperative	Onahama Fish Market (Ena)	Female	July 2014
Fisher (sea urchin, abalone)	Nakanosaku	Male	July 2014
Fisher (sea urchin, abalone)	Nakanosaku	Female	July 2014
Village chief fisher (sea urchin, abalone)	Usuiso Fisheries Office, Toyoma	Male	July 2014
Office Staff, Iwaki City Fisheries Cooperative	Iwaki Fisheries Building (Kabeya)	Female	July 2014
Office Staff, Iwaki City Fisheries Cooperative	Iwaki Fisheries Building (Uchio)	Male	July 2014
Fisher (whitebait, surf clam)	Iwaki Fisheries Building (Yotsukura)	Male	July 2014
Fisher (flounder, greenling)	Iwaki Fisheries Building (Nakoso)	Male	July 2014
Fisher (crab)	Iwaki Fisheries Building (Ena)	Male	July 2014
Fisher (sea urchin, abalone, whitebait)	Iwaki Fisheries Building (Ena)	Male	July 2014
Fisher (whitebait, surf clams)	Iwaki Fisheries Building (Toyoma)	Male	July 2014
Fisher (abalone)	Iwaki Fisheries Building (Obama)	Male	July 2014
Fisher (whitebait, abalone)	Iwaki Fisheries Building (Ena)	Male	July 2014
Chief fisher (whitebait, sand eel, surf clam)	Iwaki Fisheries Building (Numanouchi)	Male	July 2014
Local politician	Iwaki City Hall	Male	July 2014
Sociology professor	Fukushima City	Male	July 2014
Disaster management professor	Fukushima City	Male	July 2014
Team Leader, Radiation Monitoring Team, Fukushima Prefecture	Fukushima City	Male	July 2014
Research student	Tokyo (Iwaki)	Female	August 2014
Chief Scientist, local aquarium	Onahama	Male	June 2015
Scientist, local aquarium	Onahama	Male	June 2015
Project Manager,	New Onahama Fish	Male	June 2015

Fukushima Prefecture Federation of Fisheries Cooperative Associations/Onahama Danish Trawl Seines Fisheries Cooperative	Market		
Senior Environmental Planner, Iwaki City Environment Section	Iwaki City Hall	Male	March 2016
Environmental Planner, Iwaki City Environment Section	Iwaki City Hall	Male	March 2016
Manager, Iwaki City Fisheries Section	Iwaki City Hall	Male	March 2016
Staff, Iwaki City Fisheries Section	Iwaki City Hall	Female	March 2016

(b) Topic guide (fisher/fisheries cooperative staff interviews)

Interviews narrative in nature, with respondents taking lead and interviewer asking follow-up questions (Mabon and Kawabe, 2015). However, each interview sought to cover the following key areas:

1. Local environment
   a) Where in Iwaki do you live?
   b) What kind of place is it? How would you describe it to me?

2. Fisheries
   a) Tell me when you started fishing - have you always done it?
   b) What kind of fishing do you do - types of fish/techniques?
   c) What sort of boat do you own?
   d) If I were to want to try a typical Iwaki fish, which one would you recommend and why?

3. Trial fisheries
   a) For how long have you been participating in the trial fisheries?
   b) Why did you decide to get involved in trial fishing?
   c) How do you think the trial fisheries have been going so far?
   d) What message should I bring back to Scotland with me about Iwaki fisheries?

(c) Topic guide (expert/stakeholder interviews)

Again, interviews narrative in nature and led by respondents, with interviewers probing further to follow up on points raised. The following questions were therefore developed as a 'guide' for the interview of topics the respondents may wish to talk about, and the interviewers attempted to ensure these were covered during the interview (Mabon and Kawabe, 2015).

1. Fisheries and the marine environment
   a) Tell me about fisheries in Iwaki today - how important is it, what is the current situation, how was it in the past?
   b) What kinds of fish is Iwaki famous for? What is it that has historically made fish from this area so sought after?

2. The nuclear accident
   a) What is the current status of fisheries in Iwaki, and in Fukushima more widely?
   b) In your opinion, how is the radiation situation in the sea off Iwaki and Fukushima?
   c) How do you think the trial fisheries are progressing?
   d) From now on in, what do you think the biggest challenges are for restarting Iwaki fisheries?

3. Information and communication
   a) Where do you get information from about radiation?
   b) What are the hardest things to understand for you?
   c) What is the thing you most want to know?
   d) When you communicate with fishers and/or regular citizens, what is the hardest thing to explain?
   e) What kinds of questions do fishers and/or regular citizens ask you? Which are hardest to answer?

4. Society and culture
   a) What kind of place would you say Iwaki is?
   b) What do you think has changed since the disaster?
   c) What are the major social issues in Iwaki at the moment, both connected to and apart from the disaster?
   d) Apart from radiation, are there any other environmental issues on the coast and in the sea that are becoming an issue at the moment?
   e) What message would you like me to take back from Iwaki to Scotland to tell my colleagues there?

2. **Focus group**

(a) Participant list

Recruitment through intermediary in Fukushima Prefecture Fisheries Section. Focus group held 18 July 2014 in Onahama Fish Market following landing of trial fisheries catch.

Port	Fish caught	Gender	Age
Yotsukura	Sea urchin, abalone	Male	60s
Yotsukura	Sea urchin, abalone	Male	60s
Hisanohama	Sea urchin, abalone	Male	60s
Hisanohama	Sea urchin, abalone	Male	70s
Usuiso (Toyoma)	Sea urchin, abalone	Male	60s
Usuiso (Toyoma)	Sea urchin, abalone	Male	40s
Usuiso (Toyoma)	Sea urchin, abalone	Male	20s
Nakoso	Whitebait	Male	60s

1. The local environment
   a) What kind of place is Iwaki?
   b) Where in Iwaki do you live?
   c) What kinds of differences are there between the ports?

2. Fisheries in Iwaki

a) What kinds of fish are caught?
b) What types and sizes of boats, what fishing techniques?

3. Trial fisheries
a) How long have you been involved in trial fisheries?
b) When did you start and why?
c) How do you think the trial fisheries are progressing so far?

4. Information
a) Who gives you information on radiation?
b) What kinds of things do you find hard to understand?
c) What would you like to know that you don't have an answer to?

3. **Ethnography/participant observation**

For each event attended, narrative field notes written up and where appropriate photographs taken to document events and experiences.

Event	**Location**	**Date**
Landing and screening of trial fishery catch	Onahama Fish Market	July 2014
Landing and analysis of monitoring catch	Fukushima Prefecture Fisheries Research Station, Onahama	July 2014
Monitoring results information meeting (Fukushima Prefecture Fisheries Section and fishers)	Iwaki Fisheries Building	July 2014
Tour of New Onahama Fish Market including screening facilities	New Onahama Fish Market	June 2015
Exhibition detailing effects of accident and monitoring/screening efforts	Aquamarine Fukushima	June 2015
Promotion of fish and seafood to consumers	Iwaki LaLaMew Market	June 2015

4. Documentary analysis

The following documents relating to Iwaki and Fukushima fisheries were consulted, reading in particular for the language and imagery used to describe risks and uncertainties around marine radiation:

Scale	**Sampled institution / individual**	**Title of sampled document and year (in Japanese unless otherwise stated)**	**Source**
National	Japan Fisheries Agency	Information on radioactive matter in marine produce (2015)	http://www.jfa.maff.go.jp/j/press/kakou/pdf/150406-01.pdf
National	Ministry of Environment	Progress on Off-site Cleanup	http://josen.env.go

		and Interim Storage Facility in Japan (in English) (2017)	.jp/en/pdf/progresseet_progress_on_cleanup_efforts.pdf?141022.html
Regional / prefectural	Fukushima Prefecture	Marine seafood (2017)	http://www.pref.fukushima.lg.jp/uploaded/attachment/218392.pdf
Regional / prefectural	Fukushima Prefecture Federation of Fisheries Cooperative Associations	Inspection system (2014)	http://www.fsgyoren.jf-net.ne.jp/siso/buhin/kensa20140827.pdf
Municipal	Iwaki City Fisheries Section	What is Joban-Mono? (2015)	http://misemasu-iwaki.jp/joban/item/A5guidebook-201510.pdf
Municipal	Iwaki City Fisheries Section	Heisei 28: Fisheries in Iwaki City (2016)	http://www.city.iwaki.lg.jp/www/contents/1001000000620/simple/H28iwakisinosuisan.pdf
Local	Iwaki City Fisheries Cooperative – Hisanohama Section Youth Group	For fisheries in the Hisanohama area in the future: area recovery events and efforts to secure support (2015)	https://www.zengyoren.or.jp/ninaite/kouryu/download.php?docid=1038
Local	Iwaki Sea Survey Team UmiLabo	Iwaki Sea Survey Team UmiLabo (n.d.)	http://www.umilabo.jp/
Household / individual	Tatsuta Kazuto	Ichi-Efu: A Worker's Graphic Memoir of the Fukushima Nuclear Plant (Vol. 2). (2015)	Tatsuta, K. 2015. Ichi-Efu: A Worker's Graphic Memoir of the Fukushima Nuclear Plant (Vol. 2). Morning: Tokyo.
Household / individual	Quebec Delta	QD Fukushima – Big Catch	https://quebec-delta-gyogyou.jimdo.com/

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