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## Fisheries in Iwaki after the Fukushima Dai'ichi Nuclear Accident: Lessons for Coastal Management under Conditions of High Uncertainty?

### Journal Item

How to cite:

Mabon, Leslie and Kawabe, Midori (2015). Fisheries in Iwaki after the Fukushima Dai'ichi Nuclear Accident: Lessons for Coastal Management under Conditions of High Uncertainty? Coastal Management, 43(5) pp. 498–518.

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Version: Accepted Manuscript

Link(s) to article on publisher's website:

<http://dx.doi.org/doi:10.1080/08920753.2015.1051425>

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This is the peer reviewed version of the following article: 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, which has been published in final form at <http://dx.doi.org/10.1080/08920753.2015.1051425>.

## **Accepted for publication in Coastal Management**

Title: Fisheries in Iwaki after the Fukushima Dai'ichi nuclear accident: lessons for coastal management under conditions of high uncertainty?

Short title: Fisheries in Iwaki after Fukushima Dai'ichi

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Abstract: This paper evaluates factors driving perception of risk and uncertainty in fisheries in Iwaki City, Fukushima Prefecture, Japan, following the Fukushima Dai'ichi nuclear accident. Particular attention is paid to lessons that may be learned for managing uncertainties and risks in coastal management more generally. The 2011 accident has had profound effects on Fukushima fisheries. Commercial coastal fisheries have been stopped since, and efforts to understand and monitor the effects of marine radioactive contamination on produce from the sea continue. Small-scale trial fisheries have however re-commenced with a view to gradually re-starting Fukushima fisheries over time. Drawing on in-depth interviews, discussion groups and field observations from Iwaki and Fukushima Prefecture more widely, three factors are discussed: the role of trusted local-level points of contact; the value of transparent monitoring and screening that acknowledges remaining limitations and uncertainties; and the importance of taking seriously the cultural dimensions of rapid and potentially irreversible environmental change.

Keywords: coastal fisheries; environmental governance; Fukushima Dai'ichi nuclear accident; risk communication; stakeholder engagement.

### **Statement of originality/exclusivity**

*We hereby confirm that this manuscript has not been published elsewhere, and that it has not been submitted simultaneously for consideration for publication elsewhere.*

### **Acknowledgements**

The research leading to these results was possible due to funding the lead author received from a Japan Foundation Fellowship, and partly by grants from KAKEN 22310029 the second author received. The authors are grateful to Fukushima Prefectural Fisheries Development Office, Fukushima Prefectural Fisheries Research Station, Iwaki City Fisheries Cooperative, and Onahama Danish Trawl Seines Fisheries Cooperative for support in arranging the field work in Iwaki; and to all members of the Iwaki fishing communities and citizens of Fukushima Prefecture who participated in this research.

## 1. Introduction

On 11 March 2011, a magnitude 9.0 earthquake off north-eastern Japan triggered a tsunami reaching up to 40 metres in height and 10 kilometres inland. More than 15,000 people died and significant infrastructural damage occurred (National Geophysical Data Centre, 2012). The earthquake and tsunami disrupted cooling systems at the Fukushima Dai'ichi nuclear power plant (FDNPP), leading to overheating, explosions and radioactive releases into the environment (Yoshida and Kanda, 2012). This resulted in large-scale contamination of the surrounding area, forcing evacuation of over 120,000 people from their homes in Fukushima Prefecture.

70 to 80 percent of emitted radionuclides were deposited over the western North Pacific Ocean (Yoshida and Kanda, 2012). Coastal and offshore waters adjacent to Fukushima Prefecture have been affected by radiation from atmospheric fallout and also from leakage of highly contaminated water into the sea soon after the accident (and subsequent leaks of less contaminated water) (Bailly du Bois et al, 2014). The incident has been assessed as the largest-ever accidental release of radioactive material into the oceans (Buesseler, Aoyama and Fukasawa, 2011), with extent and level of contamination varying across space (Vives i Batlle et al, 2014).

This paper focuses on the effects of the nuclear accident on coastal fisheries in Iwaki in the southern part of Fukushima Prefecture – in particular how risks and uncertainties are conceptualised. After outlining the current fisheries situation and socio-cultural context in Iwaki, we discuss social science understandings of risk and explain our research method. We then explore three aspects driving perception of risk and uncertainty in Iwaki fisheries – trust,

monitoring and screening, and cultural contexts – and conclude by discussing implications of our findings in terms of scholarly thought on managing risk and uncertainty in coastal areas.

## 2. Background and context

### 2.1. Fukushima fisheries post-disaster

The fertility of Fukushima fishing grounds and importance of fisheries to the prefecture (Wada et al, 2013) compound the impacts of the nuclear disaster on coastal communities. Between April 2011 and April 2012, over 40% of fish species were found to exceed the Japanese regulatory limit for caesium of 100 Becquerels per kilogram (Buessler, 2012). These levels of radioactive contamination – and human health risks from consuming highly contaminated produce– resulted in coastal fisheries off Fukushima Prefecture being embargoed (pelagic fishing of skipjack tuna and pacific saury restarted in 2012).

Fisheries governance in Fukushima is divided into two areas – Soma-Futaba in the north, and Iwaki, the focus of this paper, to the south. In June 2012, trial coastal fisheries commenced in Soma-Futaba, and in late 2013 extended to Iwaki (Fukushima Prefecture Federation of Fisheries Cooperative Associations, 2015a). Fisheries researchers working for Fukushima Prefecture and the Fisheries Agency of Japan explain the purpose of these trial fisheries is to resume fishing operations on a small-scale controlled basis in species where radioactive caesium has not been recently detected, gradually expanding target species and areas for trial fisheries based on marine monitoring data (Wada et al, 2013). The trial fisheries also assess acceptance of Fukushima

marine produce in the market, and collect data towards the larger-scale restart of fisheries in the prefecture (Fukushima Prefecture Federation of Fisheries Cooperative Associations, 2015a). For a fuller English-language overview of Fukushima marine radiation and trial fisheries, we direct the reader to the summary produced by the Fisheries Agency of Japan (2015).

The process leading to trial fisheries is as follows. Fukushima Prefecture Fisheries Section – in cooperation with fishers – continually monitors radioactivity levels across fish stocks, sea water and bottom sediment in coastal waters, which are divided into 10 zones (see Figure 1 in Wada et al (2013)). This is titled ‘emergency monitoring’ as prior to the nuclear disaster, such a large release of radioactive material was not imagined. For species in zones where radioactive caesium has not recently been detected during emergency monitoring, trial fisheries are discussed and determined. This discussion procedure has four stages: firstly, face-to-face discussions between fishers and fish brokers over targeted species, fisheries operations, and distribution systems; secondly, consensus-building via the District Trial Fisheries Exploratory Committee; thirdly, consideration of trial fisheries at Fukushima Prefecture Regional Fisheries Rehabilitation Convention (members are representatives of fishers and distributors (including brokers), local government, and several scholars); and finally discussion at the prefectural Representatives of Fisheries Cooperative Conference. Trial fisheries are then carried out for these target species in the designated zones, with management and monitoring of catches conducted by fisheries cooperatives staff – who have been trained by local government fisheries researchers - before produce is passed on for sale (Fukushima Prefecture Federation of Fisheries Cooperative Associations, 2015b). Based on weekly emergency monitoring by prefectural scientists,

additional species may be released for trial fishery operations over time if caesium is not detected – by spring 2015, 58 species had been released (Fisheries Agency of Japan, 2015).

Fishers themselves catch fish not only for trial fisheries, but also for emergency monitoring to support data collected by Fukushima Prefecture's own research vessel. Although started on a voluntary basis after the disaster, fishers are now paid to join the emergency monitoring sampling process. This study observed both the landing of a trial fishery catch and the landing of fish for emergency monitoring.

## 2.2. Iwaki fisheries

Most coastal fishers in Iwaki belong to Iwaki City Fisheries Cooperative, one of two coastal fisheries cooperatives in Iwaki (the other is the Onahama Danish Trawl Seines Fisheries Cooperative). Iwaki City Fisheries Cooperative has six branches in coastal villages (see Figure 1), in addition to a main office at Hisanohama which was destroyed in the 2011 disaster and is now located inland. Coastal fishers are represented in the first instance by cooperative branches in their ports, then by the two fisheries cooperatives of Soma-Futaba and Iwaki City respectively, and then at prefectural level by the Fukushima Prefecture Federation of Fisheries Cooperative Associations – a group governed by fishers and an entity to hold fishing rights for coastal fisheries. Fisheries research in Iwaki is carried out at the local level through the Iwaki branch of the Fukushima Prefecture Fisheries Research Station, which also has a northern branch in Soma. Figure 2 explains the structure of the Iwaki City Fisheries Cooperative and Fukushima Prefecture (i.e. local government) fisheries governance.

Before the disaster, a variety of coastal marine products were caught in the coastal waters of Iwaki, including flatfish, flounder, abalone, sea urchin, surf clam, mackerel, and sardine. The catch - about 4,000 tons annually - was valued at around 1,500 million yen.

### 2.3. Iwaki society

Iwaki - a designated core city with a population of around 300,000 - suffered notable earthquake and tsunami damage, with loss of 293 lives (Iwaki City, 2015). Around 250 fishing vessels, and about 150 fishers' houses, port facilities and fisheries buildings, were lost or destroyed (Iwaki City Fisheries Cooperative, 2011). Reconstruction of physical fisheries infrastructure continues (Onahama Danish Trawl Seines Fisheries Cooperative, 2015). Additionally, management of Iwaki fisheries comes against a wider backdrop of societal change. Kawazoe, Urano and Nozaka (2014) discuss effects in Iwaki post-2011, including decontamination processes, psychological anxiety caused by radioactive contamination, and impacts on produce and tourism from 'harmful rumours' about radiation. It has been suggested that influx of evacuees from closer to the FDNPP has heightened tensions in Iwaki due to perceived differences in levels of compensation received (Saito and Slodkowski, 2014).

Specific to seafood, both Buesseler (2012) and Kawazoe, Urano and Nozaka (2014) suggest public anxiety about Fukushima marine produce remains. Wada et al (2013: 255) believe that fisheries have encouraged distressed fishery workers, and that monitoring marine products from Fukushima may help "prevent harmful rumours in the future". More critically, Kimura and



Katano (2014) express concern at how terms like ‘harmful rumours’ may be used to imply there is no basis for concern over Fukushima produce, and argue divergent interpretations of risk from radioactivity can exist within communities or even households. Understanding the grounds on which people’s sometimes differing assessments of risk and uncertainty may be based is a central concern of this paper.

#### 2.4. Risk, uncertainty and society

Two terms appear in this paper worth clarification: *risk* and *uncertainty*. Among other terms, Wynne (1992a) defines *risk* as when system behaviour is well known, with structured analysis defining chances of different outcomes. Wynne defines *uncertainty* as when system parameters are known, but not the probabilities of different outcomes. For Iwaki fisheries, *risks* may be situations of comparatively good knowledge of system behaviour (e.g. effects of highly radioactive produce on the human body), and *uncertainties* may be elements where understanding of system behaviour is more limited (e.g. precise nature of marine radioactive deposition and uptake by species). Different actors can of course have varying views on how well ‘system properties’ and chances of different outcomes occurring are indeed well understood.

It is also worth acknowledging another distinction. Morris-Suzuki (2014) contrasts *uncertainty* – how scientists understand what cannot be known – with *indeterminacy* – another term deployed by Wynne (1992a), reflecting the difficulty of understanding risks within the messy and complex realities of everyday life. Although Morris-Suzuki makes this point to argue the need for scientists to understand local sources of human anxiety about radiation in Fukushima, her observation of the way risk understanding is intrinsically bound up with people’s wider life

courses is significant. Indeed, both Douglas (1992) and Wynne (1992b) hold that rather than a straightforward cost-benefit analysis, individuals evaluate risks in relation to issues such as conceptualisations of fairness and ideas about the kind of world in which they wish to live.

Understanding the contextual factors influencing public and stakeholder perceptions of risk would thus seem important if management of risks in coastal areas is to be responsive to people's needs. There is awareness of such complexity in coastal management thinking. For example, Leschine, Lind and Scharma (2003) suggest acknowledgment of wider social, cultural and economic dimensions of risk led to concurrent acceptance of techno-scientific risk assessment for contaminated sediments in Puget Sound, USA. Kempton and Falk (2000) note that members of the public in Maryland, USA understood *pfisteria piscicida* (a fish-attacking microscopic marine organism) through 'cultural models', with perceptions of risks becoming over-stated if the cultural models did not match well to the actual nature of *pfisteria*. More widely, Bell (2009: 18) holds that coastal managers are "faced with many uncertainties and challenges, threats and opportunities, information needs, and panoplies of multiple resources with particular management requirements", and Miles (1999) points to the difficulties ongoing unknowns in ocean dynamics raise for ocean governance in response to climate change. This demonstrates that publics and stakeholders develop perceptions of risks in the marine environment through their own understandings and interpretations, and that decisions on uncertainties may have to be made that balance these potentially differing conceptualisations. Our study aims to contribute to this body of thought by assessing factors driving risk perception after a large-scale marine contamination event like that in Fukushima, where there is continuing uncertainty and potential

for effects on humans. In Section 5 we return to extant literature to offer suggestions for management of coastal areas under conditions of significant uncertainty.

### 3. Method

Techno-scientific risks may therefore be understood and interpreted through broader cultural contexts (Kempton and Falk, 2000; Leschine, Lind and Sharma, 2003). It was thus important to develop a methodology that allowed participants to explain how they thought of risk and uncertainty on their own terms. As such, a qualitative approach was adopted that gave participants freedom to raise issues and topics that they themselves felt were important (rather than those the researchers assumed were significant), and also permitted the researchers flexibility to follow up on issues emerging over the course of the research.

Empirical fieldwork was carried out in Iwaki in July 2014, with follow-up research in Fukushima City later the same month. 32 open-ended semi-structured interviews were conducted: 13 fishers from Iwaki ports (fishers from Hisanohama, Yotsukura, Numanouchi, Toyoma, Ena, Onahama, Obama and Nakoso were interviewed) catching a range of fish landed in the area (fish caught by interviewees included abalone, crab, flounder, greenling, sea urchin, sand lance, surf clam and whitebait); 13 staff from cooperatives involved in trial fisheries (Iwaki City Fisheries Cooperative, Onahama Danish Trawl Seines Fisheries Cooperative, and Fukushima Prefecture Federation of Fisheries Cooperative Associations staff were interviewed); 3 researchers from the Fukushima Prefectural Fisheries Research Station; a radiation monitoring specialist from Fukushima's prefecture-level team; a local politician; and 2 university professors specializing in the social dimensions of the aftermath of the FDNPP accident. A facilitated group discussion

was held with 8 fishers from ports participating in the trial fisheries (fishers from Hisanohama, Yotsukura, Toyoma, and Nakoso catching abalone, sea urchin and whitebait participated in the discussion). Participant observation was also carried out at the landings of 2 catches (a trial fishery catch at Onahama Fish Market and an emergency monitoring catch at Onahama Fisheries Research Station) and 1 information meeting at the fisheries building in Iwaki City, with the researchers observing interaction between the fishers and research officers, speaking informally to participants, and writing up field notes later. Recruitment of fishers, cooperative staff and prefectural researchers was undertaken through a prefectural fisheries contact (see below), and although the purpose of this study is not to ‘promote’ Iwaki fisheries or comment on the safety of otherwise of the area’s produce, further interviews were arranged independently with stakeholders in Fukushima Prefecture (e.g. politicians concerned about effects of the nuclear disaster, university researchers) to give additional perspectives on the marine radiation situation.

Whilst this may seem a comparatively small sample, Chase (2005: 667) notes “any narrative is significant because it embodies – and gives us insight into – what is possible and intelligible within a specific social context.” As the aim of this paper is to draw wider lessons for coastal managers on what drives perception of risk and uncertainty from the case of Iwaki fisheries, working intensively with a smaller number of participants possessing in-depth knowledge of the fisheries situation in Fukushima post-accident was considered to offer greater analytical purchase than working extensively but in less depth with a larger sample. Participants were targeted who would be able to explain the contexts of the accident and fisheries in considerable detail, thereby giving an overview of the fisheries situation and also insight into potentially complex contextual factors informing understanding of risk and uncertainty. Reflecting on similar research with

communities living close to nuclear power plants in the United Kingdom (UK), Henwood et al (2010) argue that being attentive to the complex ways in which people come to understand risk issues is part of an appropriate research strategy for studying the understanding and management of environmental and socio-technical risk. With Henwood et al (2010) continuing that qualitative narrative-based research of this kind produces extremely rich data, and bearing in mind the limited amount of previous English-language research into the human dimensions of marine contamination in Fukushima, it was thus considered important to construct a sample size that let the researchers analyse each piece of data in sufficient depth and build as full an understanding as possible of the societal factors influencing perception of marine radioactive contamination. This drive to build as full an understanding as possible of how risk and uncertainty are understood in specific social contexts also informed the decision to focus on Iwaki fisheries within Fukushima, however issues currently facing both Iwaki and Soma fisheries appear broadly similar (e.g. Asahi Shimbun, 2015; Kyodo News, 2015).

Although in-depth narratives spanning a range of perspectives were attained, the sample size and nature was influenced further by ethical considerations. The societal impacts of the March 2011 triple disaster are well documented, and particularly around fisheries there may be issues of loss of livelihood and identity. Caution thus had to be exercised not to make participants feel as if they were being ‘observed’ as part of a disinterested scientific study – especially as one of the research team was from overseas and had not previously visited Fukushima. Equally, bearing in mind the risk of certain groups becoming ‘over-researched’ (Clark, 2008), it was vital to acknowledge the possibility of fishers and fisheries cooperative representatives in particular having already been exposed to significant media attention following the FDNPP accident, and

to show sensitivity to the time commitments and emotional pressures discussing an issue like this requires. The support of the Fukushima Prefectural Fisheries Research Station, who enjoy a positive and long-standing relationship with the Iwaki fishing communities (see Section 4.1.), in recruiting participating fishers, fisheries cooperative representatives and other prefectural researchers therefore ensured that participants were fully briefed as to the nature of the research beforehand and able to give consent through a trusted intermediary separate from the research team. Consent was re-confirmed by the researchers prior to commencement of interviews. Participants recruited independently of the fisheries research station (e.g. local government officials from a different branch, university researchers) were informed as to the nature of the research prior to commencement of interviews, and consent to record the discussion was sought.

In sum, a research methodology and sampling strategy was adopted that would (a) give analytical purchase on factors driving perception of risk in Iwaki fisheries through intensive engagement with people who had a deep and embodied knowledge of fisheries in the area; yet (b) show sensitivity to the ethical challenges of doing research around a value- and emotion-laden topic with significant implications for those involved. However, we reflect on potential limitations of this methodology in Section 5.

All interviews were conducted in Japanese (one author is proficient in Japanese to a high level, the other is a native speaker) and audio-recorded. Topics and themes arising from each interview were then identified, and cross-checked with another native Japanese speaker for accuracy. Overarching themes were identified by allowing concepts and analytical categories to arise from the data itself, the themes emerging through an iterative process of reading and analysis. This involved close listening to the audio recordings, grouping the concepts identified from each

interview, and then re-listening to the recordings to ensure the key groupings reflected the content of the data. These were then further checked and refined against the field notes to ensure commonality between the researcher observations and the ‘raw’ interview data. This process of iterative analysis from the data itself is widely used in social science research into issues of energy and the environment (e.g. Kempton et al, 2005; Parkhill, Butler and Pidgeon, 2014), and offers the advantage of responding to the concerns of Henwood et al (2010) on the complexities of eliciting people’s relationships to risk by giving the researcher flexibility to start with issues research participants themselves identify as being important, rather than imposing their own interpretative frameworks on the data. The three most clearly emerging themes – trust; monitoring and screening; and cultural dimensions – are discussed below. Points are supported with extracts from the in-depth interviews, and/or reference to field observations for additional contextual information.

#### 4. Results and analysis

##### 4.1. Trust in local-level actors

The first theme discussed is trust – in particular trust between fishers, fisheries cooperative officials and administrators, and research scientists employed by the local (i.e. Fukushima Prefecture) government. Information from researchers working for the prefecture was constantly foregrounded by Iwaki fishers and fisheries cooperative managers, as demonstrated by a fisheries cooperative project leader (who is also an Onahama Danish Trawl Seines Fisheries Cooperative board member) when asked in a paired interview how and from whom fishers receive information about radiation in marine produce:

*Project leader: Every month we have a meeting about the trial fisheries. Somebody comes from the prefectural fisheries research station to talk to us and explain the results of the previous month's monitoring, and regular fishers are invited to this as well. We share news about where high levels of radiation have been found, so that even ordinary fishers can now understand it.*

[...]

*Interviewer: So who gives you information, where does your information from?*

*Project leader: It's the prefectural fisheries research station, isn't it? We also get information from the Ministry of Environment, and various other government departments who are looking at things.*

(interview with Fukushima Federation of Fisheries Cooperative Associations project leader and Iwaki City Fisheries Cooperative board member, Iwaki fisheries building)

The process through which the prefectural fisheries research station conveys monitoring results is discussed in detail before central government data is even mentioned. This hints at the significance of data collected locally (much of it by coastal fishers themselves) and analysed at the prefectural fisheries research station. Both this interviewee and interviewed prefectural fisheries officers explained central government researchers do visit Fukushima monthly to brief the fisheries cooperatives (and also work collaboratively with prefectural level researchers on monitoring, e.g. Wada et al (2013)). However, even though general consistency across data from different sources was acknowledged, information from the prefectural level appears to be of



great value. By contrast, when asked later what other knowledge they would find useful, the fisheries cooperative managers expressed concern over signals received from FDNPP operator Tokyo Electric Power Company (TEPCO) – who provide data on radioactivity levels in the sea immediately adjacent to FDNPP:

*Board member: The thing that worries me is inside the nuclear power station, in case there is some kind of contamination or not. We don't know that, so that is a worry [...]*

*Project leader: The monitoring says everything is fine, but inside the nuclear plant there are various issues, tanks are leaking, we don't know if there are still leaks and if they will leak into the sea or not. Both us and the consumers worry if that is actually happening.*

(interview with Fukushima Federation of Fisheries Cooperative Associations project leader and Iwaki City Fisheries Cooperative board member, Iwaki fisheries building)

The implication is that TEPCO monitoring data is treated with some suspicion, with processes inside the plant seen as distant and off-limits to both fishers and consumers. Indeed, in early 2015 concerns over leakage into the sea – fueled by two separate incidents where observed radioactivity levels rose in drains at the plant – led Fukushima fisheries cooperatives to criticise communication from TEPCO and claim that trust between the cooperatives and TEPCO had collapsed (Kyodo News, 2015).

For fishers, then, trustworthiness of the data source seems important in guiding perception of risks associated with post-disaster fisheries. Mode of engagement may help to explain why these differences in trust occur. Fishers' preference for small-scale, informal engagement has been noted in the UK (Gray, Haggett and Bell, 2005; Roberts and Jones, 2013), and local government researchers in Iwaki likewise seem well attuned to fishers' engagement preferences. As one prefectural fisheries officer explained when asked how he and his colleagues communicate with fishers:

*There are meetings, which is a good occasion to talk to them. Additionally we also go out to the fishing villages just to see who is there and speak to them informally, do ad-hoc interviews, talk to them individually and give them suggestions for what to do. We listen if they have any concerns or suggestions about how to continue the trial fisheries as well.*

(interview with Fukushima Prefecture fisheries officer, Iwaki coast)

Ethnographic observation supports this officer's claim of emphasising informal engagement. When fishers bring catches in to the research station for emergency monitoring, they are given a sheet with the previous week's monitoring results – providing an opportunity to discuss and clarify the results one-to-one with prefecture researchers. Prefectural researchers present monitoring results to fishers at regular closed meetings in Iwaki fisheries building – fishers ask few questions during formal proceedings, but researchers remain after the formal meeting is brought to a close to respond to fishers' questions about radiation levels and results on an individual basis. There is a marked difference between the atmosphere observed in monitoring meetings between fishers and prefectural scientists – where informal post-meeting discussion is

punctuated with occasional light-hearted banter between the groups – and reports of angry and confrontational meetings between fishers and TEPCO representatives over continuing contamination issues at FDNPP (Asahi Shimbun, 2015).

The background and motivations of individual people involved in monitoring may also influence the perceived trustworthiness the local fisheries research station's outputs. Another researcher employed by Fukushima Prefecture explained the purpose of fisheries research thus:

*[T]here were abalone and sole, because they were quite expensive fish that could make a lot of money we released them into the sea and observed how they made their habitat, grew and developed, and thought about how they could be fished. The purpose of doing all of this research was to find out how the local fishers can make money. Of course after the nuclear accident everything shifted towards radiation monitoring, but still our primary objective is to find out the most efficient way for fishers to fish in the sea and to earn a living.*

(interview with Fukushima Prefecture fisheries researcher, Onahama fisheries research station)

Engagement between fishers and fisheries researchers has thus been sustained since well before the nuclear accident. As Fukushima operates a lifetime employment system for government employees, many current research team leaders have several decades' experience working with Iwaki coastal fisheries, hence individual people within the research station are well known to fishers. Prefectural researchers attend landings of emergency monitoring and also trial fishery catches, getting physically involved in lifting crates off fishers' trucks, washing fish catches, and cleaning out barrels to return to the fishers. Prefectural fisheries staff may thus be perceived as

being personally and physically invested in the outcomes of monitoring and trials. This idea of a personal and physical stake in Iwaki fisheries was similarly borne out in interviews with cooperative employees, virtually all of whom had lived most of their lives within Iwaki:

*I was born in Izumi and now live in Kabeya [...] I moved away from Izumi when I was small, to Onahama and then from there to Taira. Then I went to Tokyo when I was a student, then came back to Taira again, got married, and that's my situation now.*

*I was born in Iwaki and still live here [...] The marine produce, right, the reputation of the produce from the sea has been damaged, it's been subjected to a lot of scrutiny by the country.*

*I'm raising children at the moment, so it's a little worrying, I don't let them eat the fish yet. Compared to before the earthquake and explosion, I don't feed fish to my children at the moment, but if we were able to return to how things were before then I would definitely let them eat the fish.*

(interviews with Iwaki City Fisheries Cooperative staff, Iwaki fisheries building and Onahama fisheries research station - places mentioned are, apart from Tokyo, towns and villages in Iwaki)

These extracts reinforce the above point about people working 'locally' – either for the prefecture or managing the fisheries cooperatives - having personal interest in the progress of trial fisheries. Rather than being detached governors, scientists or businesspeople coming from afar to pass judgment on Iwaki fisheries, cooperative administrators and prefectural researchers are perhaps viewed simultaneously as decision-makers and 'citizens' with a personal stake in the

progress of trial fisheries. As the last quote demonstrates, this personal interest need not be restoring pride and trust in Iwaki produce, but could just as equally be better understanding the radiation situation for the safety of one's own family. This notion of local-level civil servants and fisheries managers as Iwaki citizens may go some way to explaining why the Fukushima Prefecture fisheries office, fisheries cooperative management, and fishers themselves appear to have conditions of trust for discussing data on risk and uncertainty.

#### 4.2. Monitoring and screening

Closely related to trust is transparency and honesty around monitoring and screening. The risk management studies concept of 'resilience' reflects the importance of monitoring and screening – where 'success' is the ability of organisations, groups and individuals to anticipate the complexity of the real world before failures and harm occur (Hollnagel, Woods and Leveson, 2006). For post-disaster Iwaki fisheries, successful monitoring and screening entails avoiding 'harm' to consumers from the 'failure' to identify and stop contaminated marine produce being passed on for human consumption. For participants in this study, sensitivity to complexity appeared especially important to the perceived credibility of assessments of risk based on data about radioactivity.

Particularly relevant are the additional complexities from measuring radioactivity in a marine environment, described by one fisheries research officer when pressed on the differences between onshore (e.g. rice, peaches) and marine produce:

*The problem is, there is no conveyer belt for fish. Rice doesn't move about once it has been planted, so if you sample one part of a field of rice and it's okay you can get a good idea of the general status of that batch of rice. But fish are all mixed up, so just because one fish has a low level of radiation doesn't mean that the fish next to it will be the same.*

(interview with Fukushima Prefecture fisheries officer, Iwaki coast)

Fishers picked up on these challenges of monitoring at sea. In group discussion they queried the simple binary between 'safe' and 'unsafe' depending on which side of the government-imposed limit of 100 Becquerels per kilogram for radioactive caesium levels fish were measured, and problematised the geographical limitation of the fishing embargo:

*Fisher 3: We're told that over a hundred Becquerels is no good, we can understand that fine. But often when the experts do the measurements and give us the data, we see fifty Becquerels coming up a lot. We see sevens and nines as well, and we don't know what that means. If over a hundred Becquerels is no good, then what does fifty Becquerels mean?*

*Fisher 2: Fukushima Prefecture's here and Ibaraki Prefecture's here [makes gesture with hands]. There are low mountains between them, and as soon as people get ten, twenty metres into Ibaraki they think it's safe! But the roads run across both prefectures, the water from the sea and the rivers mixes, so we just can't think that one place is safe and the other isn't like that, can we? [...] The water comes whoosh, from the north and further down the coast, other water comes up from the south. The fish swim about as well and move towards the warmer currents, so how can we say Fukushima's fish are no good but Ibaraki's are fine? It's a big problem, it's not consistent.*

(group discussion with Iwaki fishers, Onahama fish market)

Ibaraki Prefecture to the south does in fact monitor around thirty species weekly (Ibaraki Prefectural Fisheries Administration, 2015). Nonetheless, frustration at varying conceptualisations of the safety of fish depending on whether or not they are landed at Fukushima ports is clear. Equally, the first fisher's questioning of what a reading of 50 Becquerels measured in a fish actually means, and the second fisher's anxiety over perceived differences in monitoring regimes across space, may also reflect wider concerns about whether national government-imposed strategies to manage radiation from marine produce are sufficiently attuned to uncertainties associated with marine environments or prolonged exposure to low-level radiation.

Although interviewed fishers and fisheries cooperative staff expressed desire to eventually restart full-scale fisheries, practical experience of factors like ocean currents made them aware of how assurances over the safety of Fukushima marine produce could be open to challenge. Both the fisheries cooperatives and the prefectural research station thus invest significant effort in making visible and transparent the *processes* undertaken to ensure fish passed on for sale are not contaminated, extending down to the traceability of particular batches of fish as outlined by a Fukushima Federation of Fisheries Cooperative Associations project leader:

*When a trial fishery catch is landed at the market and the radiation level is determined to be safe, those fish are released to be packed into boxes. The fish are not labelled individually, but our*

*rule is that an agent puts a sticker on the box to say that the fish in it are safe. The agent then goes and sells that fish on to another market.*

(interview with Fukushima Federation of Fisheries Cooperative Associations project leader and Iwaki City Fisheries Cooperative board member, Iwaki fisheries building)

More than merely demarcating that fish are ‘safe’, seals also make visible the systematic and continuing radiation screening of species released for sale via trial fisheries. Results of trial fisheries screening and explanation of the monitoring process are publicly available online (Fukushima Prefecture Federation of Fisheries Cooperative Associations, 2015a), as is the data from emergency fish stock monitoring (Fukushima Prefecture, 2015a) – prefecture researchers explained that ‘bad news’ like high instances of radioactivity are equally included in this emergency monitoring data. Yet even taking the above into account, some fishers still did not feel traceability stretched far enough - as in the following interchange:

*Fisher 1: The trial fisheries are very important, but it doesn't matter if someone has said the fish is safe or not if nobody buys it, does it? We are very busy fishing and concentrating on the trial fisheries, but we don't know if people are buying the fish.*

*Fisher 2: We get told the price the fish from the trials sell at, but we don't know if people are actually buying it and eating it or not.*

*Fisher 1: There are people that are wanting to eat the fish, but even then they don't know how the fish get to the market, where they can buy it from and whether they can eat it or not.*



(group discussion with Iwaki fishers, Onahama fish market)

One fisher at least wants ‘traceability’ of their catches to go beyond the selling agent, as described above, and extend so end consumers know better where fish have come from. This and the other fisher’s comments about not knowing whether or not members of the public ultimately eat their fisheries produce indicate a perceived need for more clarity in the processes through which fish that have been passed as safe then make their way to consumers, and also to the need for such information to find its way back to the fishers themselves.

All of the above indicates that blanket assurances of safety – or superficial attempts at monitoring – may be treated with scepticism. Further, comments on the limitations of national government regulation and the need to extend traceability demonstrate that stakeholders like fishers with intimate knowledge of natural processes can be well attuned to working within uncertainties, and may even offer suggestions as to how to improve monitoring or screening regimes. It is also worth remembering, however, that comprehensive and transparent radiation measurement may only be of value if the institution responsible is considered competent or trustworthy. Consider the thoughts of a professor specializing in regional rejuvenation, when asked about restoration of trust in Fukushima produce:

*Recently, for example in the tomato section, next to the tomatoes there’s something stuck up that tells you who grew the tomatoes. Their name is written on the sign and there’s also a photo of the farmer’s face, if you know who has grown the produce then you can feel more reassured [...] Since the disaster more and more local produce is starting to appear in the supermarkets again*

*after monitoring, everyone has become much more aware - so if you don't monitor the produce strictly then you just won't be able to sell it.*

(interview with professor, Fukushima City)

Whilst the example here is tomatoes as opposed to marine produce, the centrality of trust to effective monitoring and screening is apparent. In addition to the 'hard science' results, information is provided with the apparent aim of instilling trust in those producing the goods and carrying out radiation screening – as evidenced by the photographs of 'ordinary' farmers and the undertaking of radiation assessment by supermarkets as a matter of course. Wynne (1992b) explains that when publics are unable to assess risks themselves they assess the institutions taking the risks on their behalf, and through both screening seals on fish packaging and supermarket signage showing farmers' faces, the aim appears to be to demonstrate the trustworthiness and competence of those selling the produce and conveying radiation screening results. Linking back to Section 4.1 and the differing trust fishers held in prefectural scientists versus centrally-managed TEPCO, the visibility of 'ordinary' farmers' and fishers' faces (see promotional film produced by Miseruka Iwaki City, 2014) may also seek to imply that those benefiting from re-starting sales of Fukushima produce are locally-based small-scale producers with a personal relationship to Fukushima as opposed to distant corporations with a purely financial stake in the recovery of the area. It is such cultural dimensions that form the third part of our analysis.

#### 4.3. Cultural dimensions of energy and environmental change

Participants broadly acknowledged that whilst stringent and trustworthy measurement of radioactivity was crucial, the safe and gradual restart of Iwaki fisheries ultimately depended on a population – particularly locally – willing to buy and consume produce caught in Fukushima waters. Alongside recognition of the complexity of natural systems and associated challenges for monitoring marine radioactivity, there was also ample illustration of complexity in the interplay between risks from radioactivity and wider socio-cultural factors.

Fishers, cooperative managers and prefectural researchers all mentioned a divide in Iwaki between people who were enthusiastic about eating locally-caught fish and helping to rejuvenate the area's fisheries, and those who still did not want to eat produce even in light of information about monitoring and screening. When asked why they thought people still chose not to eat Iwaki fish, interviewees tended to suggest that some - especially those with young children – remained concerned about potential health effects from Fukushima produce, even though screening had been undertaken. This illustrates a key challenge for Iwaki fisheries going forwards – even if data and information on radioactivity is provided to allow citizens to make their own informed choice as to whether or not to consume Iwaki fish, it may still be the case that not everyone agrees on what is an 'acceptable' level of radioactivity or risk. Differing interpretations as to the safety or otherwise of Fukushima produce have been observed within communities and even families (Kimura and Katano, 2014). Such divisions also highlight the difficulty when assessing risk perception of treating 'consumers' or 'the public' as a homogenous unit.

This divide within Iwaki, whilst not acrimonious, illustrates how an event on the magnitude of the FDNPP accident may accentuate existing differences in risk perception and change the cultural makeup of a community. Restrictions on fisheries and the sale of marine produce have also changed practices previously integral to the community. For instance, when asked about the reappearance of Iwaki fish in supermarkets after the commencement of trial fisheries, staff at one fish market admitted that they were unaccustomed to buying fish from supermarkets:

*We never had a habit of buying fish in Onahama. My husband worked on the sea as well, and when the boats came in you would go and help land the catch and you would either be given a fish or someone would share one with you. But since the nuclear accident, we have had to start buying fish from the supermarket.*

(interview with administrator, Onahama fish market)

Fisheries are central not only to the economies of coastal towns in Fukushima Prefecture, but also to the culture and daily life of such places. An indirect consequence of the post-disaster fishing embargo is thus the stoppage of some daily practices associated with fisheries and a change from a society still partly based on informal exchange of food produce in return for assistance to one based much more heavily on the purchasing of fish from large retailers through money. Given the points in Sections 4.1 and 4.2 about the significance of face-to-face contact and trust in facilitating discussion on the results of fisheries monitoring, the loss of opportunities for interpersonal and informal contact may have longer-term implications for re-starting fisheries in Iwaki.

A further illustration of the perhaps unforeseen effects of the nuclear accident on culture and interpersonal relations was provided by a local politician, who responded to a question on the effects of the accident on fishing communities with an example at the personal level:

*Because the fishers are not out in their boats any more, moving their bodies and working, they are getting fat! Everyone is commenting on this. Before, among the fishers there were lots of short-tempered people, but now they have all become placid. They used to be very competitive, trying to land the most fish, their wives would boast about who had caught the most. That has all stopped now. Their eyes have changed too, the shine has gone out of their eyes.*

(interview with local politician, Iwaki City Hall)

Although somewhat anecdotal in nature, this point nonetheless shows how far-reaching the social effects of large-scale environmental change like the FDNPP disaster can be. Whilst fishers do receive financial recompense from TEPCO for effects on fisheries resulting from the nuclear accident (Nuclear Damage Compensation Facilitation Corporation, 2011), being out at sea fishing has additional values and benefits that are perhaps harder to quantify and redress. Beside the physical health benefits of a job requiring significant manual inputs and energy expenditure, the politician suggests the practice of going out fishing shapes the very personalities of the people involved. Losing the ability to participate in this practice thus changes both the nature of people in the community and the way they relate to one another. Understanding how exactly sudden large-scale long-term environmental change can affect the culture of coastal communities – and what measures can be taken to minimize the effects of this change – would seem to be as important as providing financial recompense for any immediate economic effects.

It is also important to note the cultural heterogeneity *within* an administrative district like Iwaki. Fishers felt place name association with the nuclear accident may make consumers cautious about eating ‘Fukushima’ fish, but pointed out the great differences that existed within Iwaki – and in turn Fukushima – fisheries, each port (see Figure 1) having its own character in terms of the types and sizes of boat used and fish caught. Interviewed fishers identified strongly with particular ports rather than Iwaki as an overarching entity, and also with the fish they landed, which varied significantly from port to port. The breadth of answers offered makes this worth quoting at length:

*Interviewer 2: We would like to know where in Iwaki you are all from.*

*Fisher 1: Yotsukura and Hisanohama*

*Fisher 2: Hisonahma is the furthest in the north, then Yotsukura*

*Fisher 3: Usuiso*

*Fisher 4: Usuiso*

*Fisher 5: Usuiso*

*Interviewer 1: It’s the first time I’ve heard of it, sorry! [everyone laughs] Is it in the north or south?*

*Fisher 4: The middle*

*Fisher 5: Yes, in the middle*

*Interviewer 2: Are you all from Usuiso?*

*Fisher 6: Nakoso. Nakoso is on the border with Ibaraki.*

[...]

*Interviewer: So there are lots of different fishing ports in Iwaki. What kind of fish do you all catch?*

*Fisher 2: Sea urchin and abalone*

*Fisher 1: Sea urchin and abalone*

*Interviewer: What about in the south, do you catch sea urchin and abalone too?*

*Fisher 6: Whitebait, I catch whitebait.*

[...]

*Fisher 4: Usuiso is sea urchin and abalone. From the middle up to places in the north like Hisanohama there is a lot of sea urchin and abalone, isn't there?*

(group discussion with Iwaki fishers, Onahama fish market – Usuiso is a village between Numanouchi and Toyoma ports)

Noteworthy here is the variety that exists within an administrative district like Iwaki City, and the fact that fishers may identify themselves at a smaller spatial scale (i.e. the level of individual villages) than the district as a whole. Interviewees explained participation in trial fisheries has rolled out across Iwaki at different speeds depending on the port in question, with fishers in some villages getting involved earlier and others joining in later on as cooperative branches agree to participate. This is also contingent on the kinds of fish caught - different species have been released for trial fishing operations at different speeds depending on observed levels of radioactivity, some remaining off-limits whilst others gradually return to markets. All of this illustrates the heterogeneity of experience – and thus potential for different perceptions of exposure to risk – that can exist within administrative units, and the challenge this raises for planning under conditions of high uncertainty that shows sensitivity to the differing experiences

of risk that may exist simultaneously. Equally, however, emphasising the environmental and cultural heterogeneity that exists within Fukushima fisheries may offer a means of illustrating that experiences of the disaster – whilst severe - do vary across space and thus help to move beyond perception of all Fukushima marine produce as ‘tainted’.

## 5. Discussion

The causes and immediate effects of the Fukushima nuclear accident are clearly extreme. However, the resultant social effects on coastal communities are far from unique. Ongoing scientific uncertainty over space and time, profound implications for citizens’ identities and sense of being, and varying perceptions of risk among actors are common to many environmental issues facing coastal (and indeed inland) areas. We therefore reflect on what study of Iwaki fisheries post-Fukushima accident may add to current coastal management risk and uncertainty thinking.

First, the role of trust under significant risk and uncertainty. There is good awareness (e.g. Leschine, Lind and Scharma, 2003; Kempton and Falk, 2000) that effectively managing situations involving risks in coastal areas requires sensitivity to broader socio-cultural contexts surrounding techno-scientific risk assessments. The Iwaki fisheries case emphasises the importance of trust in informing perception of information about risk, and in opening up space to question or challenge assessments of risk. In Iwaki, local level civil servants and local/regional fisheries cooperative representatives appeared the most trusted information source for fishers on marine radioactivity, and offered a conduit for fishers to air their own concerns or suggestions about radioactivity monitoring.



This trust may be facilitated by the informal interaction and long relationship prefectural scientists have with fishers (starting many years before the disaster), and by perception of prefectural government and cooperative administrators as ‘locals’ with a personal stake in post-disaster Iwaki fisheries. Considering the difference in how fisheries cooperative representatives discussed prefectural researchers compared to TEPCO, local fisheries researchers may also happen to be viewed as distinct and separate from the entity causing the disaster. Working with evacuated communities inland in Fukushima, Sato (2014) notes similar frustrations with national government and energy companies, suggesting local governments offer a pathway for engagement on management post-nuclear disaster. Evaluating relationships between stakeholders like fishers and their most immediate points of contact with ‘government’ could help to better anticipate where demands and pressures may be placed if/when coastal stakeholders claim exposure to risks from energy infrastructure, marine pollution or climate change.

Second, relating to trust, is transparency and honesty when dealing with uncertainties. It is already acknowledged that uncertainty often comes into coastal management decisions (Bell, 2009) and that fully understanding natural systems or future human behaviour may be difficult (Miles, 1999). This is true for Iwaki fisheries too, where we see the importance of coastal ‘managers’ being open and honest about how they form understandings of risks, and about limitations to their knowledge. In coastal settings, flows of fish and water across boundaries add additional complexity to the already challenging task of understanding radioactive contamination across space and time. Indeed, in addition to understanding how radiation could contaminate marine life and being aware of processes for measuring radioactivity in fish, Iwaki fishers

pointed out perceived weaknesses and limitations in extant monitoring and screening (such as possible regional regime differences), and asked sophisticated questions about risks of low-level radioactivity.

Claims that produce or living environments are 100% safe will thus likely be scrutinized and met with scepticism or even hostility. Researchers and decision-makers should therefore openly acknowledge where uncertainties remain, and explain where limitations of monitoring lie. Kimura and Katano (2014) similarly find with organic farmers in Fukushima that rather than blanket assurances of safety, acknowledging further research and information needs, communicating honestly about radiation, and cultivating understanding with consumers of challenges faced offers a more sensitive pathway to restoring consumer faith. The Iwaki fisheries approach of being clear about monitoring processes and openly sharing results (including ‘bad news’ findings), may thus be effective in allowing publics and stakeholders to assess risks for themselves. However, rigorous measurement may only garner support if conducting institutions or individuals (and indeed the people possibly gaining financially from actions taken based on monitoring and screening results) are perceived as trustworthy. The difficulty of overcoming differing individual perceptions of ‘acceptable’ risk also remains.

Third is the need to build as full a sense as possible of what is actually at risk from marine radioactive contamination – that is, how large-scale environmental change may disrupt coastal communities’ cultural values. Consequences of marine pollution – such as perception of produce as ‘tainted’ – cannot always be valued in human markets (Grigalunas et al, 1998). Coastal communities’ perception of environmental change can relate to the sense of ownership they feel

for a place or the effect on meaningful sea-related traditions (Kempton et al, 2005). Wada et al (2013) concede that complete restoration of Fukushima fisheries will be difficult, so the case of fishing in Iwaki may give insight into effects on stakeholders like fishers – and the communities they live in – subjected to potentially irreversible environmental change. In Iwaki, fishing was imagined not only as income and employment, but also as an activity that facilitated everyday interaction and shaped the identities of places and the people within them. The post-accident fisheries embargo has not only had economic implications, but also consequences for relationships between citizens. Whilst financial losses stemming from the nuclear accident appear to be (at least partly) compensated, providing recompense for negatively affecting culturally meaningful practices may be more challenging. Planning around environmental change in coastal communities thus ought to allow room for understanding on a case-by-case basis how the marine environment shapes social relations (especially in day-to-day living), and how communities may respond if environmental change threatens such relations and practices. Equally, emphasising socio-cultural differences *within* administrative units can demonstrate the heterogeneity of ways marine pollution events are experienced, in turn perhaps helping to overcome negative perception of produce via place name association.

It is also important to acknowledge limitations of this work, and suggest directions for further research. This is a focused and intensive study aiming for deep understanding of complexities in risk perception following major marine contamination, which we believe carries lessons for management of risk and uncertainty in coastal areas as outlined above. However, to allow in-depth engagement the emphasis has been on fishers themselves and on the process of locally monitoring radioactivity in marine produce. Further work may assess reasons why coastal

citizens do or do not eat Fukushima marine produce (given the distressing nature of the 2011 disaster, this would require ethical consideration). Engagement or interviews with national government and/or TEPCO marine researchers may further develop understanding of the relationships between the various actors by allowing these national-level actors to explain how they see their relationship with Fukushima fishers. Although issues affecting Soma and Iwaki fisheries appear similar, comparative research with Soma fishers may have value in identifying and explaining subtle differences in risk perception. Finally, whilst prefectural scientists and local cooperatives may offer fishers, stakeholders and citizens information on marine radiation perceived as trustworthy, they cannot control the nuclear plant itself. The spring 2015 water leaks illustrate that FDNPP will remain a concern for some time (as noted by Buesseler, Aoyama and Fukasawa, 2011; Wada et al, 2013). Socio-cultural contexts do not remain static across time, hence longitudinal research may assess changes in relationships between different actors as the issue of contaminated water at FDNPP and the adjoining sea develops into the future. Nonetheless, by highlighting the complexity of risk and uncertainty perception in Iwaki and demonstrating the importance of taking socio-cultural context into consideration, we believe our findings have a role to play in laying the groundwork for any future, more extensive research into marine radioactivity in Fukushima and beyond.

## 6. Conclusion

The case of fisheries in Iwaki offers insight into factors driving perceptions of risks and uncertainties associated with large-scale and long-term marine contamination. Data collected from interviews, discussion groups and observation suggests the value of creating conditions of trust for stakeholders and ‘managers’ to work alongside one another; the need for monitoring and

screening that is rigorous and frequent but also acknowledges uncertainty and limitations; and the importance of taking seriously the cultural effects that may arise from exposure to risk. Although the causes and consequences of the FDNPP accident are certainly unusual and extreme in nature, paying attention now to situations like fisheries in Iwaki may continue to yield useful lessons for wider coastal management practice as pressures from energy infrastructure and environmental change intensify.

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Figure 1: Maps of coastal area of Fukushima Prefecture (left) and of fishing ports in Iwaki City (right).

Adapted from map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

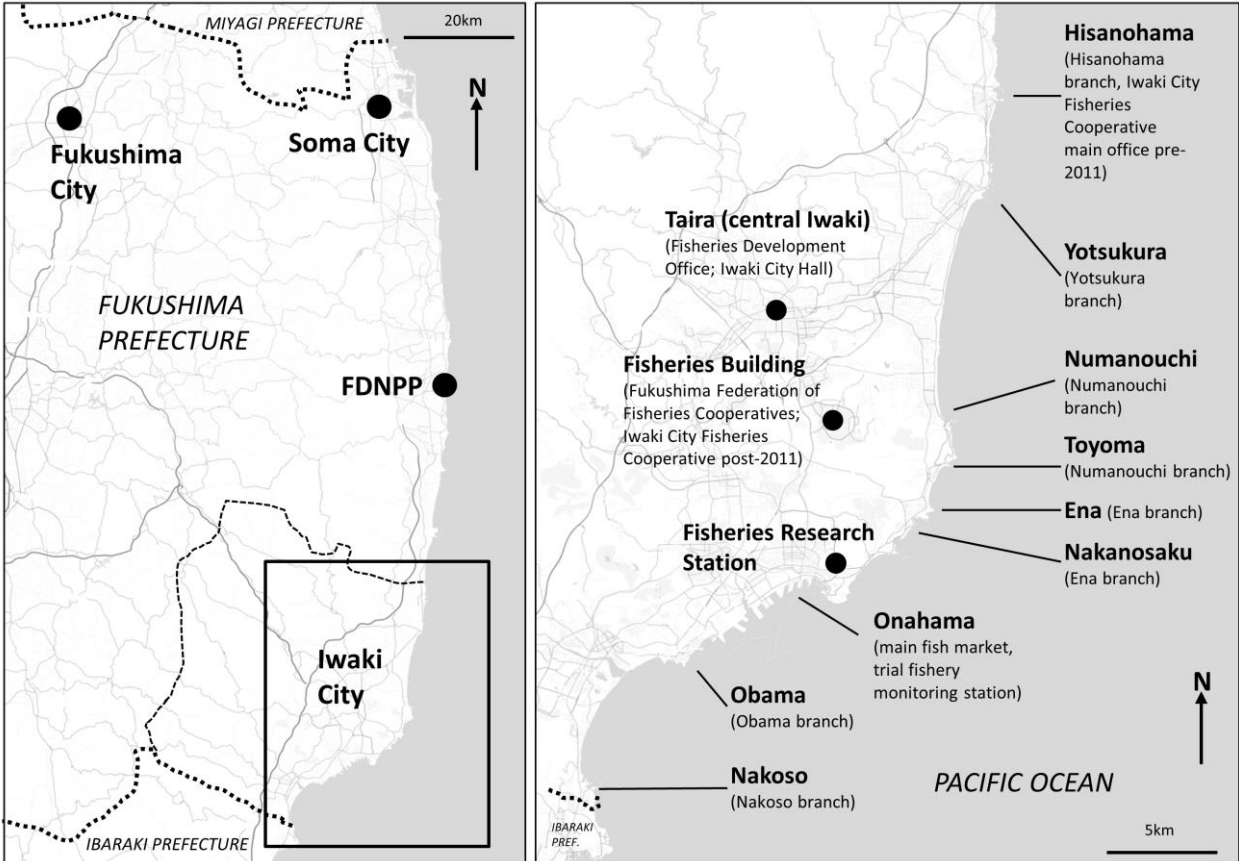




Figure 2: Relation between Fisheries Section, Fukushima Prefectural Government (left) and Iwaki City Fisheries Cooperative (right). Arrows show exchanges between the two entities. Data: Fukushima Prefecture (2015b).

