Radioactive Fish: Acting in the Uncertain Nuclear World

By

Masafumi Nishi

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Supervisor: Professor. Jean-Louis Fabiani
Second Reader: Professor. Alexandra Kowalski

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Abstract

This MA thesis examines how people in the Fukushima fishery act in the uncertainty of radioactive contamination ten after the Fukushima Daiichi Nuclear Disaster on March 11, 2011. The radioactive contamination of the ocean has caused tremendous impact on the Fukushima fishery. Uncertainties about invisible radiation exist in spatial and temporal ranges in many ways. The effect of low-dose exposure in long-term for both the environment and the human body are still uncertain. The issues of radiation and nuclear are complexly entangled with ecology, science, politics, economy, and culture. The complexity of radiation and nuclear opens room of discussion for many actors. This thesis employs the discussion of science and technology studies and anthropology of nuclear and radiation to examine the dynamics of the relationships between radiation and fish. Specifically, it implements a concept of hybrid forum to analyze the diverse actors' discourses, practices, and agencies. The official discourse by the government and Tokyo Electric Power Company is based on the geontopower that operates throughout the distinction between Life and Nonlife in the biopolitical regime. On the contrary, the fishery incorporates with fish as an ecological entity and as a commodity so that it diversifies the actors and concerns in the technical discussion of the radiation measurement and the releasing plan of radioactively contaminated water into the ocean.

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1. Prologue

Figure 1 Suffering Dragonflies on a Seawall, photographed by the author on November 3, 2020

On the first day of my field research in November 2020, I was bicycling on a brand-new seawall on the coastline of Soma city located in the north part of Fukushima prefecture. The seawall was reconstructed with white-grey concrete after the subsequent tsunami devasted the original one on the day of disaster on March 11, 2011. The empty land next to the bank was filled with solar panels as a new energy production after the nuclear disaster. I saw thousands of red-color dragonflies suffering on the bank, which made me feel about the impact of radiation because I knew that incents such as dragonflies were particularly vulnerable to radiation. I remembered the article that anthropologist Joseph Masco writes about a bee that became "measurement equipment" for nuclear experiments due to its vulnerability to radiation exposure (Masco 2004). Vulnerability of the incent reminded me of the movie "Grave of the Fireflies" (1988, directed by Isao Takahata), describing the second world war finished with atomic bombs in Hiroshima and Nagasaki. However, I did not know the real reason for their suffering since I am not familiar with the biology of the dragonfly.

The tragic scene of dying dragonflies made me wear a mask to protect myself from invisible radiation as I had done to prevent the corona virus in the global pandemic in the year. Maybe I was wrong to do so. None around me was wearing a mask during fishing on the coastline. Everything looked normal. People except me behaved as if there was no radiation in the city; people were doing tourism, fishing, and, of course, buying local fish that was famous for its freshness and

delicious taste. So maybe I was too much scared of the "very low level of radioactivity" existing in Soma city.

But I might have been right to protect myself from radiation; there might be hot spots in some areas or might be unrevealed consequences by the low-dose radiation. Who knows the truth? How can we predict the result of the radiation after ten years, twenty years, or fifty years? There are considerable uncertainties about radiation in Fukushima. What is only certain is that it is intimidating and exhausting to be conscious of the radiation. So, maybe it is also right to try to forget about it to have a "normal" life as many people there do, although it is not possible to have a normal life anymore in the fog of radiation of hundreds of years.

On another day, I decided to visit a museum newly built two months before, called "Great East Japan Earthquake and Nuclear Disaster Memorial Museum." The museum locates less than 5km away from the devastated Fukushima Daiichi Nuclear Power Plant (hereafter, FDNPP). It stands in a highly radioactively contaminated area where the former residents are still not allowed to return home and even stay overnight (officially called "areas where returning is difficult"). I get off a train at the nearest station, Futaba, with only one person who was also a museum visitor. Otherwise, there is no reason to visit the highly contaminated area. There was an air dosimeter on the gorgeous station building, saying 0.086μSv/h. I found this kind of air dosimeter all over the Fukushima prefecture, and this number was not exceptionally high. It is because the decontamination project has especially cleaned up the site of public facilities. A sign in the station recommended a visitors wear long pants, long sleeves, and a mask if they spent time in a dusty environment. Also, it said that visitors could borrow a handy dosimeter in an office next to the station.

Figure 2 Air dosimeter in Futaba Station, photographed by the author on November 15, 2020

I borrowed a bicycle to reach the museum from the station. No single person was walking on the streets, just cars driving from other cities. Ruined houses covered with grasses on roofs and gardens were blocked with metal fences. Land which used to be agricultural farms or rice fields was empty. There was a gated area full of thousands of black bags that contained contaminated soils. It is called a "temporary" storage facility for contaminated soils or ash of radioactive debris. Still, there is no fixed plan to process permanently the contaminants that emit radiation for the next hundred years[1]. The natural environment always disrupts the human's attempt of control to isolate and immobilize materials. Wind, rain, and typhoon easily sweeps the radioactive contaminants and widely diffuse them into the environment[2]. So does the ocean current with the contaminated water from the devastated reactors. Radionuclides from the accident have reached all Japanese coastlines and the whole Pacific Ocean (Kumamoto et al. 2017). It is uncontrollable.

On the contrary, the museum displayed how the government and Tokyo Electric Power Company (the owner of FDNPP, hereafter, TEPCO) had successfully controlled the situation after the accident. The museum was built with the government's fund of 5.3 billion yen (approx. 48 million dollars). The display began with a video stream about the contribution of FDNPP to the Japanese economic development after the second world war. And the museum contents displayed the "successful" treatment after the accident in terms of decontamination and reconstruction projects. The people's continuous struggle was silenced. The employed storytellers in the museum were not allowed to criticize the government and TEPCO. Official discourse about the accident is apart from the actual experience and perception of the local people[3].

When I was waiting for a train back to my guesthouse, a police officer approached me. He friendly asked me what I was doing there. I answered that I went to the museum. After he confirmed that I was a student, he said, "goodbye, take care!" Yes, I was not allowed to stay overnight in the area. Anyway, there was no hotel there. No one was living there. The governmental restrictions keep people away from the radioactive exposure while the government built the propaganda museum to show the people the governmental "success" to recover from the disaster. Contradictions lay on the radioactively contaminated land.

[1] Nikkei February 3, 2015 "Construction of temporary storage facility begins, with no timetable for final disposal" (https://www.nikkei.com/article/DGXZZO82744370T00C15A2000000/) accessed on May 13, 2021.

[2] Nikkei November 7, 2019 "Disaster prevention blind spot in "temporary storage area"; decontamination waste spills out Typhoon No. 19" (https://www.nikkei.com/article/DGXMZO51887250X01C19A1CE0000/) accessed on May 13, 2021.

[3] Tokyo Shimbun November 4, 2020 "Fukushima Prefecture's Nuclear Disaster Memorial Museum refuses to respond to Futaba Town's request for exhibition" (https://www.tokyo-np.co.jp/article/66233) accessed on May 13, 2021.

2. Introduction

2.1. Fukushima Daiichi Nuclear Disaster and Fishery

The Fukushima disaster in 2011 is the most significant environmental catastrophe in the 21st century. On March 11, the magnitude-9 earthquake called "the Great East Japan Earthquake" and subsequent massive tsunami struck Japan's eastern part. These natural disasters led to the shutdown of the power batteries for the cooling systems of the Fukushima Daiichi Nuclear Power Plant operated by Tokyo Electric Power Company, which resulted in the meltdown of the reactor cores of units 1, 2, and 3. Hydrogen was released from the reactor pressure vessels, leading to the explosion of units 1, 3, and 4 (IAEA 2015). These eruptions released a large number of radionuclides into the environment: the atmosphere, the land, the rivers, and the ocean (see Figures 3 and 4).

According to the radioactive contamination in the vast area of Fukushima, people's life has been devasted with evacuation (see Figure 5), loss of home, family and community ties, and tremendously negative effect to the livelihood. Any kind of livelihood in Fukushima has received the impact of the radioactive contamination. For example, agricultural products after the disaster have been prohibited from supplying to the market due to the high contamination. Still, some products such as mushrooms are banned from supplying or requested not to provide into the market[4]. Perhaps, one of the most severe impacts of the livelihood occurs in fishery due to the continuous contamination of the ocean and the negative image of the radioactive contamination of fish. There are some unique features of the impact of radioactive contamination on the fishery.

There are more uncertainties of the effect on fish than other products. The fishery in Fukushima mostly depends on natural resources except for seaweed and other farming fish. The fishery covers over one hundred fish species that have variations with body structure, habitat, preys, season of fishing, etc. The structure and features of the fish body render different contamination styles; for example, octopus, a mollusk, less likely to accumulate strontium and cesium compared to osteichthyan fish. The difference in prey causes the difference in bioaccumulation. Contamination of the ocean continues because of inflow from the land and the destroyed power plants. It is complex because of the ocean current and the variety of its depth and sea bottom. It is not as simple as the land contamination that decreases with natural decay and diffusion of radionuclides. These complex conditions of the fishery make the assessment difficult and hardly predictable. Therefore, it requires a wide range and long-term assessment, including environmental research, intake, and outtake of radionuclides of parts of the fish body. Complexities to treat radioactivity give space for uncertainties that should be reduced with specific scientific knowledge.

In addition to the existing radioactive contamination, a new issue of radiation comes out. On April 13 in 2021, the government decided to release radioactive-contaminated water into the Pacific Ocean to proceed with the decommissioning of FDNPP[5]. The government calls the

[4] Fukushima Prefecture, "Regarding food products that are requested to refrain from consuming or shipping" (https://www.new-fukushima.jp/storage/pdf/subject.pdf) accessed on June 18, 2021

[5] Prime Minister Office of Japan. April 13, 2021. Conference on disposal of ALPS treated water and other issues

contaminated water "ALPS (Advanced Liquid Processing System) treated water." "ALPS treated water," according to TEPCO and the government contains tritium (radioactive hydrogen isotope) that is unremovable with the existing technology. The government and TEPCO claim that tritium exists in the environment and is released in many nuclear facilities worldwide, so it will not cause health issues by diluting it thoroughly in the ocean. International Atomic Energy Agency advocates the decision. However, the Fukushima fishermen are worried about potential harm to fish products due to the associated potential health risk and consumers' negative image. Also, environmental protection groups and foreign countries such as South Korea oppose the decision due to environmental damage and food security[6].

Radioactive water and fish are complex problems. These are highly political regarding the connection to the national energy policy and security and international affairs with food security and planetary environmental issues. Also, these are economic problems with the international and national trade and livelihood of the fishermen. At last, these are environmental issues that affect ecology and biodiversity at the national and international levels. However, the problems cannot be solved with techno-scientific knowledge that shows the contamination level and effect because many uncertainties lie on radiation. There is still unrevealed space for how much radioactivity is harmful to the human body and environment. The distribution of the radioactive contamination is unsure – there are hotspots in the ocean and potentially highly radioactive fish amid the vast ocean.

(https://www.kantei.go.jp/jp/99_suga/statement/2021/0413_2kaiken.html) accessed on June 24, 2021.

[6] BBC. April 13, 2021. Fukushima: Japan approves releasing wastewater into ocean (https://www.bbc.com/news/world-asia-56728068) accessed on June 24, 2021.

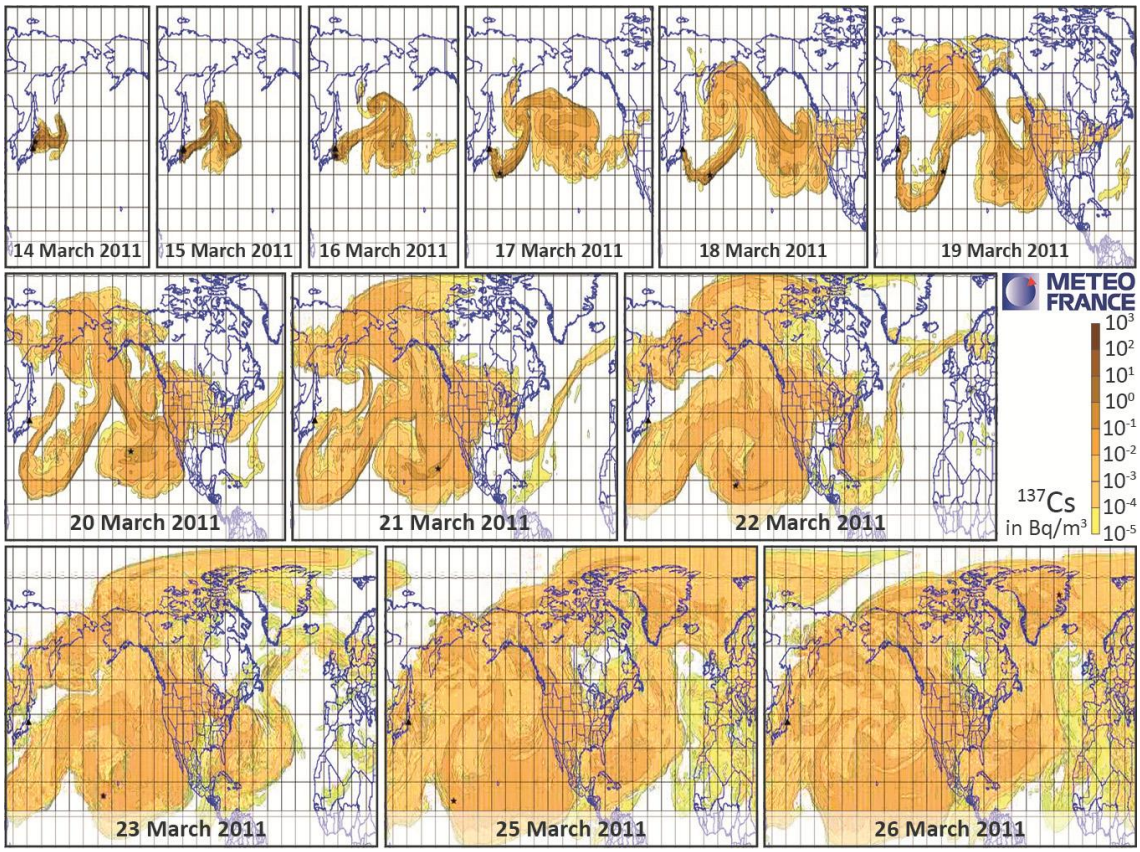


Figure 3 Oceanic Cs137 Contamination Model, cited from IAEA Report "Fukushima Daiichi Nuclear Accident" (2015) p.109

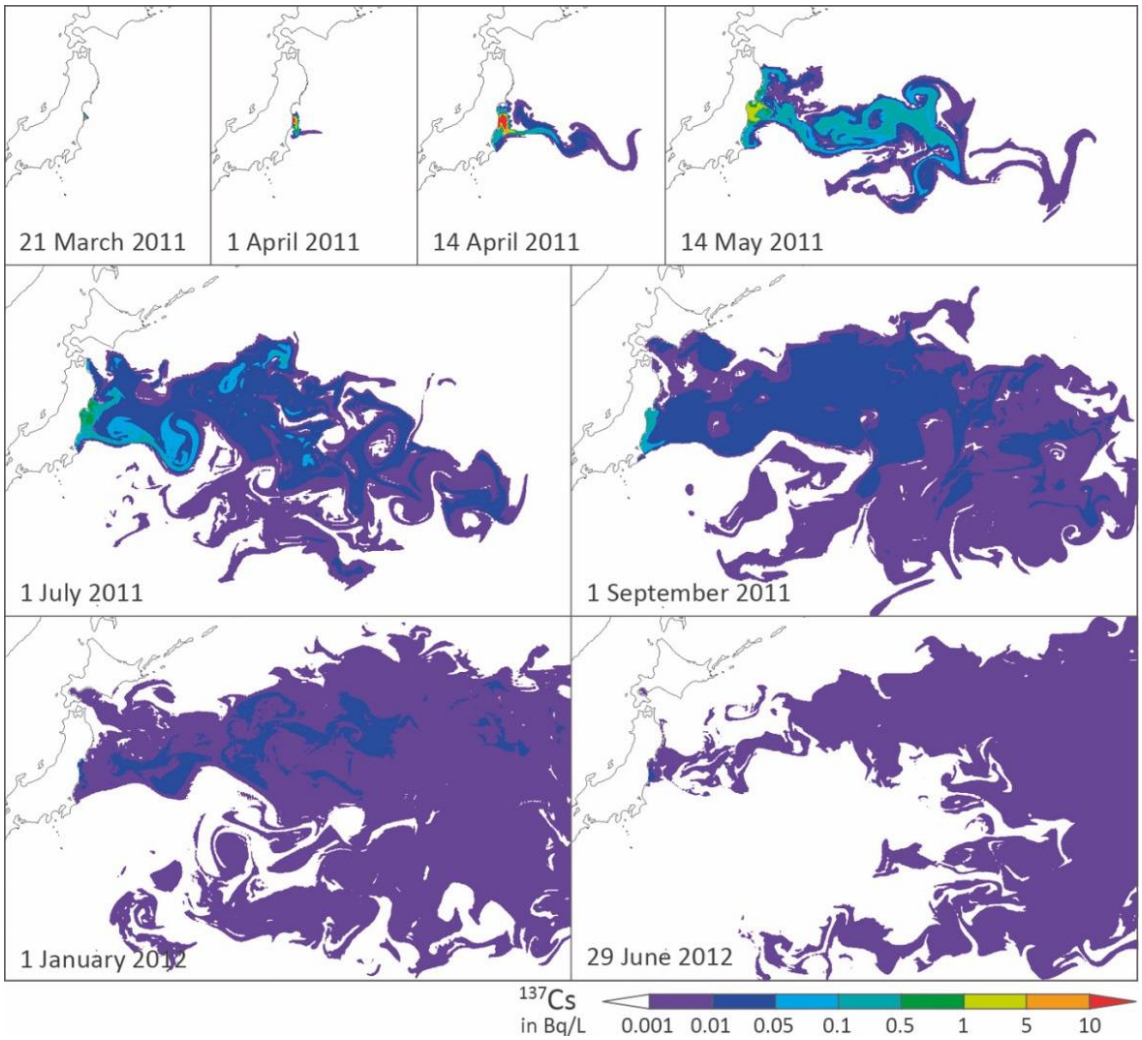


Figure 4 Atmospheric Cs137 Contamination Model created by Metro-France, cited in IAEA report "Fukushima Daiichi Nuclear Disaster" (2015) p. 108

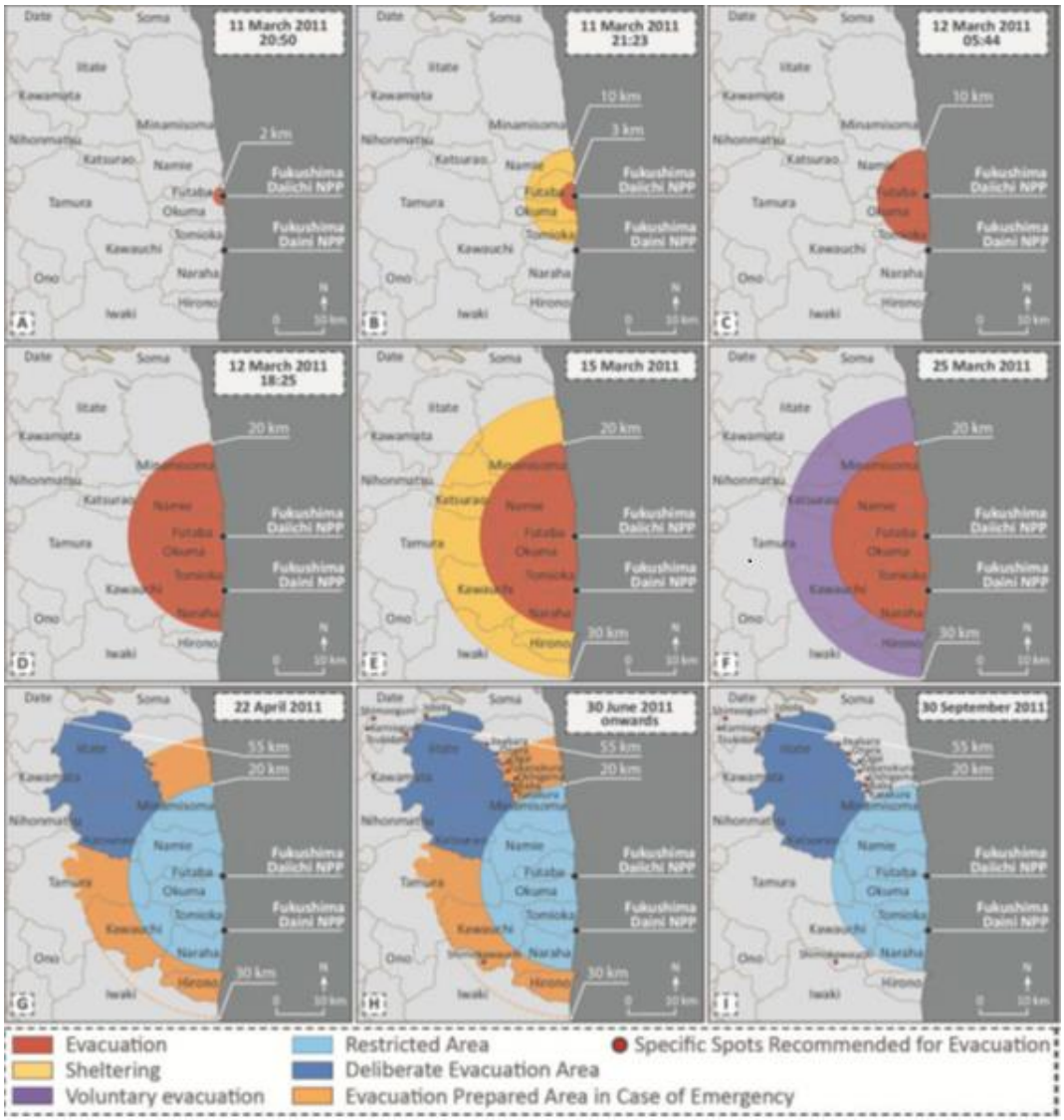


Figure 5 Evacuation Map, cited from IAEA report "Fukushima Daiichi Nuclear Disaster" (2015) p. 88

2.2. Theoretical Framework

2.2.1. Nuclear Knowledge and Uncertainty

Radiation is invisible and unstable. It raises considerable uncertainty in society after the Fukushima Daiichi nuclear disaster. The invisibility of radiation denies a direct causal relationship to its effect. Also, the long-term effect of low-dose exposure to radiation on the human body and the environment is still not fully understood.

After the Chernobyl accident, for example, the death number due to radiation determined by officials as direct casualties is only 31 that counts workers who worked in the exploded reactor. However, how many people exposed in the long-term period in the radioactively contaminated area suffered or died because of cancer, leukemia, or any other disease, or even unexplained body ailments? It is hardly possible to determine. Firstly, it is difficult to determine the amount and density of radioactive contamination because the radionuclides had gradually and unequally spread in the vast area affected by natural and geographical conditions. Secondly, under the disturbance of the social and political institutions, science can hardly engage with reality and publish the findings. And thirdly, even scientists disagree on calculating the correlation between the cause and the effect of disease or death (Petryna 2013). Uncertainty of the radiation complicates the situation and gives room for controversies in which political, economic, and scientific institutions participate.

This chapter examines how knowledge is produced and distributed in an uncertain world, focusing on radioactive issues. How does the practice of knowledge production entangle in the scientific, political, social institutions? How does it contain spatial and temporal specificity, political strategies, and imagination? This chapter reviews the literature on science and technology studies and the anthropology of nuclear. They show that knowledge production is not "pure" techno-scientific activity without any social and political settings. Instead, knowledge is produced in the specific process that carefully separates an entity from the world and objectifies it in a particular political setting. The process of knowledge production secludes its techno-scientific term from the rest of the world, such as layperson, political or economic institution. However, this practice of knowledge production still evokes controversies among society when a new actor concerns the issue. Thus, knowledge is in a continuous fluctuation of controversies in the uncertain world.

In order to reveal the dynamics of knowledge production in uncertainty, this chapter firstly uses the metaphoric concept of laboratorization of society. When society encounters a situation that it has never experienced, such as a nuclear disaster, uncertainty tremendously increases. Thus, like in a laboratory, society embraces new productions or maintenance of knowledge to normalize, generalize, resolve, or conceal the uncertainty. Without careful investigation of knowledge production, we would not be able to understand the circumstance.

The second part of this chapter employs science and technology studies to open up the black-boxed process of knowledge production. The terms of specified knowledge about nuclear or radioactive exposure, namely, nuclearity and biological citizenship, are discussed. These concepts show how political, social, and economic strategies shape scientific knowledge or vice versa. The theory of translation from the actor-network-theory is relevant here to understand the process of knowledge production. It juxtaposes human and non-human actors involved in the production of knowledge in hidden conjunctures of politics and science. Finally, the discussion introduces the concept of "hybrid forum" by Michel Callon. A hybrid forum is a space where various

heterogenous actors discuss technical options such as experts, scientists, politicians, and laypersons who consider themselves involved. It helps us to understand how these actors act in the technological dynamic in an uncertain society.

2.2.1.1. When Society Becomes a Laboratory

A laboratory is considered a place that mainly produces knowledge. Both natural and social scientists collect data from the world into laboratories. Then, the collected data are studied through experiments and/or analyzed, compared with other data, finally summarized in publication. The scholarship of science and technology studies (STS) has examined these procedures. Michel Callon, an STS scholar, has systematized and theorized the procedures of knowledge production, focusing on scientists' and experts' practices and revealed the politics of that. He employs the concept "translation" that comprises three stages (Callon, Lascoumes, and Barthe 2009).

The first stage of translation is the transportation of the complex world into the laboratory. Scientists collect reality from the world by reducing complexity. The reality becomes manipulatable with purification and simplification, but it should remain comparable to the original complex world. Using specific instruments, technologies, techniques, and methods, proceed with this procedure. The reduced reality is now brought to the laboratory in a purified form such as specimen, sample, questionnaire, observation, etc.

The second stage of translation is an inscription of reality into words. The fragments of the world collected by scientists into a laboratory do not have any scientific meanings yet. In laboratories, scientists carefully classify them so that they can be arranged, compared, and analyzed. The data now transforms into technical words, models, other visual forms with the expert's technique and instruments such as a computer. The data is utilized to support the scientist's statement by comprising a section in the paper. Objectification achieved throughout the first and the second translation simplifies the materials from the complex world and enables scientists to manipulate the objects in a secluded laboratory. Continuous adjusted and trial and error in the secluded laboratory, the entities are domesticated. Uncertainty is settled down so that it avoids new possibilities to enter. However, purified science data is brought away from the world by two practices of translation. The scientific data itself in the laboratory does not complete knowledge production without returning to the big and complex world.

In translating to the big world, the third stage of translation, political and social configuration, plays an essential role in making the research public. Callon calls it "interessement" (2009). Those who have political and economic power enrich the interest by funding the research, providing the direction or expectation from their interest, or even making up the new phase of curiosity. Curiosity itself is also partially shaped by the social setting: from the researcher's personal interest, the science community that tries to attract the public that supports curiosity or necessity, to common sense. It is impossible to distinguish technical artifacts and social organization; instead, they are interrelated so strongly.

The process of translating the knowledge from the laboratory into the big world is called the laboratorization of society (cf. Guggenheim 2012). The produced knowledge applies to society in the same way as in the laboratory. As Latour suggests in the case of Pasteur's discovery, the knowledge the scientist produces throughout translation practices is extended to other actors in society (Latour and Woolgar 1986). For an example of Pasteur's discovery, the medical sector also

learns the methods about the laboratory's technology and introduces new faculty in hospitals. Factories manufacturing a product that is applied the new technology is replicating the technology the laboratory invented. Hence, the knowledge production in the laboratory leads to the transformation of society into a part of the laboratory. It is called the proliferation of the laboratory. However, it does not mean that the society becomes a one big laboratory but embraces many laboratories (Callon, Lascoumes, and Barthe 2009).

The case of Pasteur by Latour beautifully shows the scientific practice, knowledge production, and proliferation, implementing translation. However, when scientific knowledge is not stable enough to be smoothly transformed or proliferated to other phases, how can we describe a discursive controversy? What if the knowledge is not single but plural and unestablished about uncertainty as different people and institutions argue different opinions based on different methods and technologies? Especially, nuclear knowledge and technology have not succeeded in establishing agreements about knowledge in the three translation stages. There is always an overflow of new actors that change the basement of discussion and new knowledge that contradicts each other. To understand this dynamic, we need to return to open up the black-boxed knowledge that pretends stable.

2.2.1.2. Opening the Black Box of Nuclear Knowledge

The knowledge about nuclear and radiation seems settled by nuclear promotors such as political or industrial institutions. Nuclear issues, such as nuclear energy, mining of radioactive natural resources, construction of nuclear power plants, contamination from atomic bomb experiments, or nuclear accidents, are highly political and economic. Throughout contemporary nuclear history, the atomic development for military usage and civilian usage for nuclear power cannot be separate because both developments have entangled with the politics of the states' developments, national securities, and economic independence (内山田 2019). Therefore, in many countries, the states support nuclear developments by, for example, promoting national or international policies or funding research on nuclear power. Once radioactive contamination from mining, atomic experiments, or power plants, the state is one of the central actors of the problem.

In this unique feature of the nuclear issues, knowledge production on nuclear and radioactivity is highly political. Science is not independent of politics but rather the practice of translations embedded in a network of society and politics. In the case of knowledge production on the nuclear issue, this may be more relevant than others because of the close relationship between politics and science. And, of course, an industrial institution such as an electric company running nuclear power plant also plays a crucial role as an actor of the knowledge production by lobbying the government or media, pressuring the science community, funding research that benefits the corporate's policy, or concealing facts or data they acquire. Especially in the nuclear issue, there are still many uncertainties regarding the effect of radioactive on the environment and the human body. The invisibility of the radiation gives room for many actors' act for techno-scientific knowledge—also, the social uncertainty of the controversy of nuclear issues (Goldstein 2017). The facts are unstable; when new actors enter the controversy, new phases are flowed out so that tentative knowledge turns into question (Callon, Lascoumes, and Barthe 2009).

Therefore, we must open up the dynamic of knowledge production on the nuclear issue, where many actors perform under specific policies and tactics. In order to do so, here, I carefully

investigate what kind of actors are involving in the network for knowledge production and how they are acting under certain policies. Specifically, I examine the two cases of nuclear energy. The first case is about uranium mining in Africa and the global trade of uranium (Hecht 2012). It shows that politics and industries profoundly influence knowledge production, mainly when the issue contains ambiguity. The second case is the Chernobyl nuclear accident and citizens' implementation of biological knowledge, proposed by Adriana Petryna. The layperson's biological knowledge about radiation shapes how to survive in uncertain times (Petryna 2013). In both cases, we can see how knowledge about nuclear is interwoven in the web of many actors.

Whether a material is nuclear is scientifically apparent. There are radioactive substances in the environment, and they can be scientifically defined as radioactive when they emit radiation. But natural radioactive substances are not necessarily considered nuclear (Hecht 2012). For example, Potassium 40 is a radioisotope of Kalium, which we daily intake or expose. It does not count as "nuclear."

On the contrary, the famous radioisotope, plutonium, is considered nuclear. Then, what about uranium that naturally exists in the world, which can produce plutonium for an atomic bomb or nuclear energy? That is ambiguous. Hecht (2012) describes the dynamics of the knowledge of nuclear by proposing the concept of "nuclearity." Claiming something like uranium nuclear can cause national and international politics, economic agenda, and scientific rationale. If uranium is nuclear, the international trade of it would be restricted under the control of the International Atomic Energy Agency. Uranium miners in Africa would have to be protected and compensated if injured by its radioactive exposure. Therefore, the controversy arises in the middle of political, industrial, scientific actors. The knowledge is produced as nuclearity. The process of knowledge production "requires instruments and data, technological systems and infrastructures, national agencies and international organizations, experts and conferences, journals and media exposure" (Hecht 2012, 320). The experiments conducted by scientists may show causality in animals from uranium radiation exposure. Still, they do not necessarily translate the result into causality to humans if the scientists do not agree to the link between humans and animals regarding radiation exposure. And scientific disciplines are vulnerable to challenge from industry leaders and policymakers (Hecht 2012, 184). As seen here, the knowledge production of nuclearity is under the dynamic of many actors.

Whereas Hecht's nuclearity brilliantly shows the political and industrial influence on the nuclear controversy, Petryna's work describes the layperson's knowledge of nuclear issues. After the Chernobyl nuclear disaster, the vast area around the destroyed reactor has been highly contaminated. Exposure to radiation causes unpredictable influences on the human body. Although the people exposed to the radiation have experienced unexplainable illnesses such as headaches and increased the rate of cancer and leukemia or fetal, the causality to radioactive exposure is hardly proven with scientific or medical knowledge. Moreover, politicians' concealment of the disaster and social disturbance on the data makes it difficult to predict the exact number of the victim and relationship to the illness (Petryna 2013). In this hardship, the citizens have gained technical knowledge to claim themselves as victims and connect their biological conditions to radiation exposure. Sometimes, the biological condition is manipulated by corruption or just ignored due to inapplicability to the standard. The knowledge the layperson has developed is shared among the citizens and sometimes changes the standard measurement.

In both cases on the nuclear issue, knowledge production is the dynamic of many actors such as political institutions, industrial sectors, scientists, and laypersons. The knowledge is not

stable existing from one kind of actor. It is neither produced simply by scientists nor by political agenda. All the actors involving the production interact with each other and continuously change each position. The dynamic on controversy constantly change the shape in the uncertainty of nuclear issue.

2.2.1.3. Hybrid Forum

At the end of this chapter, I propose Callon's concept of the hybrid forum (Callon, Lascoumes, and Barthe 2009). A hybrid forum is a place where controversies are taking place. Any actors who consider themselves involving the controversy are in the hybrid forum, such as policymakers, experts, scientists, and laypersons. It is the heterogeneous gathering on the controversy. In the uncertain world, knowledge production does not smoothly take place but always embraces continuous discussions and interaction of involving actors. It avoids dichotomy whether science or politics dominates the forum and constructionist approach that the social construct the natural.

In this chapter, I have reviewed STS literature and anthropology works on the nuclear issue. Firstly, as the procedure of knowledge production in laboratories, the concept of translation was discussed. Close looking at the process of the artificial modification of the world to stabilized technical and scientific knowledge enables to reveal the politics behind the scenes. Secondly, the metaphoric concept of laboratorization of society showed how society is configured from knowledge. Thirdly, I examined two case studies that show dynamics in the relationships among politics, science, economy, and people under ambiguous issues in an uncertain time. Knowledge of nuclear is embedded in the political and social settings.

A hybrid forum as a concept helps us to investigate the dynamic of all these aspects. For nuclear issues, especially, it is a relevant concept. That is because 1) the nuclear issue is highly techno-scientific. Radiological science requires expensive instruments and a lot of time to conduct experiments and analyze data. Without instruments, radiation is invisible. Also, radioactivity is uncovered yet by science, such as the effect of the human body and the environment to low-dose exposure or technical solution for long-life radionuclides; 2) it is political. The political agenda have promoted atomic development and nuclear energy. Thus, politicians are in charge of their responsibility to resolve problems. International and national security against nuclear energy and disaster is a highly political issue; 3) it affects a wide range of people. Radiation cannot be concealed from a closed space. Nuclear waste and radioactive contamination last for years and years in a vast area. Not only experts or politicians but also, and mainly, layperson receives the effect of radioactivity. Concerns regarding their health and economic means are increasing, deriving imagination for the future generation and cosmological thoughts on the environment; 4) it is economical. The nuclear industry is a big business internationally. Also, the occurrence of nuclear accidents or construction of reactors, reprocessing plants, or disposal sites of nuclear waste requires a large amount of compensation. These four aspects of the nuclear issues make the controversy more complex. Uncertainty makes room for each actor to speak up about the issue more than stable facts. By seeing controversy as hybrid forums, we can examine inclusively many actors' actions and analyze the dynamics of nuclear issues.

2.2.1.4. Discussing Technical Options

The explosion of the nuclear reactors has also led to the explosion of the discussion. The secluded space is blown up again. The official discourse about the radiation and practices of measurement based on the government's modeling are under question. A variety of aspects in Fukushima fishery comes up in the technical discussion, overflowed from the simplified model by the government. Moreover, there is a considerable debate about how to handle the contaminated water kept in the tanks. Many aspects join the technical discussion of the radiation and the contaminated water. Sometimes, a solution is invented, suggested, and tested by non-experts. Contrary to Zonabend's description of the silenced citizens (Zonabend 2007), the Fukushima disaster has opened up space for many actors to come in.

This thesis examines the dynamics of many aspects and actors. Technical options are discussed from experts to non-experts. Not only human but also non-human actors comes into the debate.

2.3. Field Site

I have conducted 4-week field research in Fukushima, extensively in Soma city. Soma city is located in the north part of Fukushima prefecture, approximately 50km far from FDNPP. Soma city has one of the biggest fishery ports in Fukushima. Soma-Haragama fishery port is the northern center for the Fukushima fishery. The landing fish on the port varies from cultivated Seaweed and clams of a brackish bay called Matsukawaura, coastal, to offshore fish.

During my field research, I have conducted semi-structured interviews with five fishermen and one manager of a fishery process company. Also, I conducted participant observation and short interviews with several fishery workers in Soma fishery port. Additionally, I interviewed a manager of the Fukushima Research Institute of Fisheries Resources that researches the radioactive impact of the fishery in Soma city. I also visited Fukushima Agricultural Center in Koriyama city to interview experts and observe the process of radiation measurement. In Fukushima city, I interviewed an activist against the release of radioactively contaminated water into the ocean.

Additionally, I have visited a museum called "Great East Japan Earthquake and Nuclear Disaster Memorial Museum" in Futaba town 5km away from FDNPP, and a research-oriented aquarium "Aquamarine Fukushima" to examine the official discourse of the nuclear disaster and radioactive contamination.

Throughout the field research, I employed the anthropological method to writing this master's thesis. The ethnographic approach enables this thesis to look closely at the details of the ongoing situation and listen to the laypeople's narratives. For privacy reasons, I anonymize the names of the informants.

3. Japanese Nuclear History and Policy

The Fukushima accident shocked the world for its serious consequence of radioactive contamination. Today, however, few people are questioning why there were nuclear reactors in Fukushima. No one knew the rural region before the accident, while almost everyone internationally already knows Fukushima. The term "Fukushima" refers to a nuclear disaster like Chernobyl, Three Mile Island, or other Japanese cities like Hiroshima and Nagasaki. Also, few people know FDNPP had been providing the generated electricity to Tokyo. FDNPP is located approximately 200km away from Tokyo. Although the transmission reduces the amount of electricity produced, why FDNPP was providing the electricity to Tokyo? In fact, not only FDNPP is far away from a big city that is a power consumption place, but almost all existing nuclear reactors in Japan are located in rural areas far from big cities. These places (villages or towns) with nuclear sites are often called "Nuclear Village (Genshiryoku Mura)" by researchers or media. The history of Japanese nuclear energy policies embraces the relationship between nuclear villages in rural areas and big cities.

Therefore, it is crucial to understand the urban-rural relation in the context of nuclear energy in Japan. As FDNPP played had done before the accident, nuclear power plants have played a role in developing the rural area – or at least under the name of it – within the huge power structure of urban-rural. At the same time, especially as seen in the case of Fukushima, the rural have been desiring the future-oriented technology site in a political, economic, and cultural sense as means to acquire independence of the region, based on local patriotism.

This chapter firstly articulates nuclear power as complicated apparatus intertwined in national security and "clean energy" policy that imposes political and economic power. Secondly, it reviews the anthropological theories of urban-rural dynamics. Thirdly, it proposes complex the urban-rural relation, which does not reduce to clear-cut urban-rural dualism by referring to an empirical sociological work by the Japanese sociologist Kainuma (2011). This chapter suggests the complex urban-rural dynamics that are culturally, politically, and economically intertwined in energy geopolitics.

3.1. Nuclear as National Security and Clean Energy

The Japanese government has promoted nuclear energy due to its strategy of reducing the emission of CO2 and the scarcity of energy resources inside Japan, and the improvement of nuclear technology in the global trend for nuclear. The nuclear policy of the government has been an economic and political choice for the nation. It has been designed not only to address environmental issues within a reasonable range of economic growth but also to contribute to the domestic economy. This section overviews the trajectory of nuclear energy policy in the relationship with political, economic, and environmental issues.

Nuclear development in Japan started in the 1950s. No later than the time of the sufferings of the atomic bombs in Hiroshima and Nagasaki at the end of the Second World War, the government was trying to follow up the global trend of the nuclear energy development that was symbolically seen in the speech of "Atoms for Peace" by the U.S. president, Eisenhower in 1953. The government sought to improve the technology of nuclear power and economic benefit. The government had offered massive support for the research and development of nuclear power plants for the domestic private sectors. Consequently, the first nuclear power plant for commerce was in the late 1960s, and rector 1 of the Fukushima Daiichi nuclear power plant started (Sagara 2009). Nuclear energy had developed as the state's project for commercial use.

The international political problem has encouraged the development of nuclear energy in

Japan. The so-called "oil shock" in the fourth Arab-Israel War in 1973 damaged the Japanese energy economy. The Organization of Oil Exporting Countries (OPEC) decided to reduce oil production, increase the oil price and prohibit export to the countries that supported Israel. Japan, the country with limited domestic energy resources and allying with the U.S. that supported Israel, encountered fossil fuel. The Japanese government reconsider the dependency of the exported fossil fuel as a fundamental energy source for electricity and shift to nuclear energy as alternative energy (Sagara 2009). The government argued diversification of the energy source, including nuclear power and renewable energy, would contribute to the stability and security of the energy (Japan Atomic Energy Commission 2005).

Additionally, the promotion of nuclear energy has been a countermeasure against global warming. For example, Japan agreed to reduce 6 percent of greenhouse effect gas compared to the emission in 1990, in the Kyoto Protocol in Conference of the Parties of the United Nations Framework Convention on Climate Change in 1997. The primary greenhouse effect gas is CO2 and is primarily produced in the generation of energy. To achieve the goal of the Kyoto Protocol, the government sought to reduce the CO2 emission from energy generation. The government has emphasized the nuclear energy is one of the most important and reasonable alternative energies instead of fossil fuel because nuclear reactor emits no CO2 in the process of generation of electricity, and the whole process of mining materials, construction, and deconstruction of the energy plant has less emission of CO2 as well as other renewable energies. The government has shown its attitude to challenge global warming by facilitating nuclear energy.

Japan's approach that develops and accelerates a new technology as means for environmental conservation seems ecological modernization. Ecological modernization is the concept that new green technology supports to tackle the environmental problem and, at the same time, achieves economic development (Mol 2002). In the case of the nuclear policy of Japan, the government and electric companies sometimes entitle nuclear energy as "environmental-friendly energy." In the document by Japan Atomic Commission, nuclear energy is emphasized as lower-cost energy than other fossil fuel energy, and so nuclear energy is "expected as an effective means of contributing to the long-term stable supply of energy and measures against global warming" (Japan Atomic Energy Commission 2005). Nuclear energy is considered a critical solution for the reduction of greenhouse gas as well as sustainable and economically beneficial.

Nevertheless, Kondoh (2009) claims that the government's policy of nuclear power promotion in the name of environmental protection is questioning. The government does not enforce domestic industries to reduce the emission of greenhouse gas, so the industry does not intend to develop new ecological-friendly technology. Instead, the policy towards the reduction of greenhouse emissions is influenced by the lobbying of the Japan Business Federation (Kondoh 2009). Also, even though the nuclear power plants are constructed by domestic heavy industry companies (e.g., Mitsubishi Heavy Industries) and operated by private electric companies (e.g., TEPCO), the government has a crucial role in the promotion of nuclear energy. Kondoh cites an analysis that nuclear energy is not economically efficient under the market economy. The relatively low cost of nuclear energy is kept by the government's support of the research and subsidies to the local governments instead of the electric companies (Asahi News Paper 2006 cited in Kondoh 2009). Thus, the promotion of nuclear energy is instead a political project supported by the government.

This section has overviewed the history and the structure of the nuclear promotion policy and found that nuclear energy is a governmental political project even it has been labeled as "environmental-friendly" and economically beneficial. The following section investigates how the government has distributed nuclear reactors in rural areas with its "support" as compensation for the risk of radiation.

Therefore, few people are welcome for the construction of a nuclear power plant in their back yard. Even the government has promoted nuclear energy as a political project, it never intends to construct a nuclear power plant near big cities like Tokyo or Osaka, which consumes electricity

the most. Hence, the government has implemented "support" to promote the construction of a nuclear power plant, which keeps away a nuclear facility away from the urban areas.

One of the most influential financial promotions of the site setting of nuclear reactors is a set of three laws established in 1974: Tax Act for the Promotion of Power-resources Development, the Special Budget Law for the Development of Electric Power and Law for the Adjustment of Areas Adjacent to Power Generating Facilities (Agency for Natural Resource and Energy of Japan 2004). These laws aim to "improve the welfare of residents by promoting projects that contribute to the development of public facilities, improvement of convenience for residents, and promotion of industry in the region, thereby contributing to the facilitation of the installation and operation of power generation facilities" (Japan Atomic Energy Commission, 2005). These laws provide an enormous amount of subsidies to the local government who set an electric generation facility, mainly nuclear power plants. For example, Fukushima prefecture and belonging cities, towns, and villages had received over 58 billion yen (approximately 530 million U.S. dollars) from 1974 to 2010 (Fukushima Prefecture, 2010). Additionally, the local government receives the property tax from the electric companies. The economic effect of relating companies and workers in the power plant contributes tremendous benefit for the local governments.

These financial benefits appear attractive for rural areas that suffer a lack of budgets. Because of the decrease in population and industries, rural areas in Japan have in a difficult situation. The young generation moves to urban areas like Tokyo due to the lack of work opportunities and inconvenience in the locals, so the inequality between urban and rural areas increases. That leads to tax decreasing for the local government. Therefore, the local governments welcome a nuclear power plant that is attached to a vast amount of money and likely to depend on financial support from the government and the nuclear industry. This rural area is sometimes called "Genshiryoku Mura" (Nuclear Village). Without the acceptance of nuclear power plants in rural areas, the development of nuclear energy led by political motivation by the government does not achieve.

Thus, the people in a rural area are facing the risk of radiation from the plants much more than those who are in an urban area. Even many people are against to the nuclear plan concerning the risk of the nuclear power plant, compensation money from the electric company, and bribes for the activist leaders and no other choices to improve the severe economic situation keeps out the opposing opinions against the plan (Kotler & Hillman, 2000 cited in Kondoh, 2009). Once a nuclear accident happens, the people who are in danger and risk are not those who have consumed the electricity in the urban area but those who have lived nearby the plant. People near nuclear plants should have their lives and economic activities at the risk of accidents and contamination. The place where people live decides the economic and social status and thus differentiates the risk of radiation.

As seen above, the selection of the site is based on the economic and social status; the rural area that is low income than the urban area is more likely to close to the risk and hazard in Fukushima. On the other hand, a big city can use electricity with little risk. Hence, urban area exploits rural area with energy distribution (Kelly-Reif & Wing, 2016).

3.1.1. Anthropological Theories on Urban-rural Dualism

Anthropology has analyzed the urban-rural relationship. The distinction between urban and rural is transmitted into respectively civilized and uncivilized, or modern and traditional. The space and the people in the dualism are separately described and analyzed in different forms. In the modern world, the urban structure of power and authority composed the relations of social and material forms of life (Mills 2001). The urban-rural dualism is, to some extent useful tool to analyze the economic, political, social, and cultural differences. Economic relations between urban and rural can be analogically traced to the relations between center and periphery in world-system theory by

Wallerstein (2004). In this sense, the center structurally dominates the systematic relations and, thus, the periphery depends on the structure by the center. The center is the most industrialized and powerfully exploiting the periphery as a resource and export destination, while the periphery supplies the materials to the center and is forced to sustain its inferior position. Similarly, the urban-rural dualism is based on the assumption that the urban dominates the political, economic, and cultural structure whereas the rural inferiorly supports the structure.

Modernization theory has also contributed to urban-rural dualism. Modernization takes the first place in the urban area while the rural maintains the non-modern traditional life which modern left behind. Ferguson (1999) articulates the cultural dualism of urban-rural. He describes the cultural style of the rural workers to obtain the modern lifestyle while the bond in the rural society facilitates the working practices. The immigrant work performs as acquire of fashion of modern city. Similarly, Mills (2001) describes women workers from rural area to city. According to her analysis, the practice of worker does not make sense in terms of economic benefit, but rather in terms of being updated to be modern. These works provide new perspective between urban and rural. The conventional dualism of urban-rural in terms of economic, political, and cultural domination does not necessarily fit to the people's practices. Similarly, the introduction of FDNP in the rural cannot be explained only in the political and economic terms.

3.1.2. Dominant Urban-rural dualism on Nuclear Installation and Alternative Complexity

According to the economic benefit, there are two widespread discourses about the acceptance of nuclear power plants in rural areas. Installment of nuclear power plants attributes to "good-will development" or "malevolent oppression/exploitation" (開沼 2011, 118). On the one hand, "good-will development" emphasizes the economic benefit for the rural area for the installation of a nuclear power plant. A huge amount of compensation money from the government and tax from the electric company can be seen as a help for the tight finance of the local administration. These abundant financial resources are used for the construction and maintenance of public facilities such as schools, hospitals, sports facilities, cultural centers. This kind of financial support would be not only attractive but also urgent to people in rural areas In Japan, where there is a large economic disparity between regions, especially between urban and rural areas. Also, the nuclear power plant produces other economic and social benefits. The plant produces a number of local employment and proliferates the related industries. For example, in case of FDNPP, there were thousands of workers in plant operation and management outside of the area and local employments for subcontracting companies. Also, the directly and indirectly related industries such as restaurants, bars, and accommodations for workers flourishes in local. As Kainuma shows from the interviews of local people before the accident, the village appeared "full of life" to locals, thanks to the plant (開沼 2011).

On the other hand, "malevolent oppression/exploitation" stresses the negative points of the structural power about the installation of the nuclear power plant. Obviously, the reason why the rural area is struggling for economic and social disparity is a result of the unequal distribution of the capital of the government. Hence, appealing to the economically challenged municipalities for the economic benefits of introducing nuclear power plants can be seen as structural exploitation of the state. Nuclear energy as national security and "clean energy" policy gives burden to the periphery area not the center of the state. For some rural municipalities, there is no other choice but introducing nuclear plants to survive. Kelly-Reif and Wing (2016) analyze this structural inequality and dependency of nuclear energy as "parasite," employing the theory of environmental justice. The state emphasizes the importance but not willing to get a risk of the nuclear accident and continuous contamination from the operation in the geopolitically important area such as

Tokyo. Say, nuclear power is important but "not in my backyard". As seen in the Fukushima disaster, the radioactive contamination affects mainly to the rural area close to the plant. The recipient city of the generated electricity, Tokyo, rarely get the consequence for the disaster. The inequality of the nuclear power installation is structural exploitation of rural by urban.

These two dominant discourses of the nuclear, however, analyze from the perspective of outsider economic determinist, Kainuma says (2011, 118). He has conducted empirical field research in Fukushima before the accident and proposes alternative perspective within the "nuclear village". From the interviews with local politicians and lay-people in Fukushima, he describes the local discourse on the nuclear power plant. His interview was conducted in 2000s before the accident in 2011 showed there were few anti-nuclear activists in the Futaba Town where the FDNP located. Instead, the nuclear power plant played a role for local people and politicians to acquire independency from the center. It seems contradicting to accept the power plant as an apparatus of national policy in periphery. However, installation of the modern technology gives a confident to the locals. As a sign on the entrance of the nuclear facility says "Nuclear, Bright Energy for the Future", nuclear power became a boom of the cutting-edge technology in the area. Nuclear technicians from other countries appeared international consciousness to the lay-people who were not familiar with the facilities (開沼 2011, 105). Local business used some words relating to nuclear power as cultural identity of the town: e.g., "Nuclear Sweet Bean Sweets", "Nuclear Logistics", or "Atom Suchi". The sports facility called "J-Village" held famous football team's camping that entertained the people to watch training scenes and matches of famous sports stars. The risk for nuclear and radiation was not widely available for the lay-people and it was not commonly recognized before the disaster, so the modernity of the nuclear power had come in front of the people.

This sense of modernity was not present at the beginning of the discussion about whether to accept the plant. For example, the local politician Tadao Iwamoto had organized an anti-nuclear movement before he was elected as the mayor of Futaba town in the period 1985-2005. However, after the decision of installment, he changed his political attitude toward nuclear into pro-nuclear. Kainuma points out Iwamoto's change not as a contradiction but as a consistent attitude based on regional patriotism (2011, 127). When the plant had already started operation and created economic and social benefits in the region, it was not a big difference between pro- or anti-nuclear power. Instead, what mattered was to sustain the region developed for the future generation. This is how the local politicians aimed the independence of the region from the influence of the state's government on the region and urban area. In fact, the economy of the Futaba town had been fairly stable, and the population sustained, unlike other rural areas without a nuclear power plant.

Kainuma analyses the relations that establish "nuclear village" in especially Fukushima case. Historical analysis of the Japanese urban-rural relations is helpful to articulate the proactive agency of the rural. Firstly, there was a separation between the center and rural areas by the centralized authority. Secondly, the re-connection between the center and the rural occurred for the powerful state policies. Thirdly, the neoliberal tactic of the government unequally distributes the capital and leaves the rural behind. According to these complex relations, the rural desires the independence to survive by implementing the center's policies, such as introducing a nuclear power plant. The decision-making is depending on the rural region's tactics whether or not to introduce the state policies regardless of the structural inequality. The rural willingly accepts the modern to sustain the premodern setting of the community, driven by regional patriotism (開沼 2011). Hence, the relation between urban and rural is not based on the domination of the urban or the center, but the desire of the modernization of the rural and independence from the center.

To sum up this chapter, I would like to emphasize the desire and agency of the rural. Unlike the conventional discussion about the urban-rural relations in the energy geopolitics studies, the rural does not only accept the risk of nuclear power plants for the economic benefit. Instead, the installation of nuclear power plants is also based on the desire of the modernization that the

local does not know well the details of the technology but implement the image of the modern. It also attributes to the regional patriotism to be independent from the central government.

4. The Biopolitical Regime in the Radioactive Contamination

4.1. What Matters with Radiation

Although a variety of actors, such as politicians, experts, fishers, activists, and laypeople are engaging the discussion about technical options with different positionalities depending on different discourses and practices, we must, first, examine the government's hegemonic discourse that sets a dominant base of the technical practices. This chapter investigates how the government sets a human-centered approach to radioactive protection, ignoring the radiation impact on the ecology, namely non-human. The government implements a "dose-effect model" that exclusively considers the effect of the radiation on a human body, reducing the complexity of radiation effect on non-human and human-in-ecology. Here, we can see how the biopolitical regime works at the molecular level only for standardized humans. In order to examine the post-Fukushima biopolitical regime that is the dominant discourse and practice, this chapter uses a diverse discussion on biopolitics.

Firstly, it uses the concept of geontology to analyze the government's power that distinguishes human and non-human, or in Povineli's words, Life and Nonlife (2016). It shows how the governmental discourse implements the specific model for radiation protection by maintaining and shaping the distinction between human and non-human such as fish or planktons, in whole ecological connections. Separated from non-human beings, biopolitics operates in the molecular level of the human body in a peculiar way. The first section considers the hegemonic discourse of the radiation that depends on the particular settings of human-radiation relationships.

In the second part of this chapter, the radioactive fish, the Nonlife, comes up into the arena of the techno-science society. Based on the hegemonic discourse, the fish is now transformed into food that humans consume. Fishery in Fukushima becomes a huge laboratory where the particular model of human-radiation relation applies to the whole fishery. The borderless ocean is cut into squares. Fish are collected as samples. The random data is translated into the whole measurement and regulation structure that become normal for the fishery practice. This series of the laboratorization of the fishery seems settled down as the governmental discourse is hegemonic. However, the reductionist biopolitics is sometimes disrupted by the overflows of other actors (see chapter 6).

4.1.1. Food or Marine Life

Fish, as a non-human being, has two characters. Fish is marine life living in ecology on the one hand, and it is a commodity as food for humans on the other hand. Although these two characteristics are intertwined, as seen, for example, in problems of depletion of fish resources and subsequent ecological degradation due to overfishing, these two characters are clearly distinguished in the discourses and practices around the fishery. Especially, the fishery in Fukushima is primarily commercial fishing that provides the landed fish and its marine products into the national and

international market. When discussing the radiation with fish, it is important to be cautious about this distinction. This is because fish is treated differently based on whether it is considered to be related to humans or not.

Anthropologist Povinelli's concept "geontology" helps us to understand the current governmentality regarding radiation protection after the Fukushima nuclear disaster. Her discussion transforms the prerequire of Foucault's theory of biopolitics, taking into account Nonlife. While biopolitics operates on the life of a human by letting it alive (Foucault et al. 2003), geontology focus on the relationship between Life and Nonlife and the power to distinguish these entities. Geontology or geontopower operates not through life and death but is "a set of discourse, affects, and tactics used in late liberalism to maintain or shape the coming relationship of distinction between Life and Nonlife" (Povinelli 2016, 4). Her argument based on the research of aboriginal people in Australia shows that the settler liberalism defines the distinction between Life and Nonlife, which conceals the indigenous people's animistic or totemistic views and relationships with non-human beings. In short, Life is the subject of governmentality, whereas Nonlife is forced away from the category of Life.

Hence, fish as species living in the complex ecology does not be the subject of biopolitics. In other words, the government rarely considers the effect of radioactive contamination on the life of fish. The impact of the radiation on fish is different from the one on the human body. The effect ought to be holistically measured and assessed with biological and environmental science research because different radionuclides differently affect species, not only to fish but also complex ecological chains from seawater, planktons, preys, small fish over big fish. Some radionuclides cause bioaccumulation depending on the features of substances. For example, tritium, radioisotope of hydrogen, bioaccumulates in planktons but not in fish (Nadesan 2013; Jaeschke and Bradshaw 2013). Some research also shows that exposure to tritium changes the form of larvae of some fish species (Suyama and Etoh 1981). Strontium 90, one of the most widely diffused radionuclides from FDNNP, is an analogous element of Calcium that accumulates to seaweed and bone of fish. Another radionuclide which is also one of the main contaminants of the disaster, Cesium 137, accumulates in the flesh of fish (Nakata and Sugisaki 2015). Each radionuclide affects a variety of fish and marine life differently depending on the species, living conditions (migratory or nonmigratory, the water depth of inhabitant, etc.), preys, and so on. Also, in case of releasing the contaminated water, the plan is justified because the main contaminant, tritium, rarely affects the human body. Based on the geontopower, the contaminated water has been renamed as "ALPS treated water". As Hecht (2012) examines the power to decide what is "nuclear", nuclearity does not apply to tritium contained water.

Therefore, if the fish life is taken seriously like human life, the assessment of the effect of radioactive contamination would be dramatically complicated embracing uncertainties. Fish life is important for environmental protection, and the biodiversity of the ecosystem closely connected to the fishermen's practices. Fishermen have lived in a close relationship with fish that is embedded in the local community and tradition. Ethnographic works show how fish plays an important role for the fishermen's local community and life (川島 2021; 相馬市史編さん委員会 2017). However, the governmental model for radiation protection is a human-centered approach that does not include fish life.

While Povinelli's argument is based on the animistic or totemistic world view of the indigenous people, her concept of geontology or geontopower is applicable to the case of Fukushima fish. Late liberalism government introduces and maintains the distinction between Life

and Nonlife, namely, human and non-human regardless of the meaning of the fish life for the environmental protection and fishermen's life. The geontopower is the basis for the biopolitical regime in the case of the Fukushima fishery.

Instead, fish come back to the biopolitical settings as food. Here, however, fish no longer has a form of life but is a subject of human consumption. Radiation effect and risk are calculated on the basis of human internal exposure from the consumption of the contaminated fish. In short, radiation in fish matters "insofar as human's food" in biopolitics. Shipping standards for radiation levels are set by the Ministry of Health, Labour, and Welfare, while monitoring of the environment (ocean, river, atmosphere) is conducted by the Ministry of the Environment. Contamination of fish is only measured as food, not an animal in the ecology. During the interview, the manager in the Fukushima Prefectural Research Institute of Fisheries Resources implied this distinction between human and nonhuman, and fish as food and non-food: "The target of the monitoring is the fish that we eat. We do not measure, for example, tiny goby fish or the tropical fish that come with the targeted fish.[7]"

In the following section, I examine the governmental implementation of the dose-effect model. As fish is separated from the environment throughout the geontopower, the model shows the biopolitics on the isolated human body at a molecular level.

4.1.2. Dose-effect Model and Molecular Biopolitics

While the life of citizens is devasted physically and mentally and fears on ever-present radiation with potential risk for diseases such as cancer or leukemia, the vitality of citizens is managed and controlled by a particular way of technocracy. Particularly, the fishers' life is separated from the accustomed livelihood connected with the environment. Life in Fukushima has transformed into a "half-life" of limited vitality even ten years after the disaster as if diffused radionuclides have a long half-life to naturally decay to induce half amount of radioactivity (Ferrier 2012).

The way of the governmentality in Fukushima is based on molecular biopolitics (Rose 2007a), implemented with molecular level scientific knowledge, namely, the dose-effect model. The molecular biopolitical regime is so solid and dominant setting of thoughts and practices that it designs not only governmental policies and medical and scientific practices in Fukushima but also shapes citizens' perceptions and practices on radioactive contamination. After the disaster, society has become a large "laboratory" where a particular scientific model is applied to Fukushima's whole population with translations intermediated by political strategies.

Widely diffused radionuclides from the destroyed reactors have raised complex issues such as people's health, nuclear policies, geopolitical tactics, and so on. The invisibility of radiation and radionuclides requires scientific and biological knowledge. For example, estimating the scale and amount of the released radionuclides on land, ocean, and atmosphere is crucial for evacuation and de-evacuation plans. Detection of radioactive contamination of food and water informs the basis for setting up a standard for restricting the commodities to prevent internal exposure. The effect of radioactive exposure on human bodies is essential for the government to make decisions for

[7] Interview conducted on November 10, 2020

policy. At the same time, it is also critical for citizen's daily practices for radioactive measurement for their products.

However, there are many uncertainties and scientific controversies about radiation. How much radioactive exposure to human bodies is harmful, which may potentially cause diseases such as cancer or leukemia in the future, is still discursive even in the scientific community (Nadesan 2013). In Fukushima, contamination is at a low level which is unknown for decisive impact on human bodies and the environment. While high-dose exposure to human bodies immediately causes the apparent symptom, for instance, headache, diarrhea, fever, and subsequently skin disorder, neurological, vascular disorder, or death[8], the effect of low-dose exposure to human bodies is still under controversy. There are deterministic effects and stochastic effects for relatively low-dose exposure. Nuclear science has shown that exposure to over 100mSv per year to a human body proportionally increases cancer and leukemia risk in the long term. This is called deterministic effects.

Meanwhile, the effects of exposure to below 100mSv per year are still unrevealed because it is difficult to prove and research about causality between low-dose exposure to radiation and increase of diseases that attribute to multiple factors in life (for example, the risk of cancer increases based on lifestyles such as smoking or overdrinking, or genetic differences) and the diseases appears in a decadal period. Therefore, the unknown effects under 100mSv are sometimes assumed as stochastic effects that dismiss the threshold of effects and hypothetically estimates the liner effect as much as the effect over 100mSv, for the purpose of radioactive protection suggested by, for example, International Commission on Radiological Protection (ICRP)[9]. Additionally, it is also difficult to assess causality between individual health issues and exposure because there was no data for individual exposure. Prediction of the radioactive exposure on individuals is derived from the environmental contamination and collective surveys. The potential risk of low-dose radiation exposure is still so uncertain and controversial that it makes room for political intentions.

Hence, even though politics implement biological knowledge and technology, science does not independently assess and show the impact of the nuclear disaster in the uncertainties and controversies. On the contrary, implementing a particular scientific and biological model to assess the impact of disaster is highly political. As Petryna shows in the Chernobyl case, real-life experience and suffering, which is often obscure, is different from the reductionist way into a particular scientific model of assessment and evaluation by the government's discourse (Petryna 2013). Even though there are many criticisms against it, the chosen model becomes so dominant in the discourse and practices from the policies to citizen science as a form of resistance. A particular science knowledge starts from the radiological science laboratory extends to the whole society in Fukushima, from discourses to practices, and from policies to ordinary life. This "laboratorization" of society (Latour and Woolgar 1986; Guggenheim 2012) is today happening at the molecular level of biomedicine.

Then, how is science knowledge implemented in real-life society in the forms of practices and discourses? How is invisible radiation transferred into measurable and manageable entities throughout the population's protection and assessments? To answer these questions, the concept of molecular biopolitics is relevant. Rose (2007b) develops the concept of biopolitics by Foucault

[8] Ministry of Environment Government of Japan. Health Effect of Radiation, Acute Radiation Syndrome (https://www.env.go.jp/chemi/rhm/h29kisoshiryo/h29kiso-03-03-02.html) accessed April 9th, 2021.
[9] ICRP, 2005. Low-dose Extrapolation of Radiation-related Cancer Risk. ICRP Publication 99. Ann. ICRP 35 (4) (https://www.icrp.org/publication.asp?id=ICRP%20Publication%2099) accessed April 9th, 2021

to fit it into contemporary liberal society. The concept of biopolitics has shown the interrelation between science and politics for governing people in modern society. Since nineteen-century biomedicine revealed physical and anatomical gaze in the human body, the body has been subject to management and control rather than punishment. Today, as biomedicine has developed at a molecular level, the biopolitical regime has entered the molecular level. A sequence of nucleotide bases and their variation (DNA and RNA components) and molecular mechanism provides the style of thoughts of the human body. This style of thought is a particular way of thinking, seeing, and practicing that creates a foundation to design certain things as evidence and gathered and used in certain ways. "Subjects are chosen and recruited. Model systems are imagined and assembled. Devices are invented to make measures and inscriptions such graphs, charts and tables" (Rose 2007b, 5). In the process of these complex practices, subjects are optimized into molecular-level data that are collectively analyzed at a population level. Technology that is an assemblage of politics, biomedical science, discourses, and practices not only cure diseases but also manage, control, and commodify vital processes of body and mind (Rose 2007b, 8). The molecular biopolitical regime has accelerated in the post-Fukushima society in Japan.

The radioactive effect is understood and treated at a molecular level of the body after the disaster. While the people's suffering is in a holistic way that is social, psychological, physical, and ecological, with uncertain long-term risk, the government's policies implement a single particular radiological model: dose-effect model (Nadesan 2019). The model considers health impacts such as cancer or leukemia in terms of radiation exposure to the human body. Based on the model, collective data is gathered. There are several surveys conducted in Fukushima: environmental surveys of real-time assessment such as atmosphere, soil, ocean, public facilities, forest, agricultural land, food, and drinking water[10]. While the standards of radioactive level of land are defined by the assumption of the yearly external exposure, the standards of food and water are defined by the assumption of internal exposure based on estimated yearly consumption. For example, the standard of food is calculated based on radioactive Cesium (134, 137) not to exceed to internal exposure of 1mSv/year[11]. Other radionuclides such as strontium 90 or plutonium are optimized with the amount of radioactive cesium even though each radionuclide effect in different way due to the chemical structure. The reason of optimization, the Ministry of Health, Labour, and Welfare is basically that it takes time to measure strontium 90 and others. The manager of the Fukushima Prefectural Research Institute of Fisheries Resources mentioned about the paradox of this in the interview:

> *"As well as cesium, there is also strontium, which of course leaks, but it is very difficult to test for it. It takes more than a week to make a sample because of the chemical treatment and the drying. That's one of the reasons why we didn't touch it in the prefecture. … Another thing is that, for food safety, the prefecture is measuring cesium that they are testing. And again, the Ministry of Health, Labour and Welfare set a standard for cesium, but they didn't set a standard for strontium. The half-life of strontium is very long. People are worried about it,*

[10] Nuclear Regulation Authority, Japan. Monitoring Information of Environmental Radioactive Level (https://radioactivity.nsr.go.jp/en/) accessed April 9th, 2021.

[11] Ministry of Health, Labour and Welfare. New limits for radioactive substances in foodstuffs New reference values (https://www.mhlw.go.jp/topics/bukyoku/iyaku/syoku-anzen/iken/dl/120117-1-03-01.pdf) accessed on June 22, 2021

yes, because it accumulates in the bones and people can't get rid of it for a long time, about a person's lifetime, so there are certainly people who are very worried about it.[12]"

In the dose-effect model, the radioactive effect is optimized in terms of the amount of exposure regardless of the difference of radionuclides, vulnerability, and lifestyle (Nadesan 2019). The impact of the radioactive contamination is reduced into a generalized effect on the human body while the effects of fish life and ecology are ignored.

The generalization feature of the dose-effect model is also apparent with external exposure calculation. Fukushima health management survey (FHMS) assesses the estimated amount of collective external exposure by collecting behavioral records, thyroid examination for under 18-year-old citizens, mental health and lifestyle questionnaire, a survey on pregnant and nursing mothers[13]. Data from the surveys are collected, stored, and analyzed with the assumption of the dose-effect model. Even though the mental health survey and lifestyle questionnaire are distributed to the Fukushima population, it does not contribute to the conclusion about radioactive impact. Instead, it juxtaposes the lifestyle risk with radiological risk. In fact, the political discourse on the risk of cancer by radioactive exposure equalized the causality. For example, a web page by the Ministry of the Environment says that the relative risk of cancer of a smoker is 160% compared to a non-smoker, which is the same relative risk to one-time exposure to 1000-2000mSv radiation[14]. The radiation effect on the human body is merely reduced to the ability to damage the DNA of body cells.

However, the dose-effect model is merely one particular model compared to other possible understanding of humans. The human body is objectified as a separate entity to be governed. Anthropologist Uchiyamada criticizes that the model is based on a peculiar and alienated assumption of worldview (Uchiyamada 2019). His argument is provocative; when we assume humans as "holobiont" (内山田 2019; van de Guchte, Blottière, and Doré 2018) – living in relation with other living beings such as intestinal bacteria, in intertwined ecology –, this modeling would collapse because the health and vitality of humans decrease as interdependent nonhuman beings are sensitive to radiation. A particular biomedical model of the dose-effect model has become dominant in creating discourses and practices by translating different conditions to collective homogenous data. Individual bodies are understood, managed, and enacted in terms of the molecular level of DNA, eliminating and abstracting individual social and other biological conditions.

As the molecular biopolitics regime has changed the way of understanding, seeing, and practicing life, the vitality of body and mind is decomposed, stabilized, managed, and transferred across space and time (Rose 2007b). The vitality of life in Fukushima has been shaped in relation to radiation measurement and concerns about radiation exposure. A French writer who experienced the disaster in Japan, Ferrier metaphorically describes life in Fukushima as "half-life":

[12] Interview conducted on November 10, 2020

[13] Fukushima Prefecture. About Fukushima Health Management Survey. (https://www.pref.fukushima.lg.jp/site/portal/ps-kenkocyosa-gaiyo.html) accessed April 9th, 2021.

[14] Ministry of the Environment, Japan. Let's Compare Cancer Risk. (http://shiteihaiki.env.go.jp/radiological_contaminated_waste/basic_knowledge/carcinogenesis_risk.html) accessed April 9th, 2021.

> "Getting used to a life of disconnection (a life where the simplest of pleasures, like the joy of eating lettuce without worry, or standing in the rain with a big smile on your face, are disconnected and completely impossible). We live in a fragile time, broken into pieces, and cut off from the rest of the world" (Ferrier 2012, 278–79)(translated from Japanese to English by the author of this thesis)

Life in Fukushima has become "half-life" as if radionuclide has a "half-life" to decay to be less radioactive in half, sometimes which takes some days, sometimes takes thousands of years depending on a kind of radionuclides. Especially, fisher's life that had connected to the fish is now disconnected due to radiation. Objectification of radiation based on the dose-effect model has disentangled the interconnected life with fish. In the following section, I describe how the scientific discourse and practice based on the particular model enter the fishery practices in the field.

4.2. Laboratorized Fishery

The triple disaster, namely the combination of the earthquake, the tsunami, and the nuclear accident of FDNPP, massively changed the fishery life in Fukushima. The earthquake and the tsunami had taken the fishers' family members, friends, and do fishing (Yanai 2019). The disaster destroyed a number of fishery properties: fishing boats, equipment, ports. Most of the fishermen I interviewed mentioned the change in the environment due to the earthquake and tsunamis. One mentioned subsidence of the seabed for several tens of centimeters, another mentioned loss of the ecosystem of the seabed such as loss of seaweed that is prey and habitat for some marine life.

The ocean could naturally recover as it had experienced several earthquakes and tsunamis before. Fishermen could repair or buy fishing equipment. However, radioactive contamination by destroyed FDNPP has been a significant burden on the Fukushima fishery, especially compared to fishermen in other prefectures affected by the disaster. Large areas of the Pacific Ocean and marine system off Fukushima have been contaminated not only by the radionuclides that fell directly from the explosion at the FDNPP but also from those washed from piles of contaminated land and rivers, and some leaked from cooling operations after the accident. The radionuclides have been found in seawater, plankton, sediments, benthos, and marine fish in a large area (Nakata and Sugisaki 2015). Radionuclides have contaminated the fish body through seawater, sea soil, and prey, sometimes accumulated with bioaccumulation in the ecological system. Thus, in the years following the disaster, high radioactivity has been detected in fish caught in Fukushima offshore. It led suspend of the operation of the Fukushima fishery (Morita 2015; Nemoto et al. 2018).

The Fukushima fishery, which has a long history, is of economic importance for the locals, struggles to recover after the disaster. Situated in a rural area of Japan, approximately 200km far from the metropolis of Tokyo, Fukushima had been one of the most successful fishery regions due to the fertile fishery ground. There, local life in the seacoast has been deeply embedded in the relationship with the sea and fish (Uchiyamada 2019). Confronted with the disaster, however, the fishermen have lost their economic means and, moreover, needed to modify their relationship with the sea. Those who still had or bought fishing boats collected debris that was carried by the tsunami

in the sea ground, waiting to restart fishing and receiving compensation money from TEPCO (Uchiyamada 2017 and data from interviews).

4.2.1. The procedure of Radiation Measurement

4.2.1.1. In Research Institute

There are two main procedures of the radiation measurement; the first one is the official measurement called "emergency environmental monitoring," the other is voluntary inspection called "screening test" conducted by the fishery cooperatives. Even ten years after the disaster, the monitoring test is named as "emergency" because this measurement is only started after the disaster only in Fukushima prefecture. The status of emergency is being normalized. Monitoring test is conducted by prefectural research institutions under the Act on Special Measures Concerning Nuclear Emergency Preparedness. The government prepares the plan of monitoring tests. Based on the result of the monitoring, the government imposes or amends the regulation of shipping and consumption. The sampled fish caught by the fishers and research ships are mapped in straightly cut areas of the ocean. The connection between the ocean area and the fish are created. Then it is sent to the Fukushima Agricultural Center in Koriyama city in Fukushima to measure the radioactivity as well as other raw food products such as rice or beef meat. This research center currently measures approximately 50-60 specimens of fish in a week, previously 120-130 until shipping restriction of fish were all rifted. (cf. After my research, regulation on one type of fish, Black rockfish (Sebastes schlegelii Hilgendorf), was reintroduced due to the detection of high radioactivity[15])

The process of the measurement is a process of the secluded research to make the data "pure." Everyone who enters changes shoes and leaves a bag not to bring radioactive contamination in the laboratory. The package of the sample is checked with a Geiger counter if there is contamination outside. Then, the fish is cut into mince and put into a container (figure 6). The rooms are separated from the potentially contaminated area to clean area. Cloves and plastic bags are changed every sample. The sample is checked in one of eleven Germanium semiconductor detectors for 2000 seconds (figure 7). The detector is special equipment made with lead not to get effect from the atmosphere radiation, which costs about 270,000 dollars. The center publishes the result weekly on the website and sends it to the national agency for the decision of the regulation.

All the processes of the measurement are secluded from society. The fish is caught, washed, and cut in the separated process. There is no chance that ordinary citizen brings their own materials to the center. While city halls in Fukushima have services for individual measurement for individual concerns, it does not render any regulation at the national level.

At the same time, the laboratory is open for the data and process. The manager told me the importance of the publication of data and the openness of the facility. They put many posters and signs of explanations and data both in Japanese and English on the corridor and in the

[15] NHK. On April 19, 2021. Sea area off Fukushima, the national government ordered to restrict shipment of black rock fish (https://www3.nhk.or.jp/news/html/20210419/k10012984641000.html) accessed on June 23, 2021.

laboratory. "We don't shy away from these opportunities, and we accept them as much as possible. Last year, we had about 100 visits a year. About 30% were overseas…. I hope you can see it in this way and understand it better.[16]" The research process is secluded, but the data is open because the radiation measurement matters for the national and international affair.

Figure 6 Putting specimen into a container, photographed by the author on November 27, 2020

Figure 7 Germanium semiconductor detectors and a researcher, photographed by the author on November 27, 2020

[16] Interview on November 27, 2020.

Additionally, the prefecture organizes research on radioactive contamination in Fukushima Prefectural Research Institute of Fisheries Resources in Soma for detailed research. It researches the difference of contamination based on the ages, sizes, and body parts of fish, preys contained in the stomach or caught by a research ship. They also feed radioactive prey to experimental fish (Spotted halibut, Verasper variegatus) to check intake and outtake process (figure 8). They incorporate with other research institutes like universities. They use the Spotted halibut because it is "very calm" that does not move in the Nal scintillation detector. While the contamination tendency is different depending on the fish species, one type represents all types of fish in terms of radiation intake and outtake. The radioactive contamination occurs in fish life both from seawater and preys, but the research is reduced based on the manageable way.

Figure 8 Experimental fish for radioactive intake and outtake, photographed by the author on November 10, 2020

Not all the data is published from the research. The manager of the institute told me they have several times more than the published data. However, the data of radioactive contamination gives meaning to the capitalist society when it is the radioactivity on the body of fish that defines the regulation, and the particular model subsequently transmits to the society. The complex and secluded research is simplified and reduced for a certain means.

4.2.1.2. Data Going Back to the Society

The government has gradually rifted the regulations on certain types of fish based on the monitoring results. Subsequently, the fishermen restarted fishing as a "testing operation" about one year after the disaster, limiting the fishing area, types, and amount of fish (Nemoto et al., 2018). Nine fishery ports have consolidated into two main ports – the northern one is Soma (my research

field), and the southern one is Iwaki – because most of the ports were damaged by the tsunami. The middle part of Fukushima had been restricted to access[17]. The recovery from the earthquake and tsunami has slowly in the process, but the radioactive contamination remains.

For consumers of the fish, the national standard (100Bq/kg) and rift of the restriction has not been sufficient (Kimura 2016). Invisible radiation renders the fear and uncertainty of the safety of the fish even though the government announces to deem the safety. To tackle the uncertainty of the radiation, the fishermen again needed to implement the scientific knowledge; they started to conduct a voluntary measurement so-called "screening test." The main two ports deployed radioactive monitoring equipment; the Onahama fish market in Iwaki city employed radioactive detectors (NaI scintillation detectors and CsI scintillation detectors) in the facility of the fishery cooperative in 2014 while the Haragama fish market in Soma did in 2016. The technical knowledge that is shaped in the technocracy and developed in the secluded research now localizes among non-expert fishermen and fishery cooperative staff.

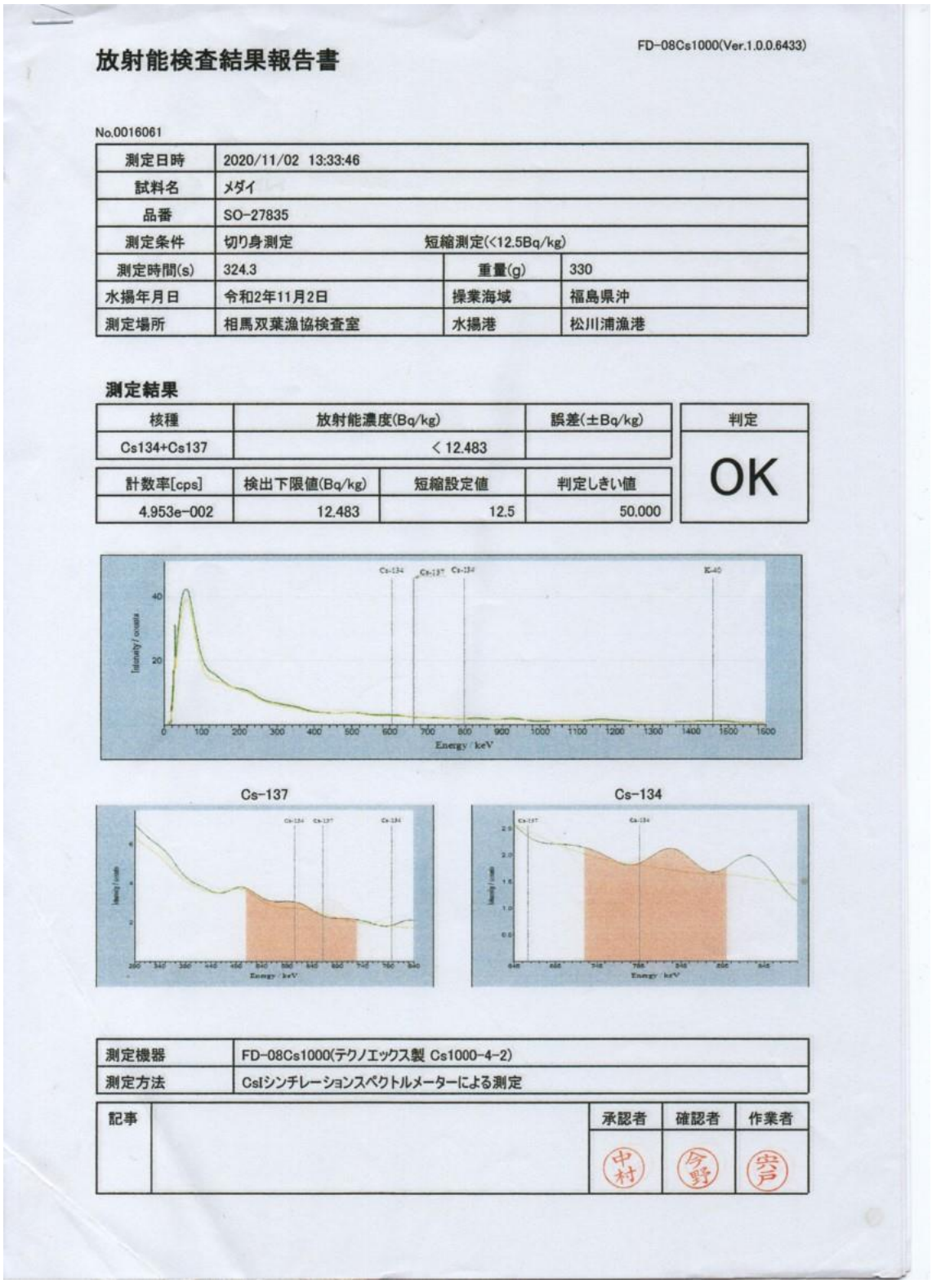
The screening test is conducted in the following process. Caught fish and clams and harvested seaweeds are sorted based on the species, size, class, and quality in the collaborative sorting facility of the fishery cooperative, prepared for sales for brokers (Figure 11 and 12). The staff of the fishery cooperative takes some of the fish into the belonged laboratory to measure the contained radioactivity level of Cesium 134 and Cesium 137 (Figure 13). The reason why they only measure radioactive Cesium is that the government's measure is based on the Cesium radioactivity as the standard. Moreover, NaI and CsI scintillation detectors are not detectable with other radionuclides such as tritium or strontium 90. The result of the measurement is published in the form of a "radiation measurement report". For example, the figure 14 is a report of a Japanese butterfish (Hyperoglyphe japonica). The fish's radioactivity is below the detectable standard of the CsI scintillation detector (12.486Bq/kg). If the number of radioactivity is detected more than 25 Bq/kg, the sample is re-examined in the prefectural testing center. The Fukushima fishery sets voluntary regulation with 50Bq/kg to ship to market while the governmental standard is 100Bq/kg. It is because the fishery cooperatives want to prevent a loss of credibility in the safety of the fish in case that it reaches the market in excess of the government's standards (Nemoto et al. 2018). This arbitrary and voluntary setting of the voluntary standard implies that the governmental "safety" standard of 100Bq/kg connects to the credibility of the society and consumer. However, in fact, the provisional regulation standard was 500Bq/kg for one year after the disaster that privatized the responsibility to citizens (Polleri 2019). The dramatical lowering of the standard implies how arbitral and political is the standard, but still, the standard itself is considered as an important reference of the society.

[17] NHK. All fishing ports in Fukushima to reopen: Tomioka fishing port expected to reopen. June 4, 2019. (https://www.nhk.or.jp/politics/articles/lastweek/18406.html) accessed on June 22, 2021.

Figure 9 Sorting Fish in Soma-Haragama port, photographed by the author on November 11, 2020

Figure 10 Sorted Fish in Soma-Haragama port, photographed by the author on November 11, 2020

Figure 11 Measurement facility in Soma-Haragama Fishing Port, photographed by the author on November 11, 2020



放射能検査結果報告書

FD-08Cs1000(Ver.1.0.0.6433)

No.0016061

測定日時	2020/11/02 13:33:46		
試料名	メダイ		
品番	SO-27835		
測定条件	切り身測定	短縮測定(<12.5Bq/kg)	
測定時間(s)	324.3	重量(g)	330
水揚年月日	令和2年11月2日	操業海域	福島県沖
測定場所	相馬双葉漁協検査室	水揚港	松川浦漁港

測定結果

核種	放射能濃度(Bq/kg)	誤差(±Bq/kg)	判定
Cs134+Cs137	< 12.483		OK

計数率[cps]	検出下限値(Bq/kg)	短縮設定値	判定しきい値
4.953e-002	12.483	12.5	50.000

Cs-137

Cs-134

測定機器	FD-08Cs1000(テクノエックス製 Cs1000-4-2)
測定方法	CsIシンチレーションスペクトルメーターによる測定

記事		承認者	確認者	作業者
		中村	今野	宍戸

Figure 12 A Radiation Measurement Report, published by the fishery cooperative laboratory on November 2, 2020

Before the disaster, the knowledge about radiation had been only in the radiology laboratories and a few food security research institutes. All the research centers I visited (Fukushima Agricultural Center, Fukushima Prefectural Fishery Resource Institute, and fishery cooperative laboratory) introduced the measurement equipment only after the disaster. The non-

expert staff has gained knowledge because they had lacked knowledge and experience of measurement before. When I asked about previous experiences of radiation, the experts of institutes answered with a laugh, "No, no. We were not used to[18]" "we started to learn about radiation by reading existing literature[19]." The knowledge distributes from a small laboratory of radiology to the institutes.

Moreover, the technical knowledge of radiation has become a widely available reference to the public as well. A marine product shop of a fishery cooperative hanged posters of explanation about the basic knowledge of radiation: "the difference between radiation and radioactivity" and "the measurement procedure" with a picture of NaI scintillation machine (Figure 13). A sticker of measurement was attached in products, saying, "Tested with Non-destructive radioactivity testing equipment" (Figure 14). The radioactivity measurement report is attached to the marine product from a broker to the retailer. The translation of the technological knowledge (Callon, Lascoumes, and Barthe 2009) implements throughout the course from a laboratory to the society. Due to the radioactive contamination, in this case, the Fukushima fishery has been laboratorized.

[18] Interview in Fukushima Agricultural Center on November 27, 2020.
[19] Interview in Fukushima Prefectural Fishery Resource Insitute on November 10, 2020.

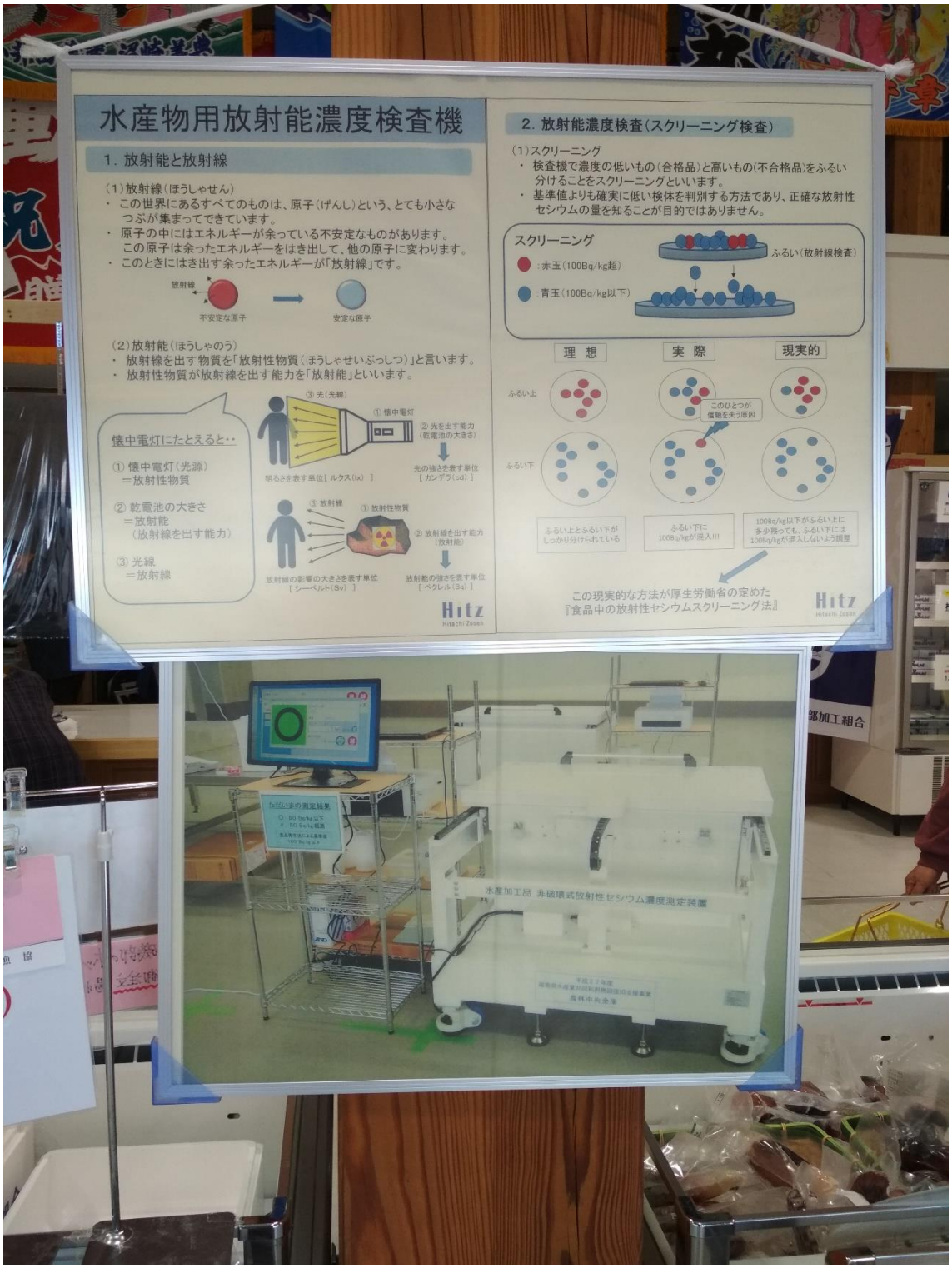


Figure 13 Posters in a marine product shop, photographed by the author on November 3, 2020

Figure 14 Marine product with sticker, photographed by the author on November 3, 2020

5. Normalization of Radioactive Contamination

When I talk about Fukushima with my colleague and friends from different regions inside and outside of Japan, what they ask me is "is it safe to go there?" or "are anyone living there?" that questions the radiation effect after the disaster. Furthermore, when I talk about my research topic, fish in Fukushima, they probably say that they would not eat the fish from Fukushima. One of my colleagues from Uzbekistan that was one of the test sites of the Soviet's nuclear weapon in 1968, even said to me, "don't eat the fish!" when I introduced my field research to her. Radiation – which is not familiar to most people at all – has an extremely powerful and negative image connecting to fear and anxiety, probably from the previous nuclear weapons and nuclear accidents. Atomic bombings in Hiroshima and Nagasaki devasted people's life in the vast area, pictured shocking tragedies that have never been seen before. The potential nuclear war in the Cold War era intimidated people with an apocalyptic scenario. Atomic and nuclear is a synonym for the layperson (Zonabend 2007). The recent TV series "Chernobyl" (2019) [20] hits worldwide, proposing continuous fear about the nuclear disaster.

At the same time, radiation is sometimes mythical because of its high scientific and technical features. Measurement of radioactivity requires technical equipment such as a dosimeter which is rarely available for the layperson. The scientific and technical language about radiation does not normally appear in daily conversations – technical words such as radiation, radioactivity, exposure, or dose, or radiological units such as Sv (Sievert) or Bq (Becquerel). Generally speaking, non-expert people rarely have ideas about radiation in scientific and technological terms. Instead, they have a negative and mythical image of radiation.

The field, however, showed a very different reaction to the radiation. Ten years after the nuclear disaster, radiation is extensively and deeply embedded in the daily life in Fukushima. There are 628 monitoring posts and 3099 real-time dosimeters to measure air dose of radioactivity in public facilities[21] (figure 15). These air dosimeters display real-time air dose radioactivity with the unit of radiation dose, the sievert. The data is available online and in a local government magazine (figure 16). The magazine below, for example, says "time: 8 am, unit: μSv/h" "Ono Kindergarten: 0.074 (October 1), height of the measurement 50cm". For those who are not familiar with radiation, for instance, as a graduate student of social science, this number does not make sense; what does the unit "μSv/h" mean? Is 0.074 high or low? Is it safe? Without technical knowledge about radioactivity, numbers from measurement do not indicate anything.

[20] HBO Chernobyl (https://www.hbo.com/chernobyl) accessed on May 18, 2021

[21] Fukushima Prefecture "Radiation levels in the prefecture" (https://www.pref.fukushima.lg.jp/site/portal/list272-851.html) accessed on May 24, 2021

Figure 15 Real-time dosimeter in a park in Soma City, photographed by the author on November 16, 2020

市内空間放射線量

●問い合わせ先　放射能対策室（☎ 37-2270）

モニタリングポストなどの測定値（市内 67 箇所・文部科学省設置）

（時間：8 時現在　単位：μ Sv/h）

■幼稚園・保育園・児童施設
（測定の高さ：50 センチメートル）

施設名	10 月 1 日	11 月 1 日
大野幼稚園	0.074	0.073
飯豊幼稚園	0.065	0.062
八幡幼稚園	0.068	0.081
日立木幼稚園	0.073	0.067
磯部幼稚園	0.076	0.070
山上幼稚園	0.103	0.095
中央児童センター	0.064	0.074
川原町児童センター	0.069	0.084
中村幼稚園	0.061	0.064
中村報徳保育園	0.058	0.069
相馬保育園	0.063	0.072
みなと保育園	0.056	0.052
さくらがおか保育園	0.050	0.068
福島ヤクルト相馬センター保育室	0.063	0.057
のびっこらんど相馬	0.088	0.103
のびっこらんどキララ	0.067	0.069
相馬愛育園	0.083	0.082

■小学校（測定の高さ：50 センチメートル）

施設名	10 月 1 日	11 月 1 日
中村第一小学校	0.077	0.063
中村第二小学校	0.072	0.065
桜丘小学校	0.061	0.055
大野小学校	0.072	0.071
飯豊小学校	0.063	0.075
八幡小学校	0.060	0.075
日立木小学校	0.067	0.069
磯部小学校	0.057	0.064
山上小学校	0.085	0.081
旧玉野小学校	0.142	0.150

■中学校（測定の高さ：1 メートル）

施設名	10 月 1 日	11 月 1 日
中村第一中学校	0.081	0.081
中村第二中学校	0.059	0.077
向陽中学校	0.079	0.074
磯部中学校	0.086	0.090
旧玉野中学校	0.125	0.131

■高等学校・専門学校など（測定の高さ：1 メートル）

施設名	10 月 1 日	11 月 1 日
相馬高等学校	0.082	0.075
相馬東高等学校	0.094	0.114
相馬看護専門学校	0.087	0.088

■都市公園（測定の高さ：1 メートル）

施設名	10 月 1 日	11 月 1 日
馬陵公園　長友グラウンド	0.097	0.099
塚ノ町緑地	0.088	0.092
大野台公園	0.111	0.113
前沢目公園	0.070	0.076
新町緑地	0.084	0.078
桜ヶ丘東公園	0.083	0.092
高平公園	0.095	0.080
高池前公園	0.084	0.088
刈敷田東公園	0.062	0.073
刈敷田西公園	0.069	0.069
角田公園	0.079	0.089
沖ノ内公園	0.071	0.080

■公共施設など（測定の高さ：1 メートル）

施設名	10 月 1 日	11 月 1 日
東部公民館	0.047	0.049
大野公民館	0.064	0.063
飯豊公民館	0.047	0.048
山上公民館	0.050	0.051
玉野出張所	0.148	0.142
スポーツアリーナそうま	0.088	0.085
図書館（振興公社振興ビル）	0.084	0.084
総合福祉センター（はまなす館）	0.130	0.129
相馬光陽パークゴルフ場　管理棟	0.079	0.091
相馬光陽サッカー場	0.085	0.092
一般廃棄物埋立処分場	0.060	0.061
道の駅そうま　体験実習館	0.092	0.098
さけふ化場	0.082	0.073
松川浦スポーツセンター	0.099	0.101
相馬地方広域水道企業団	0.063	0.063
富沢公会堂前空き地	0.069	0.071
小倉公会堂	0.073	0.074
蒲庭公会堂	0.072	0.076
東玉野農業研修施設隣	0.079	0.080
副霊山生活改善センター	0.104	0.105

※測定機器の状態により欠測となる場合があります。
※モニタリングポストの数値を、1 μ Gy/h（マイクログレイ毎時）＝ 1 μ Sv/h（マイクロシーベルト毎時）と換算しています。

令和 2．11．15　広報そうま ❻

Figure 16 Soma City magazine "Koho Soma" page 6 "Air dose in the city". November 15, from Soma city website (https://www.city.soma.fukushima.jp/material/files/group/34/kouhou_20201115.pdf) accessed May 24, 2021

The people in Fukushima have developed scientific literacy after the disaster by having their life with radiation (cf. Kimura 2016). Although the national media provided information about radiation right after the nuclear accident, it rarely broadcasts about it after ten years anymore. On

the contrary, in Fukushima, scientific knowledge about radiation constitutes a common sense that people constantly refer to, and the technical language is in the daily conversations. Throughout experiences with continuous radioactivity in everyday life, laypeople have acquired literacy of the technical knowledge of radiation. Scientific knowledge as a dominant discourse in society provides temporal relief to react to the uncertainty of radiation. Anxiety about the invisible material seems settled down. Instead, the feeling of "safety" comes to ordinary life in the radioactive environment. Since it is the most available, or rather, dominant way as seen in the previous chapters, air-dose measurement and radioactive level of the food constitute the standard for the people to refer and reflect about the life with radiation. Depending on these measurements, the people in Fukushima accept the governmental discourse about the radiation effect on the one side, and they accept the unpredictability of the radiation. Whether the measurements are convincing or not, the people living close to radiation conceive it unmythical throughout experienced practices (Storm 2018). This chapter depicts the normalization of the radiation, where the technical question seems settled down.

5.1. Acceptance of the Governmental Discourse

Although the measurements of radiation based on the dose-effect model are scientifically and socially controversial, as discussed in the previous chapter, they create the hegemonic setting where the politicians, experts, and laypersons think, act, and practice inside. This section focuses on how the laypersons in the Fukushima fishery conceive safety referring to the governmental standards. Although there are always uncertainties regarding the radiation, such as the potentiality of high contamination from hot spots or unknown effects from the long-term exposures, etc., the official discourse based on the particular and arbitral scientific knowledge (dose-effect model) tends to conceal other ways of understanding and interpretation of the radiation. This hegemonic discourse converts the particular scientific knowledge into a universal reference for safety. When the scientific knowledge is produced in the secluded setting is put into a black box, the laypeople do not question the inside of the box but implement it for their own means.

As seen in the previous chapter, radioactivity measurement of the landed fish, clays, and seaweed has become a part of the fishery processes in Fukushima. The measurement conducted in the fishery corporative is normalized in the conventional process from catching to the distribution of marine products.

The interviews with the fishers show that the measurement has been recognized as if it is the same as the other checking. The practice of radioactivity measurement is not mythical and highly technical but a normal and everyday practice (Storm 2018). Mr. Kumagai is a fisher specializing in clam and seaweed for more than 50 years. He explained the process of radioactive measurement as normalized practice. "Whatever I catch, like clams, fish, or seaweed, I bring it to the fishery cooperative. You know, there is equipment for radiation checking. … They check if the seaweed contains some dust. And they label a class based on the quality[22]". He aligned the radioactive measurement as a part of the other non-radiation measurement. He had not seen how the measurement was conducted since he relied on the fishery cooperative. The radioactive measurement is not something technological away from the ordinary practice but a part of the fishery practices that fishermen consider normal.

[22] interview with Mr. Kumagai, conducted on November 4, 2020

The measurement based on the hegemonic model visualizes the existence or nonexistence of radiation so that some fishermen argued that the checked fish in Fukushima is much more "safe" than unchecked fish from another prefectural coast. I interviewed a young fisherman when he was doing leisure fishing with his wife and small kids.

> *Conversely, I think it (fish from the Fukushima coast) is safe because they check every time. Do they check in Miyagi or Ibaraki (neighbor prefectures)? It seems to me that they do not want to check because if they detected high radioactivity in fish, it would cause big trouble. The fishermen there are not receiving compensation money (from TEPCO). … here, the (fishery cooperative's) standard is stricter than the normal (standard by the government) and still pass. So, conversely, I think it is safe. … Our family does not care what to eat that much (regarding radioactive contamination).*[23]

For the most non-expert, the hegemonic model conceals other technical options and shapes the settings for practice and discourse that laypeople conceive and act inside. Petyna (2013) reveals the laypeople's implementation of biological knowledge that shapes citizenhood after the Chernobyl disaster. Also, Sternsdorff-Citerna (2019) shows the scientific citizens that acquire the scientific knowledge and literacy to protect their lives in the case of food safety in Fukushima. Both works of the literature show the agency of citizens implementing technological knowledge. As seen in the young fisherman's narrative above, the non-expert has gained the knowledge and literacy to make a decision whether the fish from Fukushima is safe or not. However, the technical knowledge is already put into a "black-box" inside of which is unquestionable; once put into a black-box, the whole process of the knowledge forming from the choice of a particular model over sampling translations to the result of the measurement is immobilized.

5.2. Ignorance

The normalization of radiation in a different shape as well. It is also important to mention here that the people get accustomed to radiation by living with it for 10 years. The closer the people live with radiation, the less they are afraid of it. Radiation has become unmythical for the people living with it (Storm 2018). This section focuses on the people's practice and discourse about food. The discourse about "safety" is divided into two words in Japanese: anzen (safety) and anshin (feeling of safety) (cf. Sternsdorff - Cisterna 2019). These two words are sometimes used in the set "anzen-anshin" that fulfills the objectivity and subjectivity of safety. However, of course, the objectivity of safety cannot be objective like as stable science facts people imagine but constituted in a certain setting of the discourse and practice as seen in the previous chapters. The subjectivity of safety is often supported by the objectivity of the safety. But subjectivity of the safety can also be made up from getting accustomed and/or getting tired to be conscious about radiation. A 60s-year-old fisherman mentioned:

[23] Interview on November 20, 2020

I live in Fukushima, so I have some knowledge about radiation. But there are many prejudices in other prefectures. People from Osaka or Kumamoto (other prefectures) were surprised that we were drinking tap water. … right after the disaster, I was drinking bottled water. But we have never been told to stop drinking tap water because they check it. You would be careful if you have children, but I do not care about radiation at all, in my daily life. … a few years ago, the city decided to provide school lunch for free by using local food. That is because it would be wrong if the local people don't eat local food when we are saying food from Fukushima is safe [24]

When I asked a manager of a marine product company, he emphasized that the decision of whether to eat or not depends on the individual. He eats a wild mushroom that is famous for accumulating radionuclides and is still prohibited from shipping to market.

But you cannot avoid eating if you are here. I eat wild mushrooms during its season. Three or four years after the disaster, people did not eat mushrooms, saying "it is gross." Now I eat if I get one from someone. In the end, it's the decision of the person who eats it that counts. If they think it's OK, they'll eat it. As advertised on TV, saying like all rice is tested, the people who eat it will eat it, and the same logic applies to fish. In the end, it's up to the consumer to decide[25].

68-year-old fisherman's narrative implies the uncertainty of radiation risk.

I'm fine. I eat radioactive mushrooms. I'm fine, you know. I'm old. There are people who bring mushrooms. I do not have much risk of getting cancer even if it contains 100 Bq or 10,000 Bq. You know, some people say that getting cancer is like a car accident. If you think about it, some people don't get it until they die, some people do. Some people just die. Some people are born with it. Human beings are given life by God. We don't live by ourselves. We are only kept alive by God. In the end, our life span is fixed[26].

Even though radiation is visualized with measurements, there is no information covering every food they eat, every corner they live in. To act in the uncertain world is also one choice to ignore the uncertainty. A narrative of the manager of the marine product company implies this kind of action.

There is no guarantee that there are no "bacteria"(analogy to radiation) in Hokkaido products. It's just not tested. We don't even know where the radiation is spread in the sea. In reality, there have been cases in the past where spot checks have been carried out on random seabed locations, point A, point B, point C, and the result was that the numbers were drastically higher there. That's why, if you examine it carefully, there is nothing you can eat. It's just a matter of saying, "We've tested it," and then it's up to the consumer to decide whether they want to eat it or not. People can't stop eating. So, if you take 100 fish and test them all, you might get a very high figure. But we don't do that. We just pick them up and do it. Realistically, we can't get the whole amount[27].

In the previous section, I have examined how the governmental discourse dominates the discourse and practices that non-expert people trust. In this section, I have described how people with knowledge sometimes choose to ignore radiation to maintain life. Measurement, to some

[24] Interview on November 17, 2020.
[25] Interview on November 16, 2020.
[26] Interview on November 13, 2020.
[27] Interview on November 16, 2020.

extent, reduces uncertainty by visualizing the amount of radioactivity with the technological and scientific procedure of translation. However, it cannot completely eliminate the uncertainty of hot spots or unknown effects. Rather, it merely makes a reference to society. Therefore, to live in the uncertainty of the radiation is also one way to ignore the uncertainty and have life "as usual."

6. Overflows

6.1. Ecological fish

Fish lives in the ecological chain with other non-human beings in the environment. It complexly migrates based on the ocean temperature difference, the ecological activities such as spawning, and shifting of feeding grounds, etc. The measurement conducted by the official research institutes, as mentioned before, do not cover the complex migration of fish. One fisherman was angry about the devastation of the environment by the contamination, mentioning migratory fish, mackerel. Tracking research showed a mackerel migrated from Fukushima coast to approximately 300km away, Chiba coast. He accused TEPCO made the disaster, and the fishing practice was devasted[28]. The expert of the Fishery Resource institute was also conscious of the migration of the fish.

> *We are getting to know the flounder ('s migration). There are some flounders that go far away. Some went to Kanagawa after they passed Tokyo Bay (approx. 500km away), and some maybe as far north as Iwate (approx. 250km). With Pacific cod, looked at the cesium levels not just in the prefecture, but in the whole of the country, there were some tested over 100Bq/kg in Aomori or Hokkaido (approx. 550km away). So, it's definitely from here*[29].

The manager of the marine product company, as quoted before, was also skeptical of the way of the measurement: "*There is no guarantee that there are no "bacteria"(analogy to radiation) in Hokkaido products. It's just not tested. We don't even know where the radiation is spread in the sea. In reality, there have been cases in the past where spot checks have been carried out on random seabed locations, point A, point B, point C, and the result was that the numbers were drastically higher there. … So, if you take 100 fish and test them all, you might get a very high figure. But we don't do that. We just pick them up and do it. Realistically, we can't get the whole amount*[30]" Migration of fish proposes a question about the way of the measurement. While scientific practice requires the process of separation, optimization, and translation, the complexity of the fish migration and measurement limitation for number shake the credibility of the process of the measurement and its prerequisite. The fishermen who are working in the ocean know the fallacy of the governmental logic of the measurement.

Moreover, the government's logic about radioactive contamination is only based on the prerequisite of fish as food. However, the radioactive effect on the ecology where fish are a part should be taken into consideration, Mr. Oda warned through his experience of the environmental change of the Ocean.

> *There are more fish without eggs. … Fish eat all sorts of things when they grow up, but when they're born, they eat plankton. … Fukushima prefectural research only conducts once or twice a year. We, fishermen, know more (about ocean) because we go there every day. We don't know the effect (of radiation) on planktons because they don't research about it. … Ocean has really changed, compared to before the earthquake. The ocean is always*

[28] Interview on November 7, 2020.
[29] Interview on November 10, 2020.
[30] Interview on November 16, 2020.

changing. I don't know if it is the effect of tritium or if it is the effect of radiation, but we don't know. That's why we need researchers. People think there are fish in the sea all the time, but there are not. It's nature. There are no fish anymore. The fishing way is different from the one I did 50 years ago. The sea has really changed. … There is also global warming. Lobsters and other fish used to be caught in the south. I don't know if that's due to radiation or not. Is this a radioactive effect? There are many factors, and radiation should be one of them. I'd like to know why the government doesn't spend enough money to investigate the effects of radiation. I think we should have more results. Then, we can deal with it, like releasing fry fish[31].

Mr. Oda considered the effect of the radiation on the whole ecology throughout his experience in the ocean. He compared the lived experience to the prefectural research. While research is secluded, fishermen's experience is open that does not translate but updates with small details throughout the everyday encounter. Here, a question about the research and measurement arises. However, the knowledge from the lived experience is so unstable that it does not develop into a collective political claim. According to my interviews, many fishermen and fishery workers notice or heard about the notion "there are fish without eggs." However, some fishermen hesitated to attribute the reason to radiation. The uncertainty of the effect of radiation is not solved.

The radiation effect on the ecology also concerns the releasement plan of the contaminated water. Some fishermen mentioned the ecological effect of tritium and other radionuclides on the contaminated water. The government and TEPCO claim the main contaminant, tritium, is not harmful to the human body and fish when diluted sufficiently[32]. TEPCO is planning to conduct research to grow fish in the treated water to assess the effect[33]. TEPCO argues that this research will show the safety of releasing the water and no harm to fish. However, the setting of the research – growing adult fish in the contaminated water and assess the effect on the fish body – is isolated from the ecology. This experiment plan does not settle the concerns of the fishermen who are worried about the consequence of the release.

Rather, the fishermen proposed other technical options for the contaminated water. The options are to keep the water into big tanks or release it from the ocean of all.

They can prepare big tanks to keep the contaminated water for 60 years because 60 years is roughly the half-life (of tritium). That'd be cheaper, I think. ... If you consider the effects overall. And it's a global problem. It's not just for Fukushima. It could affect almost everyone who uses the sea. ...

If it's going to be discharged into the ocean, one option would be the decentralized one, from all over the country. Not just in the Fukushima ocean if it's really going to be released. Why Fukushima? Osaka raised its hand (to release the water into Osaka Bay), so why don't we start with Osaka first, on a trial basis?

[31] Interview on November 13, 2020.

[32] TEPCO. Treated water portal site. (https://www.tepco.co.jp/en/decommission/progress/watertreatment/index-e.html) accessed on June 26, 2021. Ministry of Agriculture, Forestry and Fisheries. Questions and answers about marine products (radioactive material survey) (https://www.jfa.maff.go.jp/j/kakou/Q_A/) accessed on June 26, 2021.

[33] TEPCO. April 16, 2020. The Company's response in light of the government's basic policy on the disposal of ALPS treated water from FDNPP (https://www.meti.go.jp/earthquake/nuclear/decommissioning/committee/fukushimahyougikai/2021/pdf/siryou4-1.pdf) accessed on June 26, 2021.

The worst thing you can do is to release in Fukushima. If they release it from all over the country, it also spreads harmful rumors, and it wouldn't lower the price of fish. If it is really safe (anshin-anzen). If the government and TEPCO can guarantee it. But they can't guarantee.[34]

He implemented the knowledge about the contaminated water and radiation and claimed technical options based on the technical knowledge and experienced knowledge. However, this claim that other fishermen also mentioned does not go into public. Here is a representative problem (Callon, Lascoumes, and Barthe 2009). When I interviewed another fisherman, he showed me a piece of paper from the fishery cooperative, saying, "The fishery cooperative prohibits fishermen from being interviewed by a press or other media because the fishery cooperative announces the position against the releasement on behalf of the fishermen. The problem of treated water, as well as the economic effect of the COVID-19 pandemic, is a sensitive topic, so individual interviews may cause negative effects on the fishery.[35]" The individual opinion for a technical option is silenced in the process of the actor's claiming. The representative problem came up when we were talking about the president of the Fukushima fishery federation. Mr. Oda argued the difference between fishing ways: offshore fishing and coastal fishing. The president of the federation is running offshore fishing, which is not affected by the radioactive contamination, while Mr. Oda is running coastal fishing, which is vulnerable to contamination. However, the claim of the fishery cooperative is represented by the president's opinion based on offshore fishing.

Fish as an ecological entity cannot be reduced to the governmental discourse based on the human-centered approach. The fishermen claim technical options with the implementation of scientific knowledge and lived experience with the oceanic ecology. Technical options for radioactive measurement and releasing the contaminated water are challenged by the ecological fish and fishermen working with ecology even though the individual fishermen's voice is reduced to come to the hybrid forum.

6.2. Fish as a Commodity

As well as an ecological entity, fish acts as a commodity in the commercial fishery. The fish from the Fukushima coast is not only consumed inside of Fukushima but rather in the national-level market and sometimes an international market. The standard measurement does not satisfy the concerns of the consumer. During interviews, there was no time without hearing the word "harmful rumor (fuhyo-higai)." This word means a negative image or misinformation, which does not root in evidence and causes economic damage. Particularly, it the consumer's fear or worry about the fish from Fukushima due to its potential of radioactive contamination. Generally, harmful rumors as opposed to scientific knowledge based on measurement or research. The dualism between harmful rumors and scientific knowledge strongly exists from the governmental discourse, media to the fishermen's everyday language, and it is problematic to separate, but I do not examine that in this thesis for reasons of space. What I discuss here is how the harmful rumor damages the fishery business regardless of the measurement practices. If the measurement practice and the government's human-centered approach to radiation were dominant and shut out all the

[34] Interview on November 13, 2020.
[35] Interview on November 17, 2020.

concerns, there would not be a harmful rumor that damages the fishery economy. Also, the releasing plan of the contaminated water would not raise the huge discussion in the fishermen. However, in reality, harmful rumor is a big issue in the Fukushima fishery.

The fishery system is based on the prefectural level. Fishing rights and piscaries exclusively restrict to the registered fishermen, so the Fukushima fishermen can only conduct fishing on the coast or offshore of Fukushima and land the fish in a fishing port in Fukushima. The landed fish is labeled as "from Fukushima." The monitoring measurement by the official and screening tests by the fishery cooperatives are only conducted for the fish from Fukushima. The fishing areas are bordered in the ocean, although there is no border in the ocean. Mr. Oda, who was fishing on the border coast to the next prefecture, was ironically laughing, "I'm fishing right there, just next to Miyagi. And fish are moving around.[36]" However, a label of fish as a commodity has dramatical meanings for the consumer. According to fishermen, the price decreased by 70% from the original prices before the disaster. Fish from Fukushima devalued with price and brand. The manager of the marine product company depressingly mentioned the brand of Fukushima fish fallen:

> *Rather than low prices, everywhere from Kushu to Hokkaido, the fish from Fukushima are seen as second-rate or third-rate. Buyers admit "the quality is good, though" (but do not buy) … In reality, we do not have fish detected of radioactivity, and every time we test. And we publish the result every month that the number is zero. But harmful rumor is elusive.*
>
> *In the end, the price of everything in the world is decided by the consumer. It's not up to us. When there are comparison products from Hokkaido, from the Japan Sea, from Kyushu, Fukushima is the last one.*
>
> *The continental shelf is very big here. That's why the fish here is so nutritious and used to be valuable in the market. It used to be branded, but now it's gone. We're trying to get it back, but we don't have an answer.*[37]

The consequence of the radioactive contamination does not reduce the technical sphere. The value of the fish is decided with another logic of the consumer, including conception or image of the radioactive contamination. The consumption of the Fukushima fish reflects the practice of the fishing of deciding how much fish and what kinds of fish they fish. Even though the Fukushima fishery federation announced its plan to start full-scale operation fishing from April 2020, it is not realistic for fishermen. A fisherman said: "I would like to fish in full-scale, but only if I can sell the fish. I don't do fishing for fishing. I do it to earn money.[38]"

International export of the Fukushima fish has severely decreased. Some countries such as China, Hongkong, Korea still prohibits the import of fish and marine products from Fukushima[39]. European Union asked radiation measurement certificate made by the government as a condition to import fish from Fukushima. The Japanese standard for the radiation on a marine product is much stricter than the other countries – for example, the standard for radioactive Cesium 134 and

[36] Interview on November 13, 2020.
[37] Interview on November 16, 2020.
[38] Interview on November 20, 2020.
[39] Ministry of Ministry of Agriculture, Forestry and Fisheries. January 29, 2021. Regulatory measures in other countries and regions. (https://www.maff.go.jp/j/export/e_info/pdf/kisei_all_210129.pdf) accessed on June 27, 2021.

137 is 100Bq/kg in Japan while 1250Bq/kg in European Union. The notorious nuclear disaster devalued the fish from Fukushima with skepticism of safety and shrank the market for the fish.

The market logic on Fukushima fish reflects the technical issues. The reason why the fishery cooperative voluntarily implemented expensive measurement equipment (approx. 50,000 dollars for one) was to allay consumer fears about radiation. Also, one of the main issues in the releasing plan of the contaminated water is that the release will cause a more negative image on the fish than ever. Fish as a commodity can not be settled down with the government's discourse. Rather, the concerns about the price of the fish and sustainability of the fishery enter to the discussion about the technical option about the measurement and the releasing plan for the contaminated water.

6.3. Fishing as Life

While the fishery is an economic practice for the fishermen, as seen above, the fishery is a livelihood. The fishing practice itself has cultural and social values for their life. Most of the fishermen in Fukushima start fishing when they graduate from secondary school or high school, taking over their parents' livelihood with fishing equipment. Some fisher families have a long history from ancestors; for example, Mr. Oda's family have been fisher from the Edo era, at least for 200 years. The lifestyle, knowledge, and equipment are inherited from generation to generation. After the nuclear disaster, the Fukushima fishermen had to stop the fishing practice due to the high radioactive contamination, and then they have reduced the fishing from five or six days to two or three days a week as trial fishing.

Although fishermen's livelihood is sustained by compensation from TEPCO based on lost sales, the fishermen's life is not as vital as before, according to my interviews. Fishing is not just an economical means for life but a social practice that connects with identity, lifestyle, and the local community. During my interview with Mr. Kumano, 70s-year-old seaweed and clam fisherman talked about difficulty fishing and self-confidence from hard work before the disaster with a twinkle in his eye. He was running a small guesthouse but, for him, the guesthouse was just for fun, imitating other fishermen's ones. He thought of himself as a fisherman, and he said, "I would be an idiot[40]" if his life continues as it was. The loss of regular fishing practice with trial fishing and life depending on compensation money devastate fishermen's identity and lifestyle. Mr. Oda mentioned the psychological and physical health of the fishermen:

> *The fishermen in Fukushima Prefecture don't know what lies ahead. That's why fishermen in Fukushima are in so much physical and mental pain. I think 80% of them are probably metabolic syndrome. Because people who used to work six days a week, now work twice a week. What else do they do? Drinking, playing, you know. That's what people do. Playing pachinko (gambling). Because there is nothing to do.*[41]

[40] Interview on November 4, 2020.
[41] Interview on November 13, 2020.

When I was in the field, I saw a pachinko (gambling) store full of people. A staff of a bar told me they had a lot of fishermen as customers. The life of the fishermen has changed under the radioactive contamination. The claims based on the life devastation by the radioactive contamination overflows into the discussion about the government's and TEPCO's responsibility for the disaster and the releasing plan.

Over 3000 citizens, including fishermen and farmers, organized collective lawsuits against the government and TEPCO, accusing the responsibility of the accident. It is called livelihood (Nariwai) lawsuits with the slogan "Give us back our livelihood, give us back our community" and anti-nuclear position. In some cases, the court recognized the liability of the government and TEPCO for ignoring the tsunami risk before the accident and for causing the resulting accidents[42]. A fisherman also told me with anger that the accident would not have happened if TEPCO put seawater into the reactors at the beginning instead of freshwater[43]. The devastation of life by the radioactive contamination revealed the technical failure of the nuclear power plant.

The releasing plan of the contaminated water was also challenged by the claim based on life. An activist against the plan told me about his motivation for the movement. He mentioned people who committed suicide due to the devastation of their livelihood by the radioactive contamination. He said some of the fishermen might suicide because of the devastation of life if the government decided to release the contaminated water into the ocean[44]. Some media also points out the impact of the plan on the fishermen's life[45]. Some fishermen were worried about the successors of their fishing. Mr. Oda, who had three sons who worked for fishing, was worried about the succession of the fishery. Existential concerns based on the fishery as life comes into the technical discussion.

6.4. Mistrust and Analogy

Although there are many more actors and concerns overflowing with the radioactive fish and fishery with radiation, I close this chapter with the argument relating the technical discussion from past to future: mistrust and analogy. The radioactive contamination problem does not exist separated from the previous nuclear disasters and mistreat of the government of the Fukushima disaster. Indeed, the practice and discourses around nuclear and radiation always refer to the Chernobyl disaster, the "safety myth," and the collapse of the nuclear policy of Japan. Whatever the government's discourse and practice are, the people's mistrust of the government and TEPCO does not be eliminated (Sternsdorff - Cisterna 2019). The spillover and relevancy of the discourses and practices of technical options are interconnected to the credibility of the government and TEPCO. Discussions are overflowed; "is what the government says trustable?" "isn't it the same as before, like at the moment of the accident?". It is especially relevant when it comes to the discussion about the decommission of FDNPP and the releasing plan.

[42] See more in Citizens' Nuclear Information Center website published on November 30, 2017. (https://cnic.jp/english/?p=4018) accessed on June 28, 2021.
[43] Interview on November 7, 2020.
[44] November 28, 2020.
[45] Tokyo Newspaper. Aril 13, 2021. *Fishermen: "We can't trust the government or TEPCO" Where is the promise made six years ago to release contaminated water from the Fukushima Daiichi Nuclear Power Plant into the sea?* (https://www.tokyo-np.co.jp/article/97727) accessed on June 28, 2021.

Mr. Oda considered decommissioning as a tentative solution for the radiation problem of the fishery. But he emphasized that he cannot prospect for the future in the condition that the decommissioning plan was not succeeding. Subsequently, the governmental attitude of lack of responsibility cannot be tolerated for him. "Nothing is solved so far.[46]" Then how can he accept the government's discourse about the radioactive contamination? – No.

People question the governmental discourse on the releasing plan. At the moment of the decision, the government made a promotion video using the mascot "Little Mr. Tritium" that was criticized for ridiculing the people in concern, trivializing the actual problems of radiation, and trying to cover them up[47]. The criticism resulted in a scrap of the mascot from the webpage of the government. The technical issues surrounding the nuclear power plant and accidents have been hidden or manipulated in certain ways from before. Mr. Oda questioned the responsibility of the decision-makers. The radioactive effect may appear in long-term so the responsibility

> *The current chairman of the committee says that there is no scientific evidence (of harm of the contaminated water), so they can dump. But then I can ask the chairman whether if he can actually live here, whether he can take his grandchildren and eat fish or whatever. Would he be ready for that? If so, I could trust him.*[48]

The technical discussion loses relevancy under the circumstance of the mistrust. And again, the trust was betrayed. The government broke the promise between the government and the fishery cooperative that the decision of releasing the water would be made only under the understanding of the fishermen and fishery workers[49]. The lack of credibility of the government and TEPCO contributes to the skepticism of the technical discussion. The technical discussion can be made only when the base of the mutual understandings and trust among actors. Therefore, concerns overflow, and the discussion mismatches.

When there is no trust for the government, the fishermen understand and claim based on the previous incidents and experiences. The analogical chain appears. So-called "safety myth" of nuclear power plants that the government and electric companies continued to say "nuclear power is safe. An accident cannot happen." This myth resulted in the accident by overestimating the danger and risk of nuclear power as well described in the movie *Fukushima 50*[50]. The fishermen I interviewed was questioning the information from the government and TEPCO, for example:

> *They say it's diluted, it doesn't affect human body, it doesn't affect the natural environment. But it's the same as the "safety myth" of nuclear power plants, it may be safe and secure now, but what about in the future?*[51]

The government's claims of "safety" about the contaminated water are understood as the same claim of the "safety myth" of nuclear power. For the fishermen who have suffered from radiation

[46] Interview on November 13, 2020.
[47] Justin McCurry. April 15, 2021. *Japan scraps mascot promoting Fukushima wastewater dump*. In Guardian (https://www.theguardian.com/world/2021/apr/15/japan-scraps-mascot-promoting-fukushima-wastewater-dump) accessed on June 29, 2021.
[48] Interview on November 13, 2020.
[49] Tokyo Newspaper. Aril 13, 2021. *Fishermen: "We can't trust the government or TEPCO" Where is the promise made six years ago to release contaminated water from the Fukushima Daiichi Nuclear Power Plant into the sea?* (https://www.tokyo-np.co.jp/article/97727) accessed on June 28, 2021.

[50] Fukushima 50, directed by the Setsuro Wakamatsu (https://www.fukushima50.jp/) accessed on June 29, 2021.
[51] Interview on November 17, 2020.

contamination, technical discussions about nuclear and radiation do not differ from one to another. Instead, they are on the same ground.

The analogy applies to the previous nuclear disaster, Chernobyl. Even though the time, region, and seriousness of the Chernobyl accident differs from the Fukushima one, Chernobyl evokes opinions and concerns in Fukushima. The experts in the Fukushima Prefectural Fishery Resource Institute and Fukushima Agricultural Center who measured radioactivity in fish referred to Chernobyl in terms of radioactive contamination. "Human has contaminated the planet, so the radioactivity in fish has been detected even before the Fukushima accident,[52]" the manager of the Institute said. Likewise, Mr. Kumano, the seaweed and clam fisherman, made a comparison between Chernobyl and Fukushima; "like Chernobyl, the harmful rumor does not go away after 40 years or 50 years. Still now, people from Tokyo get scared when they see a car from Fukushima.[53]" The analogy extends spatiality and temporality of the technical discussion. The government's and TEPCO's discourses and practices do not converge the diverse spatiality and temporality of the discussion throughout analogy, with claims based on the isolated understanding of the nuclear and radiation after the disaster. As if the radioactive contamination widely spreads and continues in the long term so that it cannot be contained, the actors and concerns diverge so that it cannot converge in the hybrid forum.

[52] Interview on November 10, 2020.
[53] Interview on November 4, 2020.

7. Conclusion

In this thesis, I have examined how the people in the Fukushima fishery act in the uncertainties of the radioactive contamination after the Fukushima nuclear disaster. Uncertainties about radiation exist in spatial and temporal ranges in many ways. Firstly, the invisibility of radiation imposes difficulty for the non-expert people to access the existence and its perception of radiation without the implementation of certain technoscientific knowledge and practices. Secondly, the complexity of the radioactive contamination arises with the different kinds of radionuclides with different chemical properties. The sea topography and ocean currents unevenly diffuse radionuclides and create hotspots in the borderless ocean. Bioaccumulation and bioconcentration are different depending on the species, habitat, prey of fish. Thirdly, "safety" is an ambiguous concept that is fluidly shaped with both physical and psychological agreements, especially when it comes to food. Fourthly, issues of nuclear and radiation are complexly entangled with the environment, science, economy, politics, and culture. Each aspect has different issues and concerns based on each logic. The claims conflict with each other, sometimes on the one hand, and partially corporate with each other. Each claim is not sufficiently stable to dispute the others. There is no agreement in the forum in a discussion. It is not the case, as modern society assumes that science, as an objective fact, is the dominant solution to everything. Science, as seen above, is a practice implemented with a particular model that is also partially under the influence of politics, economics, and culture. When no one of science, politics, economy, and culture can dominantly occupy the discussion, knowledge remains unstable.

Before the Fukushima disaster, the technical discussion about nuclear energy had been more or less moderated, convinced with the dominant mixture of science, politics, and economy (chapter 3). The state had claimed nuclear as future-oriented "clean energy." Nuclear power had been a solution for the resource-scared country as well as national security policy. Economic benefit and safeness of the high technology were emphasized. The local people had accepted nuclear power plants with the confidence of contributing national economy as well as the rural area development plan.

The explosion of FDNPP was, at the same time, an explosion of the discussion. Radioactive contamination spread in a wide area and stays in the long term. Uncertainties about the physical and psychological effects of radiation, political, economic, and cultural impact have dramatically arisen. In the uncertainties, the biopolitical regime has dominated the official discourses and practices (chapter 4). Geontopower to distinguish Life and Nonlife operates for the Fukushima fishery. It subjects the human body as an object to govern, implemented with a certain scientific model – dose-effect model – that separates the human body from the environment under the peculiar understanding of humans. Fish has become a subject of governmentality insofar as food for humans, or more precisely for consumers of the fish. The particular scientific model widely spread from secluded scientific knowledge to society. Measurement practices practice in the chains of translation. Technical knowledge diffuses to the whole fishery process from measurement to shipping.

The governmental discourse and practice on the Fukushima fish are, to some extent, hegemonic to the society since the simplified version of technical knowledge about radiation is widespread and accessible for non-expert people (chapter 5). After the translation, knowledge is put into a black box that limits room for questioning and criticizing for a non-expert. At the same time, radiation has become business as usual for laypeople throughout their experiences.

Confronted uncertainties of the radiation, there are ignorant attitudes and practices against radiation. Endless uncertainties exhaust people to care about in every moment of eating practices every day.

Although the government's official discourses and practices, to some extent, establish hegemony shaping the setting for people to see, understand, and practice, some concerns, and facts overflow from the official discourse and practice (chapter 6). Fish as an ecological entity, a fact ignored in the official discourse, enters the technical discussion. The government's and TEPCO's human-centered approach to radiation does not withdraw the ecological aspects claimed by the fishermen who have a close relationship to the environment. Also, market logic evaluates fish as a commodity. While the official discourses and practices should have been taken into account the economic aspect of fish, this aspect goes beyond the "safety" of the fish. Instead, fish as a commodity connecting to the fishermen's life enter as an actor in the arena of technical discussion about the releasing plan of the contaminated water. Likewise, a technical option that affects the life of the fishermen questions the relevance of the option with existential problems. And finally, a technical discussion is not independent of the past and future. Mistrust about the government and TEPCO unsettles the technical option they propose. People extend the analogy with Chernobyl and the moment of the accident to understand the technical option and claim different options. Even the government proposes information based on certain scientific knowledge, the debate about the technical option continues to diverge. Science and political power are not sufficient to settle down overflowing concerns from diverse actors.

To close the discussion in this thesis, I would like to draw the attention of the readers to the decision made by the government. After conducting my research in November 2020, the government announced the decision to dump the contaminated water into the ocean on April 13, 2021. This news was shocking, reminding me of the suffering of the Fukushima fishermen I interviewed, but at the same time, it was predictable in terms of the general attitude of the Japanese government on nuclear and radiation. Even though the technical option about disposal or treatment of the contaminated water has been challenged and shaken, as seen above, politics still exercises its power for decision making. Here is a weakness of the discussion of the hybrid forum.

The concept of a hybrid forum has a tendency to equalize agencies of the actors inside of the forum. A hybrid forum is appropriate to examine the dynamics of technical discussion, providing a new perspective on science and technology studies. It denies a general assumption about a technical discussion in which science settles down other actors and provides the conceptual framework to understand and analyze the dynamics of technical discussion overflowed with other actors. The feature of a hybrid forum in which non-scientific actors' agencies reframe and reshape the technical discussion gives wider perspectives to analyze the relationship among science, technology, and society than the conventional theories in Anthropology and Sociology that focus on the political and social side of technical discussion. The discussion of the hybrid forum is provocative and relevant, especially in the era of climate change, that forces us to rethink the relationship between nature and culture, and human and nonhuman – as some authors propose new concepts such as Anthropocene (Crutzen 2006; Haraway et al. 2016; Dalby 2017) or Capitalocene (Moore 2017). The Fukushima disaster, the biggest nuclear disaster in these three-decade dramatically represents the necessity to rethink the social scientific framework on environmental issues. The concept hybrid forum describes the ongoing dynamics of nuclear and radiation in the post-Fukushima society, especially in the case of the fishery.

However, the decision of the government to release the contaminated water after my field research cannot prevent me from realizing the power of politics. The biopolitical regime is still very dominant in the current Japanese society even though there are many actors overflowing the biopolitical discourse and practices. The concept of a hybrid forum less likely to examine the uneven power distribution of actors. The ecological entity of fish and Fukushima fishermen do not have power as much as politics. Ten years after the Fukushima disaster, IAEA continues promoting nuclear energy[54] , and the Japanese government tries to restart existing nuclear power plants[55] to "tackle the climate change." In order to analyze the current nuclear society, it is crucial to reconsider the power distribution in the technical discussion in social science.

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