

AFTER THE DARKNESS

TEACHER'S GUIDE

Developed by Waka Takahashi Brown

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—Waka Takahashi Brown, Curriculum Specialist, SPICE

AFTER THE DARKNESS: THE MARCH 11, 2011, EARTHQUAKE, TSUNAMI, AND NUCLEAR DISASTER

Essential Questions

- What were some physical, environmental, and social effects of the March 11, 2011, earthquake and tsunami on Japan?
- How did the earthquake and tsunami contribute to the nuclear disaster in Fukushima? How did human error exacerbate the nuclear disaster?
- How did the Japanese people respond to these disasters?
- How do other natural disasters compare to the March 11, 2011, earthquake and tsunami?
- How has youth leadership played a role in the future development of the Tohoku communities that were affected by the March 11, 2011, earthquake and tsunami?

Introduction

On Day One, students engage in a directed thinking activity regarding Japan and the March 11, 2011, earthquake and tsunami. After discussing the answers, students listen to and take notes during a PowerPoint presentation that provides a general overview of the disaster as it unfolded. Students will then explore the Fukushima nuclear disaster in more depth through an informational handout and an optional group activity.

On Day Two, students view *After the Darkness*, a documentary film about the Tohoku disaster, take notes, and answer discussion questions about the film. After students have discussed the film, they will complete a project of their choice to present the following class day.

On Day Three, students present their projects to the class. To conclude the lesson, students revisit the initial directed thinking activity and write about what they have learned about the March 11, 2011, earthquake, tsunami, Fukushima nuclear disaster, as well as recovery and reconstruction efforts.

Objectives

In this lesson, students will

- anticipate consequences of physical processes on Earth;
- describe the effects of natural hazards on human systems;
- describe how the Fukushima nuclear disaster took place;
- examine the physical, environmental, and social effects of the March 11, 2011, earthquake and tsunami on Japan;
- examine how the Japanese have coped with the disaster;

- learn about Japan's efforts to recover from the earthquake, tsunami, and nuclear disaster;
- explore the development of youth leadership in Japan as a result of the March 11, 2011, earthquake and tsunami; and
- compare and contrast other natural disasters with the Tohoku earthquake and tsunami.

Connections to Curriculum Standards

This guide has been designed to meet certain national history, social studies, geography, and standards as defined by the National Center for History in the Schools, the National Council for the Social Studies, the National Council for Geographic Education, and the Common Core State Standards Initiative. The standards for the guide are listed here.

National History Standards (from the National Center for History in the Schools)

Era 9, Standard 2A: The student understands how population explosion and environmental change have altered conditions of life around the world.

- Grades 5–12: Assess the effectiveness of efforts by governments and citizens' movements to protect the global natural environment. [Obtain historical data]

World History Across the Eras, Standard 1: Long-term changes and recurring patterns in world history.

- Grades 5–12: Analyze ways in which human action has contributed to long-term changes in the natural environment in particular regions or worldwide.

National Social Studies Standards (from the National Council for the Social Studies)

- Culture; Thematic Strand I: Social studies programs should include experiences that provide for the study of culture and cultural diversity.
- Time, Continuity, and Change; Thematic Strand II: Social studies programs should include experiences that provide for the study of the ways human beings view themselves in and over time.
- People, Places, and Environments; Thematic Strand III: Social studies programs should include experiences that provide for the study of people, places, and environments.
- Individual Development and Identity; Thematic Strand IV: Social studies programs should include experiences that provide for the study of individual development and identity.
- Individuals, Groups, and Institutions; Thematic Strand V: Social studies programs should include experiences that provide for the study of interactions among individuals, groups, and institutions.

- Power, Authority, and Governance; Thematic Strand VI: Social studies programs should include experiences that provide for the study of how people create and change structures of power, authority, and governance.
- Production, Distribution, and Consumption; Thematic Strand VII: Social studies programs should include experiences that provide for the study of how people organize for the production, distribution, and consumption of goods and services.
- Science, Technology, and Society; Thematic Strand VIII: Social studies programs should include experiences that provide for the study of relationships among science, technology, and society.
- Global Connections; Thematic Strand IX: Social studies programs should include experiences that provide for the study of global connections and interdependence.
- Civic Ideals and Practices; Thematic Strand X: Social studies programs should include experiences that provide for the study of the ideals, principles, and practices of citizenship in a democratic republic.

National Geography Standards (from the National Council for Geographic Education)

The geographically informed person knows and understands:

- Standard 1: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective.
- Standard 3: How to analyze the spatial organization of people, places, and environments on Earth's surface.
- Standard 4: The physical and human characteristics of places.
- Standard 6: How culture and experience influence people's perceptions of places and regions.
- Standard 7: The physical processes that shape the patterns of Earth's surface.

Reading Standards for Literacy in History/Social Studies (from the Common Core State Standards Initiative)

- Standard 2, Grades 9–10: Determine the central ideas or information of a primary or secondary source; provide an accurate summary of how key events or ideas develop over the course of the text.
- Standard 2, Grades 11–12: Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.
- Standard 3, Grades 9–10: Analyze in detail a series of events described in a text; determine whether earlier events caused later ones or simply preceded them.

- Standard 4, Grades 9–10: Determine the meaning of words and phrases as they are used in a text, including vocabulary describing political, social, or economic aspects of history / social science.
- Standard 4, Grades 11–12: Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text.

English Language Arts Standards for Writing (from the Common Core State Standards Initiative)

- Standard 2, Grades 9–10, 11–12: Write informative/explanatory texts, including the narration of historical events, scientific procedures / experiments, or technical processes.
- Standard 4, Grades 9–10, 11–12: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

English Language Arts Standards for Science and Technical Subjects (from the Common Core State Standards Initiative)

- Standard 2, Grades 9–10: Determine the central ideas or conclusions of a text; trace the text’s explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- Standard 2, Grades 11–12: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Subjects and Suggested Grade Levels

The curriculum unit is recommended for the following secondary school classes:

Asian Studies
Contemporary Issues
Global/International Issues
Social Studies
World Cultures
World History/Studies

The reading level is suitable for students in grades 9 through 12.

Materials	<p>Handout 1, <i>Directed Thinking Activity</i>, pp. 10–12, 30 copies</p> <p>Handout 2, <i>March 11, 2011, Overview Note-Taking Sheet</i>, pp. 13–15, 30 copies</p> <p>Handout 3, <i>Fukushima Nuclear Disaster Overview</i>, pp. 16–17, 30 copies</p> <p>Handout 4A, <i>Nuclear Disaster: Earthquake and Tsunami</i> (Optional), pp. 18–19, three copies</p> <p>Handout 4B, <i>Nuclear Disaster: TEPCO's Top Leadership</i> (Optional), pp. 20–21, three copies</p> <p>Handout 4C, <i>Nuclear Disaster: Early Information and Communications Difficulties</i> (Optional), pp. 22–24, three copies</p> <p>Handout 4D, <i>Nuclear Disaster: The Race to Provide Electricity</i> (Optional), pp. 25–26, three copies</p> <p>Handout 4E, <i>Nuclear Disaster: Venting the Reactor Buildings</i> (Optional), pp. 27–28, three copies</p> <p>Handout 4F, <i>Nuclear Disaster: Kan's Visit to the Fukushima Dai-Ichi Plant</i> (Optional), pp. 29–30, three copies</p> <p>Handout 4G, <i>Nuclear Disaster: The Reactor Building Explosions</i> (Optional), pp. 31–33, three copies</p> <p>Handout 4H, <i>Nuclear Disaster: TEPCO's Abandonment Request Controversy, Establishment of Joint Headquarters</i> (Optional), pp. 34–35, three copies</p> <p>Handout 4I, <i>Nuclear Disaster: Reactor Pools—The Other Serious Danger</i> (Optional), pp. 36–37, three copies</p> <p>Handout 4J, <i>Nuclear Disaster: Reactor Pools—Emergency Mobilization to Cool Used Fuel Pools</i> (Optional), pp. 38–39, three copies</p> <p>Handout 5, <i>Anticipation Guide</i>, p. 40, 30 copies</p> <p>Handout 6, <i>After the Darkness Note-Taking Sheet</i>, p. 41, 30 copies</p> <p>Handout 7, <i>The Effect of the March 11, 2011, Natural Disaster on Japanese Youth</i>, pp. 42–43, 30 copies</p> <p>Handout 8, <i>Project Choices</i>, pp. 44–45, 30 copies</p> <p>Answer Key 1, <i>March 11, 2011, Overview Note-Taking Sheet</i>, pp. 47–48</p> <p>Answer Key 2, <i>Fukushima Nuclear Disaster Overview</i>, p. 49</p> <p>Answer Key 3, <i>After the Darkness Note-Taking Sheet</i>, pp. 50–51</p> <p>Presentation Script, <i>March 11, 2011, Overview</i>, pp. 52–54</p> <p>Teacher Information, <i>Timeline and Primary Actors</i>, pp. 55–57</p> <p>Documentary film, <i>After the Darkness</i>, available at http://spice.fsi.stanford.edu/multimedia/after-darkness.</p> <p>PowerPoint presentation, <i>March11Overview.ppt</i>, located on the SPICE website</p> <p>Butcher paper and markers</p>
Equipment	<p>Computer with projector</p> <p>Computer with Internet access for student research use on Days Two and Three (optional but recommended)</p>

procedures

Teacher Preparation	<ol style="list-style-type: none">1. Screen <i>After the Darkness</i> and set up the computer projector for the film as well as for the PowerPoint presentation.2. Review all handouts and make the appropriate number of copies.3. Label three sheets of butcher paper, one with the topic heading “March 11, 2011, Tohoku Earthquake and Tsunami,” another with the topic heading “Fukushima Nuclear Disaster,” and the third with the topic heading “Recovery and Restoration.”
Time	At least three 50-minute class periods
Procedures Day One	<p>Students engage in a directed thinking activity regarding Japan and the March 11, 2011, earthquake and tsunami. After discussing the answers, students listen to and take notes during a PowerPoint presentation that provides a general overview of the disaster as it unfolded. Students will then explore the Fukushima nuclear disaster in more depth through an informational handout and an optional group activity.</p> <ol style="list-style-type: none">1. Inform students they will be learning about the March 11, 2011, Tohoku earthquake (also known as the Great East Japan Earthquake) and tsunami as well as the Fukushima nuclear disaster.2. Distribute one copy of Handout 1, <i>Directed Thinking Activity</i>, to each student and review directions as a class. Allow students time to complete the first three rows for each topic.3. When students have finished, ask volunteers to share their answers. Record answers on sheets of butcher paper with the topic headings listed below. If needed, use the prompts to elicit additional student answers. <p><i>March 11, 2011, Tohoku Earthquake and Tsunami</i></p> <ul style="list-style-type: none">- Where in Japan is the Tohoku region?- What magnitude on the Richter scale do you think the earthquake was?- What height did the tsunami reach?- How far inland did the water reach?- How many casualties do you think there were? <p><i>Fukushima Nuclear Disaster</i></p> <ul style="list-style-type: none">- Where in Japan is Fukushima?- How does the Fukushima disaster compare to the Chernobyl disaster?- Did government authorities handle the disaster well?- How did the Fukushima nuclear disaster affect Japan’s energy consumption and supply? <p><i>Recovery and Restoration</i></p> <ul style="list-style-type: none">- Have people returned to live in the Tohoku area?- What are people’s attitudes toward the area after the disaster?

- Has all the debris been cleaned up? What does the area look like?
 - What role has youth leadership played in rebuilding the Tohoku areas affected by the March 11, 2011, earthquake and tsunami?
4. Inform students they will revisit this handout at the end of the lesson. Collect handouts.
 5. Tell students they will view a brief presentation pertaining to the earthquake and tsunami. Distribute one copy of Handout 2, *March 11, 2011, Overview Note-Taking Sheet*, to each student and direct students to take notes during the PowerPoint presentation, *March 11, 2011, Overview*. Use the Presentation Script, *March 11, 2011, Overview*, while delivering the presentation.
 6. Inform students that they will now learn more about the Fukushima nuclear disaster. Distribute one copy of Handout 3, *Fukushima Nuclear Disaster Overview*,* to each student. Ask volunteers to read sections aloud to the class. Discuss the questions at the end of the handout, using Answer Key 2, *Fukushima Nuclear Disaster Overview*, as a guide.

Optional Activity

For advanced high school or college students, consider exploring the Fukushima nuclear disaster in more depth through the following activity.

1. Divide the class into 10 small groups of three students each. Assign a letter to each group, A–J. Distribute the appropriate Handouts 4A–J to the corresponding groups. Review the directions as a class.
2. Allow students time to read their handouts and to complete the tasks outlined in them.
3. When students have finished their tasks, reorganize the class into three large groups of 10 students each so that each group has a student representing each letter.
4. Distribute one large sheet of butcher paper to each group. Instruct groups to compile a master timeline of events and primary actors. Refer to Teacher Information, *Timeline and Primary Actors*, as you check for comprehension with each group.
5. Debrief the activity with the following questions:
 - In what ways was the Fukushima Dai-Ichi nuclear power plant prepared for a disaster? In what ways did these measures fall short?
 - In what ways do you feel the government handled the disaster well? In what ways do you feel the government did not handle the disaster well?

* Note to teacher: Handouts 3, and 4A–J are examples of “informational text” (a broad category of nonfiction resources, including biographies; autobiographies; books about history, social studies, science, and the arts; technical texts; literary nonfiction; newspaper articles; essays and opinion pieces; as well as “diverse media and multimedia,” such as photographs, graphics, and video) as defined by the Common Core State Standards (CCSS). Also, one of several key shifts in teaching the CCSS is in the “text complexity” of instructional materials. Text complexity refers to providing challenging material for students at or above their grade level.

- As of early 2011, nuclear energy provided approximately 30 percent of Japan's electricity and was expected to increase to at least 40 percent by 2017. In light of the Fukushima disaster, estimates are now for half that amount. However, nuclear energy had allowed Japan to lower its carbon dioxide emissions. Discuss the pros and cons of nuclear energy.

Day Two

Students view *After the Darkness*, a documentary film about the Tohoku disaster, take notes, and answer discussion questions about the film. After students have discussed the film, they will complete a project of their choice to present the following class day.

1. Inform students that they will view *After the Darkness*, a documentary film about recovery after the March 11, 2011, disaster.
2. Distribute one copy of Handout 5, *Anticipation Guide*, to each student. Instruct students to complete the "Before" column.
3. Distribute one copy of Handout 6, *After the Darkness Note-Taking Sheet*. Direct students to answer the questions on the handout as they view the documentary.
4. View the documentary film *After the Darkness*, (available at <http://spice.fsi.stanford.edu/multimedia/after-darkness>) as a class.
5. When the class has finished viewing the film, distribute one copy of Handout 7, *The Effect of the March 11, 2011, Natural Disaster on Japanese Youth*, to each student. Allow students time to read the handout.
6. Revisit Handout 5, *Anticipation Guide*, and direct students to complete the "After" and "Proof" sections.
7. Review student responses to Handout 5 and the answers to Handout 6 as a class. Collect both handouts for assessment.
8. Inform students that they will now work on a project based on the material they have covered in this lesson.
9. Distribute one copy of Handout 8, *Project Choices*, to each student. Review the choices and guidelines as a class.
10. Allow students time to work on their projects in class or as homework.

Day Three

Students present their projects to the class. To conclude the lesson, students revisit the initial directed thinking activity and write about what they have learned about the March 11, 2011, earthquake, tsunami, and Fukushima nuclear disaster, as well as the recovery and reconstruction efforts.

1. Allow students five minutes to finalize their projects or rehearse their presentation of their projects.
2. Facilitate student presentations of their projects from Handout 8.
3. Debrief the research activity and the lesson by revisiting Handout 1, *Directed Thinking Activity*. Return Handout 1 to each student.

4. Direct students to complete the final section for each topic. Tell students they may use the backs of their handouts or additional sheets of paper, if necessary. Collect for assessment.

Assessment

The following are suggestions for assessing student work in this lesson:

1. Handout 1, *Directed Thinking Activity*, based on students' ability to assess what they have learned throughout the course of this lesson.
2. Handout 2, *March 11, 2011, Overview Note-Taking Sheet*, using Answer Key 1, *March 11, 2011, Overview Note-Taking Sheet*, as a guide.
3. Optional group projects for Handouts 4A–J, using the Teacher Information, *Timeline and Primary Actors*, as a guide.
4. Handout 5, *Anticipation Guide*, based on students' ability to document changes in their answers and provide proof to support their answers.
5. Handout 6, *After the Darkness Note-Taking Sheet*, using Answer Key 2, *After the Darkness Note-Taking Sheet*, as a guide.
6. Handout 8, *Project Choices*, using the criteria outlined on the handout as a guide.
7. Student participation in group and class discussions, evaluating students' ability to
 - clearly state their opinions, questions, and answers;
 - exhibit sensitivity toward different cultures and ideas;
 - respect and acknowledge other students' comments;
 - ask relevant and insightful questions; and
 - provide correct and thoughtful answers.

DIRECTED THINKING ACTIVITY

Directions: Complete the first three rows for each topic. Be prepared to share your answers with the class.

The March 11, 2011, Tohoku Earthquake and Tsunami**What I know I know...****What I think I know...****What I think I'll learn...****What I know I learned...**

The Fukushima Nuclear Disaster

What I know I know...

What I think I know...

What I think I'll learn...

What I know I learned...

handout 1

Restoration and Recovery

What I know I know...

What I think I know...

What I think I'll learn...

What I know I learned...

MARCH 11, 2011, OVERVIEW NOTE-TAKING SHEET

Directions: Listen closely as the teacher presents the PowerPoint, *March 11, 2011, Overview*. Fill in the blanks below and be prepared to discuss the questions at the end of this handout.

1. Fill in the blank:

On March 11, 2011, Japan was hit by the largest recorded earthquake in its _____ recorded history.

2. Circle the area of Japan that was most affected by the earthquake and subsequent tsunami.



handout 2

3. How far did the earthquake move Honshu toward the continental United States?

4. How tall was the tsunami at its highest?

5. How far inland did the tsunami reach?

6. How many deaths did the earthquake and tsunami cause?

7. Even though the Great Kanto Earthquake of 1923 was not as powerful as the one on March 11, 2011, there were more casualties in 1923. Why?

8. What are the constantly shifting tectonic plates on which Japan sits known as?

9. On average, how many earthquakes does Japan experience every year?

10. True or False?
The Fukushima nuclear disaster has yet to be completely resolved. It will take decades to clean up, decontaminate, and decommission.

11. What is one example of how the Japanese cooperated and exhibited a commitment to the national interest in the wake of the March 11, 2011, disaster?
 12. Did any of the images in the presentation make an impression on you? If so, which ones, and why?
 13. What information in this presentation surprised you?

FUKUSHIMA NUCLEAR DISASTER OVERVIEW*

Directions: Read the following handout aloud with your class.

The magnitude 9.0 earthquake that struck northeastern Japan on March 11, 2011, was the world's fourth largest in modern recorded history, jolting the island of Honshu 2.4 meters to the east. A massive tsunami followed shortly, reaching an estimated height of over 30 meters in some places. A 500 km swath of Japan's northeastern coast was devastated, with a death toll of more than 15,000 people. Damage from the earthquake and tsunami led to one of the world's most serious nuclear disasters at the Fukushima Dai-Ichi ("number one") Nuclear Power Station, owned and operated by the Tokyo Electric Power Company (TEPCO).

The Fukushima Dai-Ichi plant had six nuclear reactors, three of which were operating on March 11, with the rest undergoing routine maintenance. As the earthquake hit, the active reactors immediately succeeded in emergency shutdowns. All power lines leading to the plant were severed, but on-site backup generators, installed for such contingencies, kicked in seamlessly.

Forty minutes later, the tsunami of over 12 meters hit, well exceeding the maximum design limit of 5.7 meters, and obliterating the 10-meter-high seawall. Critically, the tsunami irreparably damaged virtually all on-site backup power sources, including emergency diesel generators and batteries, along with most electricity circuit switchboards within the plant.

Despite successfully shutting down, the fuel rods within Fukushima Dai-Ichi Reactors 1, 2, and 3, combined, still required approximately 70 tons of water per hour for 10 days, to avoid fuel core meltdowns. However, the tsunami damaged most of the primary cooling pumps. Emergency cooling systems required electricity, but all backup power had been lost.

In the critical first two days, efforts to cool the reactors failed. All three reactors experienced fuel core meltdowns, and hydrogen explosions blew off the roofs and walls of three reactor buildings. While there were no immediate deaths from direct radiation exposure, the accident emitted at least 168 times the amount of radioactive cesium 137 compared to the Hiroshima atomic bomb. Mandatory evacuation zones of a radius of 10 km were imposed on March 11, and expanded to 20 km the following day, affecting more than 80,000 residents. The disaster was eventually declared level 7 on the International Nuclear Event Score (INES)—the maximum. Chernobyl was the only other level 7 nuclear accident, although it released approximately six times more radioactive material than Fukushima, since Chernobyl was an explosion of an active reactor with no concrete containment vessel. In Fukushima, seawater pumped into the reactors and used fuel storage pools contaminated more than 100,000 tons of water, about a tenth of which was released into the ocean by mid-2011.

meltdown—the melting of a significant portion of a nuclear-reactor core due to inadequate cooling of the fuel elements, a condition that could lead to the escape of radiation

cesium 137—the radioactive cesium isotope with mass number 137 and a half-life of 33 years

International Nuclear Event Score—a tool for promptly communicating to the public in consistent terms the safety significance of reported nuclear and radiological incidents and accidents

Chernobyl—site of a nuclear power station accident in 1986

containment vessel—a steel or reinforced concrete structure enclosing a nuclear reactor

* Excerpt from *The Fukushima Nuclear Disaster and the DPJ, Leadership, Structures, and Information Challenges During the Crisis*, by Kenji Kushida, <http://ssrn.com/abstract=2334523>.



Discuss the following as a class:

1. How was the Fukushima Dai-Ichi Power Station prepared to handle a natural disaster prior to the March 11, 2011, earthquake and tsunami?
2. In what ways was the Fukushima Dai-Ichi Power Station not adequately prepared to handle the March 11, 2011, earthquake and tsunami?
3. Compare and contrast the Fukushima nuclear disaster to the Chernobyl nuclear disaster of 1986.
4. During the Fukushima disaster, seawater was pumped into the reactors in an attempt to cool them. What was a negative consequence of this action?

NUCLEAR DISASTER: EARTHQUAKE AND TSUNAMI* (OPTIONAL)

Directions: Read the following handout with your group members and complete the tasks at the end of the reading.

The magnitude 9.0 earthquake occurred at 2:46 p.m. on March 11, 2011. The three operating reactors at the Fukushima Dai-Ichi nuclear plant immediately shut down. However, the earthquake severed all external power lines connecting the plant to the external power grid, and the on-site emergency backup power generators kicked in.

The quake itself caused major damage at the plant. Much of the plant was over 40 years old, and, in particular, the operations buildings with the control rooms, monitoring devices, information, and equipment, were catastrophically damaged to the point of becoming unusable. The extent of earthquake damage to the reactor buildings themselves is still unclear. However, while the reactor buildings themselves had been strengthened to some degree over the years, the operations centers were essentially 40-year-old buildings whose walls, ceilings, and other structural elements were vulnerable.

The vibration frequency of the earthquake was particularly damaging to the Fukushima plant. Despite the truly massive amount of force from the 9.0 earthquake, it is notable that most buildings in much of the Tohoku region remained relatively undamaged. For wooden buildings, frequencies of around 1 second are known as the “killer pulse,” since the buildings resonate at that wavelength, magnifying the sway to create catastrophic damage. The Tohoku earthquake had a far shorter wavelength of approximately 0.1 to 0.3 seconds. Unfortunately, the nuclear facilities, which consist primarily of massive concrete structures, thick steel reaction chambers, and a myriad of pipes, have short resonance frequencies of approximately 0.02 to 0.4 seconds. The Tohoku earthquake therefore fell exactly within the range of resonance frequencies for much of the nuclear facilities, creating massive damage even before the tsunami hit.⁴

After the earthquake, the Fukushima Dai-Ichi operations headquarters staff quickly evacuated to a new operations center on slightly higher ground; the center was designed to withstand strong earthquakes. This seismically reinforced operations center had been completed just eight months before the earthquake—without which there would have been no local operational staging ground for efforts to contain the catastrophe. Of the 6,350 workers at the Dai-Ichi plant, 5,000 or so of whom were contract workers, about 400 remained after the tsunami, with the rest leaving to check on their families and houses.

frequency—the number of periods or regularly occurring events of any given kind in unit of time, usually in one second

resonate—to vibrate in response to an external stimulus

wavelength—the distance, measured in the direction of propagation of a wave, between two successive points in the wave that are characterized by the same phase of oscillation

seismic—pertaining to an earthquake

staging ground—temporary location of available emergency responder resources

* Handouts 4A–J are adapted with permission from “Japan’s Fukushima Nuclear Disaster: Narrative, Analysis, and Recommendations,” by Kenji E. Kushida, http://iis-db.stanford.edu/pubs/23762/Japans_Fukushima_Nuclear_Disaster.pdf

The tsunami hit [the Fukushima Dai-Ichi nuclear plant] in multiple “waves” ... starting at 3:27 p.m., 40 minutes after the earthquake. The second wave, which hit at 3:35 p.m., exceeded 12 meters, easily obliterating the 10-meter-high concrete seawall designed to withstand a tsunami of only up to 5.7 meters. The tsunami took out much of the primary cooling system, largely consisting of pumps responsible for pumping seawater into the reactor building to cool the fuel rods. Devastatingly, it also irreparably damaged virtually all emergency backup power sources, including diesel generators, batteries, and circuit boards. The generators and batteries were located in the basement of the turbine buildings, in between the seawall and the reactor buildings. Without these power sources, there was no way to run the emergency backup cooling pumps.

The need for truly massive quantities of water for nuclear reactors cannot be exaggerated. The Fukushima Dai-Ichi Reactors 1, 2, and 3 that were operating at the time of the disaster were Boiling Water Reactors (BWR). In essence, heat from the nuclear reactions of the fuel rods within a sealed chamber boiled water under high pressure, creating steam that rotated turbines to generate electricity. The primary, or first stage cooling system for the three reactors, required 5,600 tons, 7,570 tons, and 7,760 tons of seawater, respectively, per hour during normal operations. Then, in addition, to cool the steam and convert it back to water, approximately 20 tons per second, 70,000 tons per hour, or 1.7 million tons per day of seawater is required.⁵ This massive amount of water required is why nuclear power plants are built next to large bodies of water. Even after successful emergency shutdowns of the fuel core reactions,⁶ the fuel rods retain considerable heat, requiring nonnegligible amounts of water for cooling. For Reactor 1, this was approximately 20 tons per hour immediately after halting the reaction, 5 tons per hour after 10 days, 3 tons per hour for a month, and then 2 tons per hour for a prolonged period.... Put simply, the three reactors combined required approximately 70 tons of water per hour for 10 days, even after shutting down, to avoid a catastrophe.⁷ Restarting the pumps, or at minimum the emergency cooling system as a short-term solution,⁸ was critical. To do this, electricity was needed.

Yet, the plant had lost all external power in the earthquake, and the tsunami destroyed almost all emergency backup diesel generators and batteries. There was no way to pump the large amounts of water absolutely necessary to cool the reactors.

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one “Timeline of Events.” Label the second one “Primary Actors.” Label the third one “What Went Wrong.”
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: TEPCO's TOP LEADERSHIP (OPTIONAL)

Directions: Read the following handout with your group members and complete the tasks at the end of the reading.

[After the tsunami destroyed almost all emergency backup diesel generators and batteries for the Fukushima Dai-Ichi nuclear plant], events unfolded rapidly. During this initial time of crisis, however, neither Tokyo Electric Power Company's (TEPCO) chairman, widely considered the center of power, nor the president, was at TEPCO headquarters. Worse yet, since telephone networks were down following the earthquake, neither could communicate effectively with TEPCO headquarters, let alone the Fukushima plant operations center. The president's whereabouts were uncertain. (He was in Nara, on vacation with his wife.) Neither could return to TEPCO headquarters for more than 20 hours after the earthquake and tsunami. Moreover, the political leadership, led by Prime Minister Naoto Kan, who became intimately involved with the Fukushima disaster mitigation efforts, was unaware that TEPCO's chairman and president were absent from TEPCO until much later.

mitigation—the act of lessening the force or intensity of something unpleasant

Chairman Tsunehisa Katsumata was in China at the time of the disaster ... and had no way to return to TEPCO headquarters. The Chinese government offered free use of an airplane, but the Tokyo airports of Narita and Haneda were closed. Kansai airport, near Osaka, was not an option, either, since domestic rail travel and freeways were all shut down due to the earthquake. Katsumata returned to Japan the following morning. In the meantime, most communications lines were down within Japan, and it is not clear that he was able to communicate effectively with headquarters.⁹

TEPCO president Masataka Shimizu was in Nara on a short vacation following meetings in Shikoku. His whereabouts were seemingly unknown to many of his staff.... With rail and road transportation to Tokyo closed, Shimizu traveled to Nagoya, attempting to use a TEPCO-affiliated company's helicopter to fly to Tokyo. However, by the time he reached the heliport, it was discovered that the company had neither the equipment nor permits to fly at night. Shimizu and his staff were then able to contact the government for use of a Self-Defense Forces (SDF) aircraft to fly Shimizu to Tokyo. [They] took off toward Tokyo at 11:30 p.m. [on March 11], eight hours after the disaster. Yet, due to a combination of terrible judgment by the minister of defense and information failures within the SDF, the plane made a U-turn at 11:45 p.m. and returned to its base in Aichi Prefecture.

What had transpired was the following. Upon hearing that Shimizu would be transported via an SDF aircraft, the defense minister had ordered that all SDF resources should focus on rescue and recovery from the earthquake / tsunami disaster. The SDF at the time was fully consumed with the disaster, which far exceeded anything it had ever dealt with. Somewhere in the chain of command, the information that the aircraft was

already on its way had been lost, and the minister's order was interpreted as a command for the plane to turn back.

Shimizu had to wait until the next morning to take the helicopter, which landed him at the Tokyo heliport. From there he was stuck in the post-disaster traffic jam that gridlocked Tokyo on March 12. It took him two hours to reach TEPCO headquarters, finally arriving around 10:00 a.m.—almost 20 hours after the disaster. By then, the Fukushima reactors were ... likely already melted down—and about to experience the first hydrogen explosion. The prime minister's office and TEPCO had been working through the night in an attempt to contain the crisis, making a series of critical decisions, and more seriously, not making particular decisions that might have helped the situation.

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one "Timeline of Events." Label the second one "Primary Actors." Label the third one "What Went Wrong."
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: EARLY INFORMATION AND COMMUNICATIONS DIFFICULTIES (OPTIONAL)

Directions: Read the following handout with your group members and complete the tasks at the end of the reading.

Rewinding to the afternoon of the disaster on March 11 and to the Fukushima plant, the severity of information and communications problems was immediately apparent. The plant was not designed to operate under conditions entailing complete loss of external and on-site backup power, and it lacked measures to cope with a breakdown in communications. The nearby cellular communications tower was damaged in the earthquake, rendering cell phones useless. Handheld transceivers also incurred massive static. From the operations headquarters, the plant manager in charge, Masao Yoshida, was working with very little information. Control panel indicators and sensors were mostly unusable or unreliable due to earthquake and tsunami damage, and a lack of electric power. To grasp the situation on the ground, Yoshida had to repeatedly send staff into the plant, near the reactors, to assess the situation.

Some information and communications failures were worse than others. It turned out that the emergency cooling system in Reactor 1, which converts steam into water, had started automatically. However, 11 minutes later, an operator had manually stopped it because it was cooling the reactor faster than the guidelines set by the Nuclear and Industrial Safety Agency (NISA). Yoshida, unaware that the system had been stopped, was given unreliable instrument readings, and assumed that it was operating. He therefore prioritized cooling Reactor 2 rather than Reactor 1, though in reality Reactor 1 was in far worse condition.¹⁰

Ministry of Economy, Trade and Industry (METI)—the Japanese government ministry that deals with the economic, industrial, and trade-related issues of the country

At 3:00 p.m. on March 11, Yoshida sent faxes to Tokyo Electric Power Company (TEPCO) headquarters and NISA (located within the Ministry of Economy, Trade and Industry), officially declaring that a nuclear emergency was likely to occur. This was the first time ever that such a notice was sent.¹¹ At 4:30 p.m., he sent another message upgrading it to “emergency in progress,” a status that automatically triggers an evacuation order. This was also unprecedented. Yoshida noted that they were unable to cool the reactors and could not monitor the water levels of Reactors 1 and 2. The implications were serious, since the reactor fuel cores needed to be immersed in water; if the hot core evaporated all the water, the core would be exposed,¹² and fuel core rods would overheat and become damaged—the phenomenon commonly known as a “meltdown.” At 4:54 p.m., Prime Minister Naoto Kan issued a two-minute statement at the pressroom saying that the nuclear reactors had stopped and no radiation leakage had been observed. He took no questions. While Kan’s statement was true, it did not acknowledge that a report of “nuclear emergency in progress” had been issued by the Fukushima Dai-Ichi plant.

Democratic Party of Japan (DPJ)—political party in Japan founded in 1998 by the merger of several opposition parties. After the 2009 election, the DPJ became the ruling party in the House of Representatives, defeating the long-dominant Liberal Democratic Party (LDP) and gaining the largest number of seats in both the House of Representatives and the House of Councillors. After winning a landslide victory in 2009, it was ousted from government by the LDP in the 2012 general election.

Diet—legislative body of Japan

Kan's two close aides, Manabu Terada, age 34, and Goshi Hosono, age 39, both Democratic Party of Japan (DPJ) members, were at the prime minister's residence when Banri Kaieda, minister of METI, rushed to join them at about 5:45 p.m. Kaieda wanted Kan to immediately declare an emergency. However, although Kan listened to Kaieda's report and urgings, he left in less than 30 minutes (around 6:15 p.m.) to attend a meeting between his party and opposition parties to seek cooperation in the disaster recovery. Only after he returned from this meeting did he proceed to finalize the emergency declaration.¹³ Kaieda later testified to a Diet investigation commission later that it took time to get Kan's understanding and agreement to declare the emergency.¹⁴

One problem was that the prime minister's office lacked the know-how of exactly how to do so, with secretaries and aides busy reading the relevant laws. NISA staff, who were METI bureaucrats rotating through the agency every few years, also lacked such operational knowledge. The relevant law was the Special Law for Emergency Preparedness for Nuclear Disasters, which had been formulated after a 1999 nuclear accident at the Tokaimura uranium reprocessing plant in Ibaraki Prefecture. The problem with this law, however, was that it did not provide for a nuclear disaster occurring simultaneously with an earthquake / tsunami disaster. It called for a gathering of the Nuclear Safety Commission (NSC), which was to establish an emergency technical advisory group to advise the prime minister. The problem was that the NSC was made up of about 40 members, and with communication networks offline, all public transportation in the Tokyo Metropolitan area frozen, and roads in gridlock, there was no way to gather the members.¹⁵

At 7:00 p.m., Kan declared a nuclear emergency to the nation—the first time such a declaration had been made. This should have triggered an evacuation order, but Kan's staff was unable to effectively orchestrate evacuation procedures. He and his staff could not gain information about conditions on the ground, and although according to law, several off-site emergency operations centers were to be established, the transportation and communications paralysis made it impossible to set up the designated 22 locations, including Fukushima. At 7:45 p.m., Chief Cabinet Secretary Yukio Edano advised the public not to panic and flee, but to stay indoors and wait.¹⁶

At 8:50 p.m., around four and a half hours after the “nuclear emergency in progress” was declared, the Fukushima prefectural government took matters into its own hands. It announced that residents within a 2 km radius of the Fukushima Daiichi plant should evacuate. Half an hour later, at 9:23 p.m., the Kan government announced a 3 km radius for evacuation, ordering people to stay indoors in the radius between 3 km and 10 km; this was three hours after Kan had declared an emergency.¹⁷ It was later determined that by around 5:00 p.m., four hours earlier, Reactor 1's core was already exposed, and by 5:50 p.m., the radiation monitor began showing increased radiation levels.

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one "Timeline of Events." Label the second one "Primary Actors." Label the third one "What Went Wrong."
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: THE RACE TO PROVIDE ELECTRICITY (OPTIONAL)

Directions: Read the following handout with your group members and complete the tasks at the end of the reading.

Starting in the late afternoon of March 11, Prime Minister Naoto Kan directly dispatched power trucks, carrying large batteries, to the Fukushima Dai-Ichi plant to provide electricity for the cooling systems. Kan had an engineering background with a degree from the Tokyo Institute of Technology, which had given him a basic grasp of nuclear plant design and operations. He understood the critical need to supply water to the reactors (for cooling) and procure electricity to operate the pumps.

Around 6:00 p.m., the Fukushima Prefecture Emergency Headquarters announced that the Tokyo Electric Power Company (TEPCO) had sent eight of its power trucks, the Self-Defense Forces (SDF) Fukushima base had sent one, and TEPCO had asked the Tohoku Electric Power Company to send any available power trucks. However, since all highways and roads surrounding the Tokyo Metropolitan area were gridlocked, with many roads in the Fukushima area impassable due to earthquake damage, their progress was slow. Kan ended up spending much time making phone calls to dispatch SDF power trucks, involving himself in minute details of the operations....¹⁸

prohibitive—sufficing to prevent the use of something

With land routes uncertain and slow, Kan explored other options. Attempting to arrange an airlift of the power trucks, at one point Kan phoned the SDF, investigating the power trucks' weights and measurements. Finding the weight prohibitive for SDF helicopters, Kan also inquired of the U.S. military—but the trucks were simply too heavy. All told, 40 to 69 power trucks were dispatched by Kan's political leadership.¹⁹

After 9:00 p.m., one of the power trucks finally reached the Fukushima Offsite Center, 5 km from the reactor. More arrived over the next few hours. However, to everyone's dismay, they were unusable—the voltage was incorrect, and the plug sockets were incompatible. Kan was furious at TEPCO, and plant manager in charge Masao Yoshida's attempts on the ground to use converters within the Reactor 2 building were unsuccessful, since extensive debris and damage within the plant made it impossible for the truck to get close. A 200-meter-long cable was needed, far longer than the cable equipped by the truck. It took some time to locate a cable within the plant....²⁰

Once the cable was located, transporting and connecting it was a challenge, since it weighed more than one ton and most equipment was unusable. A four-ton truck with a crane was mobilized to haul the cable out of storage, and about 40 men began pulling it to where it was needed. Phones did not work, the area was pitch dark, debris was scattered, strong aftershocks kept occurring, and with manhole lids often missing, this was

highly treacherous—and, critically, time-consuming—work. At 11:50 p.m., with the power truck yet to be connected, Yoshida faxed another report to the Nuclear and Industrial Safety Agency (NISA): Radiation levels within the reactor building were rising. Radiation was leaking.²¹

This is when it became apparent that Yoshida's assumption that the emergency cooling system for Reactor 1 was working was clearly wrong. It also became clear that the instrument panel he relied upon was unreliable, since it read that water levels were sufficient.²² Water levels were clearly insufficient, and the exposed fuel core had damaged the containment vessel, leading to radiation leakage.

containment vessel—a steel or reinforced concrete structure enclosing a nuclear reactor

All the while, the political leadership was unaware that TEPCO executives were not in command at headquarters, with TEPCO Chairman Tsunehisa Katsumata stuck in China and TEPCO president Shimizu's SDF transport plane just having turned back to Aichi Prefecture. Although there are no reports of Kan directly demanding that TEPCO leadership contact him, he and his aides were clearly frustrated at the lack of information from TEPCO. Kaieda later testified that they knew that the "messaging game" of indirect communications was ineffective. Deeply mistrustful of not only TEPCO, but also of government bureaucrats and nuclear researchers possibly tainted by TEPCO,²³ Kan had already begun assembling a private group of friends for advice about the nuclear plant.

Back on the ground at Fukushima, operational and informational difficulties frustrated crisis management efforts on the ground. Earlier that night, Yoshida had wanted to use fire trucks to inject cooling water into parts of the plant. However, since nobody had foreseen such an action, the lines of command were unclear, and the plan was not actually operationalized. There were no useful operations manuals to fall back upon, either. Although there were 50 pages in the operations manual for nuclear critical events, in its 16th revision at the time and released just two months earlier, it was almost completely useless; it did not assume the loss of electricity to the nuclear plant.²⁴

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one "Timeline of Events." Label the second one "Primary Actors." Label the third one "What Went Wrong."
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: VENTING THE REACTOR BUILDINGS (OPTIONAL)

Directions: Read the following handout with your group member and complete the tasks at the end of the reading.

kilopascal—a measure of force per unit area

schematics—diagrams, plans, or drawings

Around 11:50 p.m. [on March 11], the plant manager in charge, Masao Yoshida, discovered that the pressure containment vessel in Reactor 1 had reached an internal pressure of 600 kilopascals (kPa), well exceeding its maximum design of 427 kPa. Unless pressure was reduced, the containment vessel for the fuel rods could break. Yoshida decided to “vent” the reactor—the process of releasing hot air from the vessel itself into the atmosphere in order to lower the reactor pressure and temperature. The design of the Fukushima Dai-Ichi reactors was such that this would release substantial radioactive material into the atmosphere.²⁵ There were two types of vents in these reactors, motor operated valves and compressed air operated valves. Without electricity, neither worked. Therefore, they would have to be opened manually. Yet, nobody in the operations headquarters knew the exact design or location of the manual open hatches. This was knowledge held by contractors rather than TEPCO staff, who rarely went into the reactor buildings, and most contractors had left. Yoshida had to send staff with flashlights into the destroyed operations rooms in search of design schematics showing whether the vents could even be opened manually.²⁶

At the prime minister’s residence, in the underground emergency operations center, Prime Minister Naoto Kan; Banri Kaieda, minister of the Ministry of Economy, Trade and Industry (METI); Chief Cabinet Secretary Yukio Edano; Fukuyama; Hosono; the head of the Nuclear and Industrial Safety Agency (NISA); and a senior official of TEPCO debated the venting procedure. The politicians other than Kan lacked knowledge about venting, so questions such as the potential amount of radiation released and the degree of evacuation needed, were discussed. By 1:00 a.m. [on March 12], they decided that venting was necessary. They asked Yoshida to commence with venting procedure after the government would announce its action at 3:00 a.m. After Edano announced to the press at 3:12 a.m. that venting would occur shortly, the political leadership expected imminent news of venting—but it never came. As Kan waited, his mistrust and suspicion of TEPCO no doubt growing by the minute, he began saying that he would visit the Fukushima Dai-Ichi plant himself that morning.²⁷

During the night, as they worked straight through until morning, the prime minister’s staff learned to their surprise that the TEPCO executive in the emergency headquarters in the prime minister’s residence, former TEPCO Vice President Ichiro Takekuro ... was not directly in touch with the Fukushima Dai-Ichi plant. He was instead relaying messages via TEPCO headquarters. As the political leadership’s frustration mounted, Takekuro could not provide clear answers to their inquiry as to why the venting had not occurred by 5:00 a.m.

At 5:44 a.m., the prime minister decided to widen the evacuation area from 3 km to a 10 km radius. Around this time, reports came from the Fukushima Dai-Ni plant, 8 km south of the Dai-Ichi plant. Another crisis was looming. The report from Fukushima Dai-Ni was that temperatures in three of its four reactors were rising. The primary water pumps facing the ocean had been damaged by the tsunami, and the reactors could not be cooled. Therefore, it looked as though both Fukushima plants were headed for catastrophe. Receiving this news, Kan issued a second nuclear emergency decree, ordering that everyone within a 3 km radius of both plants evacuate, and that people stay indoors in the radius between 3 km to 10 km.

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one “Timeline of Events.” Label the second one “Primary Actors.” Label the third one “What Went Wrong.”
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: KAN'S VISIT TO THE FUKUSHIMA DAI-ICHI PLANT (OPTIONAL)

Directions: Read the following handout with your group member and complete the tasks at the end of the reading.

At 6:00 a.m. on March 12, only 15 hours after the earthquake hit, Prime Minister Naoto Kan officially decided to visit the Fukushima Dai-Ichi plant. His aides warned him about the potential political repercussions, but he was determined. Kan left the prime minister's residence by helicopter at 6:30 a.m. In the meantime, he had instructed Banri Kaieda, minister of the Ministry of Economy, Trade and Industry (METI), to issue a legally mandated order to TEPCO to commence venting. Kaieda did so at 6:55 a.m. Kan clearly no longer trusted TEPCO to act voluntarily, assuming that its delay to vent the reactors was deliberate.²⁸

Kan visited the emergency operations building at the Fukushima Dai-Ichi plant for just under an hour, meeting the plant manager in charge, Masao Yoshida, and seeing the exhausted ground-level workers throughout the building.²⁹ He was reportedly reassured by Yoshida's competence and strong leadership. The latter promised that he would gain control of the situation even if it meant assembling squadrons of workers who were prepared to die in the attempt. During the helicopter ride, Kan was accompanied by Haruki Madarame, the chairman of Japan's Nuclear Safety Commission (NSC). Kan directly inquired whether a hydrogen explosion might occur from the reactor's zirconium case³⁰ melting and reacting with water. Madarame's answer was no—there was no oxygen,³¹ so there would be no explosion.

Kan left the Fukushima plant just after 8:00 a.m. At the plant at 9:04 a.m., two-man teams began heading to the reactor building to manually open the vent. In the absence of mobile communications, the second group had to wait for the first group to return in order to get information. The first group opened one of the vents about a quarter of the way before their radiation levels reached the maximum levels deemed reasonably safe. The second team, however, had to turn back before reaching the vent due to high levels of radiation that triggered their alarms. One of them received a dose of approximately 106 millisieverts (mSv), far exceeding the yearly limit of 1 mSv deemed safe (the others received 89 and 95 mSv). The most exposed worker reported a headache and high body heat, suggesting that he had been irradiated, or *hibaku*—a Japanese term loaded with connotations of the Hiroshima and Nagasaki atomic bomb victims. There was no doctor within the operations center, so he was rushed to the local hospital. However, it had already been evacuated, so no doctors were available there, either. Yoshida deemed it too unsafe to send the third group into the reactor building.³²

Yoshida then attempted to connect a compressor to one of the vents that could be opened with compressed air. He sent staff to procure such a device from one of the contractors' offices. They succeeded in finding one, but discovered that they could not find an adapter to connect the

millisievert—unit used to measure the amount of radiation received by people

compressor. At 12:30 p.m., they used a truck with a crane to carry out the compressor and found something that could function as a converter. At 2:00 p.m. they were finally able to vent Reactor 1—almost 14 hours after Yoshida’s decision, and eight hours after Kan’s legal order. The reactor pressure, designed for a maximum of 427 kilopascals (kPa), had risen over 840 kPa at one point.³³

By then, the fuel core of Reactor 1 had already melted through. An hour and a half later, at 3:36 p.m. on March 12, a hydrogen explosion blew off its roof and upper walls....

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one “Timeline of Events.” Label the second one “Primary Actors.” Label the third one “What Went Wrong.”
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: THE REACTOR BUILDING EXPLOSIONS (OPTIONAL)

Directions: Read the following handout with your group member and complete the tasks at the end of the reading.

[At 3:36 p.m. on March 12, a hydrogen explosion blew off Reactor 1's roof and upper walls blowing debris all over the plant, and injuring two workers.] It severely disrupted operations on the adjacent Reactor 2. Falling debris damaged the 200-meter cable that connected the power truck to Reactor 2. A fire truck that had been preparing to inject seawater was also damaged, as was its hose. Workers had been close to powering up a system that would insert a boric acid solution at high pressure to cool the reactor, but fear of high radiation kept workers away. By this time, the core fuel had melted considerably. Five months later, the Tokyo Electric Power Company (TEPCO) revealed that radiation levels near an exhaust duct between Reactors 1 and 2 at this time read 10 sieverts (Sv), or 10,000 mSv, an hour, with 5 Sv an hour inside Reactor 1's building pipes (enough to kill a person in 40 minutes).³⁴

boric acid—a weak acid of boron used in nuclear power plants as a neutron poison to slow down the rate at which fission is occurring

sievert—unit used to measure the amount of radiation received by people

At 6:00 p.m. on March 12, Prime Minister Naoto Kan expanded the 10 km evacuation radius to 20 km.

Injecting Seawater

By 5:00 p.m. on March 12, the prime minister's command center had been moved from the underground emergency headquarters to his fifth-floor office. The problem was that the underground emergency headquarters could not receive cellular phone signals—a serious hindrance for operations. As it later became clear, however, the move to the fifth floor entailed its own set of problems. Many of the dedicated emergency landline phones and faxes from various agencies to the prime minister's office were connected directly to the underground headquarters. Staff had to manually relay messages up to the fifth floor—sometimes losing information along the way. This certainly increased the prime minister's sense of frustration in receiving timely information from TEPCO.³⁵

By 6:00 p.m., Kan strongly advocated injecting seawater into the reactors. This would produce radiation-contaminated seawater, and almost certainly ruin the reactors. Confusion during this period created a situation that later became infamous. It turned out that the plant manager in charge, Masao Yoshida, had already begun injecting seawater at around 7:00 p.m., before the political leadership had given the order. However, the TEPCO executive in the prime minister's office, Ichiro Takekuro, thought that it would look bad if TEPCO were found injecting seawater before the prime minister's office issued the order. He therefore advised TEPCO to command Yoshida to halt injection of seawater until further notice. Yoshida acknowledged but disobeyed the order, continuing to pump seawater. When Banri Kaieda, Minister of the Ministry of Economy, Trade and Industry (METI), ordered TEPCO to pump seawater at 8:05 p.m., as relayed by Takekuro to TEPCO headquarters immediately thereafter,

the political leadership did not know that seawater injection had already begun, and TEPCO leadership was unaware that it had not stopped.³⁶

Fukushima Dai-Ichi's Reactor 3 was deep into crisis as well. Some combination of miscommunication and bad judgment from the prime minister's office led to an attempt to shift the cooling method of Reactor 3 from seawater to foam water from fire engines. Fire trucks were sent by the Nuclear and Industrial Safety Agency (NISA), but the Fire and Disaster Management Agency (FDMA) was unwilling to send them to the Fukushima Offsite center 5 km from the Dai-Ichi plant, since the evacuation zone was 20 km. Fire engines on the ground had to find and uncover connectors to the storage tanks of anti-fire foam. To inject water from fire trucks, pressure within the reactor had to be released through a safety release valve, but there was insufficient battery power to open the valve. Yoshida collected his employees' commuter car batteries to get enough power for the operations center, opening the valve just past 9:00 a.m. on March 14. Six hours and 43 minutes had elapsed since the high-pressure coolant injection system had stopped, and heat had risen to 2,000 degrees Celsius. At about 10:30 a.m., just as Yoshida attempted to switch back to seawater since water tanks were becoming depleted, a strong aftershock hit, delaying the switchover. As a result, there was a gap of over an hour between the end of sending foam, and the recommencing of seawater injections at 1:12 p.m.³⁷

Reactor 3, which was later thought to have reached temperatures exceeding 2,000 degrees Celsius, had already begun to melt down around 8:00 a.m. Earlier in the morning at 6:50 a.m., as pressure within the reactor chamber had begun to rise, all outdoor workers were given evacuation orders. At 11:01 a.m., the Reactor 3 building exploded—a much stronger explosion than that of Reactor 1. A black plume like a mushroom cloud rose high into the sky.... Approximately 11 people were injured, and the operations center was thrown into panic.

Efforts to sustain temperatures in Reactor 2 were halted as fire trucks and hoses were destroyed. Vents had been opened approximately 25 percent, but they slammed shut again with the explosion, and all workers evacuated to the operations center for some time. At this point, the battery for Reactor 2's cooling system ran out, just after 1:00 p.m. Another process of gathering car batteries to open the safety valve to lower the pressure and connect fire engines was completed by around 7:20 p.m. It was then discovered that the fire trucks had run out of fuel, with no supplies on hand. Kan, who had received this latest update, was furious, ordering helicopters to send in fuel.³⁸

It was later estimated that Reactor 2 experienced a meltdown about six and a half hours after the cooling system had stopped. Large quantities of hydrogen were produced as a result of the zirconium shell of the fuel rods drawing oxygen from the surrounding water—which can occur at high temperatures. By 10:50 p.m., Yoshida determined that the internal pressure had risen to 540 kilopascals (kPa), exceeding the 427 kPa maximum.

zirconium—covering used in nuclear reactors to provide the cladding, or outer covering, for the cylindrical fuel rods that power a nuclear reaction

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one “Timeline of Events.” Label the second one “Primary Actors.” Label the third one “What Went Wrong.”
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: TEPCO's ABANDONMENT REQUEST CONTROVERSY, ESTABLISHMENT OF JOINT HEADQUARTERS (OPTIONAL)

Directions: Read the following handout with your group members and complete the tasks at the end of the reading.

After the hydrogen explosion in Reactor 3 [on March 14], Tokyo Electric Power Company (TEPCO) executives began asking the political leadership whether they could abandon the Dai-Ichi plant and regroup at the Dai-Ni plant, 8 km to the south. TEPCO President Shimizu telephoned Banri Kaieda, minister of the Ministry of Economy, Trade and Industry (METI), then Chief Cabinet Secretary Yukio Edano. In events that became the focal point of intense scrutiny in subsequent investigations, TEPCO executives and Shimizu later insisted that they were not seeking permission to fully abandon the Dai-Ichi plant. They contended that they had said "retreat," implying that key personnel would stay behind to continue seawater injection operations. Kaieda and Edano dispute this view, contending that nothing was ever said about core personnel remaining. They argued that if it was simply a strategic "retreat" leaving necessary personnel, Shimizu would have had no need to call each of them, and after making no headway, then attempt to reach the prime minister.³⁹

Prime Minister Naoto Kan was awakened around 3:00 a.m. on March 15, with Kaieda, Edano, Head of the Nuclear and Industrial Safety Agency (NISA) Hosono, and Prime Minister's Aide Terada in the prime minister's office on the fifth floor. He was informed that TEPCO was considering abandonment of the Dai-Ichi plant. Kan forcefully asserted that this could not happen. He summoned TEPCO president Shimizu at around 4:00 a.m., and Shimizu arrived around 4:20 a.m.⁴⁰

Kan was concerned not only with Reactor 2, which was close to exploding, but also with the pools of used fuel stored in the reactor buildings of Reactors 4, 5, and 6, shut down for maintenance at the time of the disaster....⁴¹

The prime minister took the unprecedented step of ordering a joint government-TEPCO headquarters within TEPCO. He told Shimizu to get a desk ready for Hosono within half an hour, and that he, Kan, would visit TEPCO headquarters within the hour. Kan rode into TEPCO headquarters at 5:35 a.m., announcing to the 300 or so employees working around the clock that TEPCO would not be allowed to abandon the Dai-Ichi plant. He told them that they, TEPCO, were responsible, and if they fled, there was no way the company would survive. This visit increased antagonism between TEPCO and the political leadership. However, the establishment of joint headquarters was later considered a critical turning point in management of the disaster.⁴²

antagonism—an active hostility or opposition, as between unfriendly or conflicting groups

At the TEPCO headquarters, Kan saw for the first time that there were video feeds from the Dai-Ichi plant emergency headquarters. Once

Hosono and some of his staff members were established in TEPCO's headquarters, they were able to communicate far more effectively with the prime minister's office, rather than waiting for TEPCO to relay information from the ground operations.

During Kan's visit, just after 6:30 a.m., a large explosion sound emanated from Reactor 2. It later became apparent that hydrogen gas from Reactor 2 had leaked into Reactor 4 through a shared (and likely damaged) venting pipe. There it accumulated in the Reactor 4 building, and when it ignited, the explosion blew off the roof and much of the walls. The sound of the explosion traveled back through the pipes and reverberated through the Reactor 2 building. Yoshida sought permission to leave 70 critical operations staff for water injections and take the rest of the approximately 650 staff to Fukushima Dai-Ichi plant to stage operations from there. Kan observed and interacted with the TEPCO chairman and president during the exchange, as much of plant manager Yoshida's staff was evacuated to the Dai-Ni plant. All the while Kan continued to forcefully demand that some TEPCO staff remain at the Dai-Ichi plant to continue water injections. He was at TEPCO headquarters for approximately three hours, until 8:45 a.m.⁴³

At 11:00 a.m., Kan expanded the evacuation radius to 30 km.

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one "Timeline of Events." Label the second one "Primary Actors." Label the third one "What Went Wrong."
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: REACTOR POOLS—THE OTHER SERIOUS DANGER (OPTIONAL)

Directions: Read the following handout with your group member and complete the tasks at the end of the reading.

Prime Minister Naoto Kan's forceful rejection [early in the morning on March 15] of the Tokyo Electric Power Company's (TEPCO) apparent request to abandon the Dai-Ichi plant was a response to potentially critical problems with the reactors undergoing routine maintenance at the time of the disaster—in particular Reactor 4, located right next to Reactors 1–3....

The fuel rods of Reactor 4 had been taken out of the reactor and placed in storage pools. The fuel rods still required cooling—at least several tons of water per hour to avoid additional nuclear catastrophe. The storage pools of these fuel rods, numbering in the thousands, were at the top of the reactor buildings.

Although the explosion that rocked the Dai-Ichi plant at 6:00 a.m. on March 15 was not from the “live” Reactor 2, but actually the building of the stopped Reactor 4, in some ways, this was worse. The used fuel pool had 1,535 fuel assemblies (of which 204 were actually unused), each with a dozen fuel rods. Since the pumps had stopped, the temperature of the pool had risen from 40 degrees Celsius to 84 degrees. Unlike the nuclear reactor cores, which were inside multiple layers of containment vessels, the storage pools were unprotected. Once the hydrogen explosion blew off the roof and much of the walls, the pool itself was exposed directly to the outside. This could speed up the evaporation of water in the pools, which could then lead to various terrifying scenarios; if a meltdown began, the fuel rods could burn through the bottom of the containment pools, falling all over inside the reactor building. Radiation would be so strong that cleanup and cooling activities would be highly problematic, and a vast area would need to be evacuated, jeopardizing operations at the Fukushima Dai-Ni plant as well. Without sufficient protection from radiation in the operations centers, let alone near the reactor buildings, on-the-ground efforts to pump water into the reactors in both Fukushima plants would have been critically hindered; therefore, the possibility of uncontrolled reactions was a real possibility.

With the roof and walls severely damaged from the hydrogen explosion, a strong aftershock could potentially bring the entire water pool, with its fuel rods, tumbling down into the reactor building. This was not a far-fetched scenario by any means. On March 12, a day after the 9.0 earthquake and three days before Reactor 4’s roof and walls blew off, a magnitude 6.6 aftershock, centered in northern Niigata, occurred—a major earthquake when compared to almost any quake other than the March 11 quake. Moreover, the heavy lids of the containment vessel and the equipment used to move it were all stored in the upper parts of the reactor building 4, making it further vulnerable to structural collapse....

containment vessel—a steel or reinforced concrete structure enclosing a nuclear reactor

Diet—legislative body
of Japan

The U.S. government was highly concerned about the vulnerability of these used fuel pools. It feared that the bottom of the pool in Reactor 4 had already given out, with exposed nuclear rods falling around the building. The U.S. embassy recommended evacuation of U.S. citizens living within a 50-mile (80.5 km) range, and Japan's stock market plunged as soon as news of the explosion at Reactor 4 was announced. Indeed, internal worst-case scenarios within the prime minister's office suggested the possibility of an evacuation radius of 250 to 300 km. This included the entire Tokyo Metropolitan area.⁴⁴ In interviews and Diet testimonies months later, Kan stated that his concern was that Japan as a country might not survive the accident if Tokyo had to be evacuated.

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one “Timeline of Events.” Label the second one “Primary Actors.” Label the third one “What Went Wrong.”
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

NUCLEAR DISASTER: REACTOR POOLS—EMERGENCY MOBILIZATION TO COOL USED FUEL POOLS (OPTIONAL)

Directions: Read the following handout with your group members and complete the tasks at the end of the reading.

A positive turning point in the disaster came on March 17, almost 6 days after the earthquake and tsunami hit. The previous day, a Self-Defense Forces (SDF) helicopter with Tokyo Electric Power Company (TEPCO) employees on board confirmed visually and through photographs that Reactor 4's used fuel pool contained water, and that the fuel rods were not exposed. On the morning of the 17th, another SDF helicopter, reinforced with tungsten on its lower side to mitigate radiation, flew over the reactor and dumped a large bucket of water onto Reactor 3, which was issuing white steam. Although the amount of water was minuscule in comparison to what was needed even in the short to medium term—and disheartening television broadcasts seemed to show that some of the first buckets missed almost entirely—it was the first indication that the government was finally able to take some tangible measures to manage the disaster.

More importantly, on the evening of the 17th, a number of SDF fire trucks equipped with aircraft catastrophe grade fire extinguishers were collected from SDF land and air forces. At 7:35 p.m., they began dousing Reactor 3 with water, taking turns for five dousings. The following day, they moved in even closer, hitting Reactor 3, and expanding to cover Reactor 4 from the 20th.⁴⁵ Coordination between SDF, the Fire and Disaster Management Agency, and National Policy Agency was necessary for these actions, and the government succeeded in bringing them together.⁴⁶ On March 20, power from the electricity grid to the Fukushima Dai-Ichi plant was finally restored. However, to the shock and dismay of all involved, the cooling systems did not restart. Monitoring instruments were unstable, and the motor to pump water to the used fuel pools did not work.⁴⁷

Luckily, further reinforcements for the manual hosing of the reactors and storage pools were on the way. A large concrete pump truck called Kirin ("giraffe") was deployed on March 22. In an incredible (but in this case, positive) coincidence, it was passing through Yokohama port on route to Vietnam, from Germany; all parties agreed to divert it to Fukushima. Two other large concrete pumps, with cameras on top, also arrived from other parts of Japan, pumping water into the 30-meter-high fuel pools. On March 23, a pump truck with an arm reaching 63 meters high arrived from China, as a gift to TEPCO. Just after that, the world's tallest pump truck—with an arm reaching 70 meters—arrived from the United States.

These measures were used until March 24, when the cooling pumps became operational.⁴⁸ On April 11, the government announced a 20 km radius for emergency and planned evacuation areas.

The Disaster as a Critical Juncture

The Fukushima nuclear disaster has unleashed a major wave of industrial, institutional, political, and social challenges. The issues are complex and intertwined, with acute short-term crises and highly transformative medium- to long-term implications for change. Political processes will invariably shape the nature of change, as one of Japan's largest companies is restructured, the crucial energy industry is restructured, and government organizations that manage energy are reorganized. Social forces, with media attention on nuclear "refugees" who cannot or choose not to return to Fukushima, and voter support for localities that stand up to the national government and refuse to restart local nuclear plants, will also shape outcomes.

Unfortunately, the potential for bold and decisive political leadership in the face of the crisis was squandered, with political discourse turning into squabbles within and among political parties—highly disappointing to most voters and observers. Yet there is potential for Japan to emerge from this experience with new strengths and international relations....

Activity

1. For each group member, obtain three sheets of blank paper (nine sheets total). Label one "Timeline of Events." Label the second one "Primary Actors." Label the third one "What Went Wrong."
2. Using the information on your handout, analyze the content in your handout and organize the information accordingly.
3. Be prepared to share this information in a larger group.

ANTICIPATION GUIDE

Directions: Complete the “Before” column prior to viewing the documentary film *After the Darkness* and reading Handout 7, *The Effect of the March 11, 2011, Natural Disaster on Japanese Youth*. When prompted to do so by your teacher, complete the “After” and “Proof” sections after viewing the film and reading Handout 6.

Before		After		
True	False	Statement	True	False
		Prior to March 11, 2011, the Japanese media portrayed its youth as ambitious and hardworking.		
		Prior to March 11, 2011, Japan's economy was growing rapidly. However, the natural disaster caused Japan's economy to slip into a recession.		
		Japan's generational differences and its older generation's general opinion of the younger generation parallel the opinions in the society in which you live.		

AFTER THE DARKNESS NOTE-TAKING SHEET

Directions: Answer the following questions as you view the documentary film *After the Darkness*.

1. Fill in the blanks:

This film focuses on the journeys of two people:

- Masahide Chiba, ____ years old, born in Ofunato City _____ Prefecture.
- Naomi Fukuda, ____ years old, born and raised in _____.

2. After the earthquake struck, Naomi worried her mother had gone to do what?
3. Describe the 2013 landscape of Rikuzentakata as Naomi describes what happened in 2011. Is there a lot of debris? Has everything been rebuilt?
4. Who did Masahide lose in the earthquake and tsunami?
5. How was Naomi feeling two months after the March 11, 2011, disaster?
6. What is the Tohoku Future Leaders Summit?
7. What career path did Naomi decide she wanted to pursue, and why?
8. What career path did Masahide decide he wanted to pursue, and why?
9. What did you see in the documentary film that shows how Masahide and his family are recovering from the disaster?
10. What did you see in the documentary film that shows how Naomi and her family are recovering from the disaster?

THE EFFECT OF THE MARCH 11, 2011, NATURAL DISASTER ON JAPANESE YOUTH

bubble economy—a booming financial situation that is unsustainable, often seen in inflated land and stock prices, excessive lending, and low interest rates

recession—a period of an economic contraction, sometimes limited in scope or duration

degenerate—a person who has declined, as in morals or character, from a type or standard considered normal

disproportionate—unequal

mobilize—to organize for a purpose

In the 1980s, Japan's economy was booming. Many Japanese people assumed that good school grades for their children would lead to their entrance into good universities, which would then lead to jobs for life for every graduate. When Japan's “bubble economy” popped in the early 1990s, however, the country's economy experienced two decades of recession. As a result, a generation of Japanese were faced with the insecurity of part-time and temporary work, if they were lucky enough to find jobs at all.⁴⁹

During the 1990s and 2000s (often referred to as the “Lost Decades”), the Japanese media discussed 20-somethings in two mainstream perspectives. The first perspective was that Japanese youth were essentially moral degenerates who lacked a proper work ethic. The second perspective was that the Japanese youth were underdogs who had to shoulder disproportionate costs during Japan's long recession. The first perspective that Japanese youth were morally inferior to older generations, however, was the one that dominated the Japanese domestic media up to 2011.⁵⁰

Japanese youth who hopped from one job to another were referred to as *freeters*—a combination of the word “freelance” and the German word for “worker,” *arbeiter*. Freeters were frequently bundled together with *neets*—an acronym imported from Britain meaning “not in education, employment, or training.” In Japan, another term—*hikikomori*—describes a phenomenon of young people, predominantly men, who have withdrawn from society, sometimes refusing to leave their rooms for months and even years at a time. A 2010 survey by the Japanese Cabinet Office estimated there were as many as 700,000 hikikomori nationwide. Many members of the older generation, who graduated and worked in steady careers during the 1960s and 1970s, could not relate.⁵¹

At the time of the March 11, 2011, earthquake and tsunami, Japanese youth were not the only people struggling to find their way. Many Japanese were already frustrated with their country's political leadership, concerned about Japan's sluggish economy, and alarmed at nearby Chinese, Russian, and North Korean political developments. Undoubtedly, the March 11, 2011, disaster struck a devastating blow to Japan. However, it also revealed hidden strengths and a new resolve in the Japanese society.⁵²

In contrast to the view that many Japanese youth were listless and unambitious, many students were actually energized and mobilized by the disaster. As of May 2011, close to 300,000 Japanese had volunteered to help with relief and recovery efforts in Tohoku. The Japanese government and many firms contributed to this drive by offering “volunteer holidays” to their employees.⁵³ After March 11, a steady trickle of news stories that featured young volunteers traveling to Tohoku to contribute to rebuilding efforts also began to change many people's perceptions that young people were lazy, passive, inward-looking, or pitiful.⁵⁴

tedium—the state of being bored or the quality of being boring; monotony

For example, Mamoru Kondo, a Japanese man in his late 20s, had a job at an eyewear firm, which he obtained after graduating from college. He lived in Nagoya and returned home usually only once a year to visit his parents. After the March 11, 2011, earthquake and tsunami, however, Kondo realized that he was gradually losing his roots. He returned home and felt a strong urge to “witness the recovery of [his hometown] together with [his] parents and friends there.” Leaving his job at the eyewear firm, Kondo returned to Tohoku to support those who had lost their homes to the tsunami and who are still living in temporary housing. Some of Kondo’s responsibilities include listening to people’s needs, providing feedback to municipal authorities, and organizing events to help alleviate the survivors’ tedium and encouraging them to interact socially. “Maybe what I can do is little, but I want to support my hometown,” Kondo said. According to the nonprofit organization Entrepreneurial Training for Innovative Communities, an increasing number of young people (like Kondo) are willing to return and help rebuild their shattered hometowns.⁵⁵

During the “BEYOND Tomorrow Global Leadership Academy 2013,” which was organized by the Tokyo-based Global Fund for Education Assistance and funded by Bank of America Merrill Lynch, James Seddon, assistant vice president of marketing and corporate affairs for Merrill Lynch Securities Co., stated, “I feel really hopeful for Japan to know that there is this kind of generation that—even though they have gone through this terrible experience—they are looking toward the future, they have very clear goals and a lot of confidence with which to pursue them.”⁵⁶

PROJECT CHOICES

Option 1

Research one of the following natural disasters:

Your teacher will assign each group a recent natural disaster from the following list:

- 2004 Indian Ocean tsunami
- 2005 Hurricane Katrina, United States
- 2008 Cyclone Nargis, Burma
- 2008 Sichuan earthquake, China
- 2004 floods, Haiti, Dominican Republic
- 2001 Gujarat earthquake, India
- 2013 typhoon, Philippines

Prepare a poster depicting the following information:

- When and where did the natural disaster take place?
- What were the casualties?
- Were there any factors that may have caused the casualties to be exceptionally high or low?
- How did the community surrounding the disaster respond?
- How did local governments respond to the disaster?
- In what ways did human response help alleviate or exacerbate the suffering caused by the natural disaster?
- In what ways were this natural disaster and the response to it similar to Japan and the March 11, 2011, earthquake and tsunami? In what ways were they different?

The poster should have at least two images.

Sources for information, map, and visuals must be properly cited.

The text used in the poster or report should be well organized, grammatically correct, and effectively answer the questions posed above.

Option 2

Write a poem or song lyrics to commemorate the March 11, 2011, Tohoku earthquake and tsunami.

- The poem or song lyrics must be at least 30 lines long.
- The poem or song lyrics must convey information or images depicted in the documentary film *After the Darkness*.

Option 3

Compose a two-part poem about Masahide Chiba's experience with the March 11, 2011, disaster.

- The first part should focus on his emotions and feelings at the time of the disaster.
- The second part should focus on his emotions and feelings two years after the disaster.
- The poem must be at least 30 lines long.
- The poem must convey information or images depicted in the documentary film *After the Darkness*.

Option 4

Compose a two-part poem about Naomi Fukuda's experience with the March 11, 2011, disaster.

- The first part should focus on her emotions and feelings at the time of the disaster.
- The second part should focus on her emotions and feelings two years after the disaster.
- The poem must be at least 30 lines long.
- The poem must convey information or images depicted in the documentary film *After the Darkness*.

Option 5

Create an oral history project. Think of someone who has experienced a tragedy, small or large. Make an audio or video recording of a 10-minute oral history interview with this person. Key questions to ask: What was the difficulty that you faced? How did you overcome it?

- Additional interview questions should exhibit sensitivity to the person's tragedy.
- Questions should be formulated before the interview (not created as the interview is being conducted).

Option 6

Write an account of a person's experience with the March 11, 2011, Tohoku earthquake and tsunami in the style of a newspaper article.

- The account should be at least 250 words long.
- The account must be typed.
- Sources for information, map, and visuals must be properly cited.
- The text used in the poster or report should be well organized and grammatically correct.

handout 8

Option 7

Read three film reviews from a newspaper or online. Formulate your own review for *After the Darkness*. Describe what aspects of the film you liked, and what aspects of the film you felt needed improvement.

- The review should be at least 250 words long.
- The review should be typed.
- Your review should be well organized and grammatically correct.

Option 8

Write a personal essay in which you reflect upon how Masahide and Naomi are coping with their tragedies and draw parallels to how you have coped with or overcome your own personal difficulties or tragedies.

- Your essay should be at least 250 words long.
- Your essay should be typed.
- Your essay should be well organized and grammatically correct.

All options

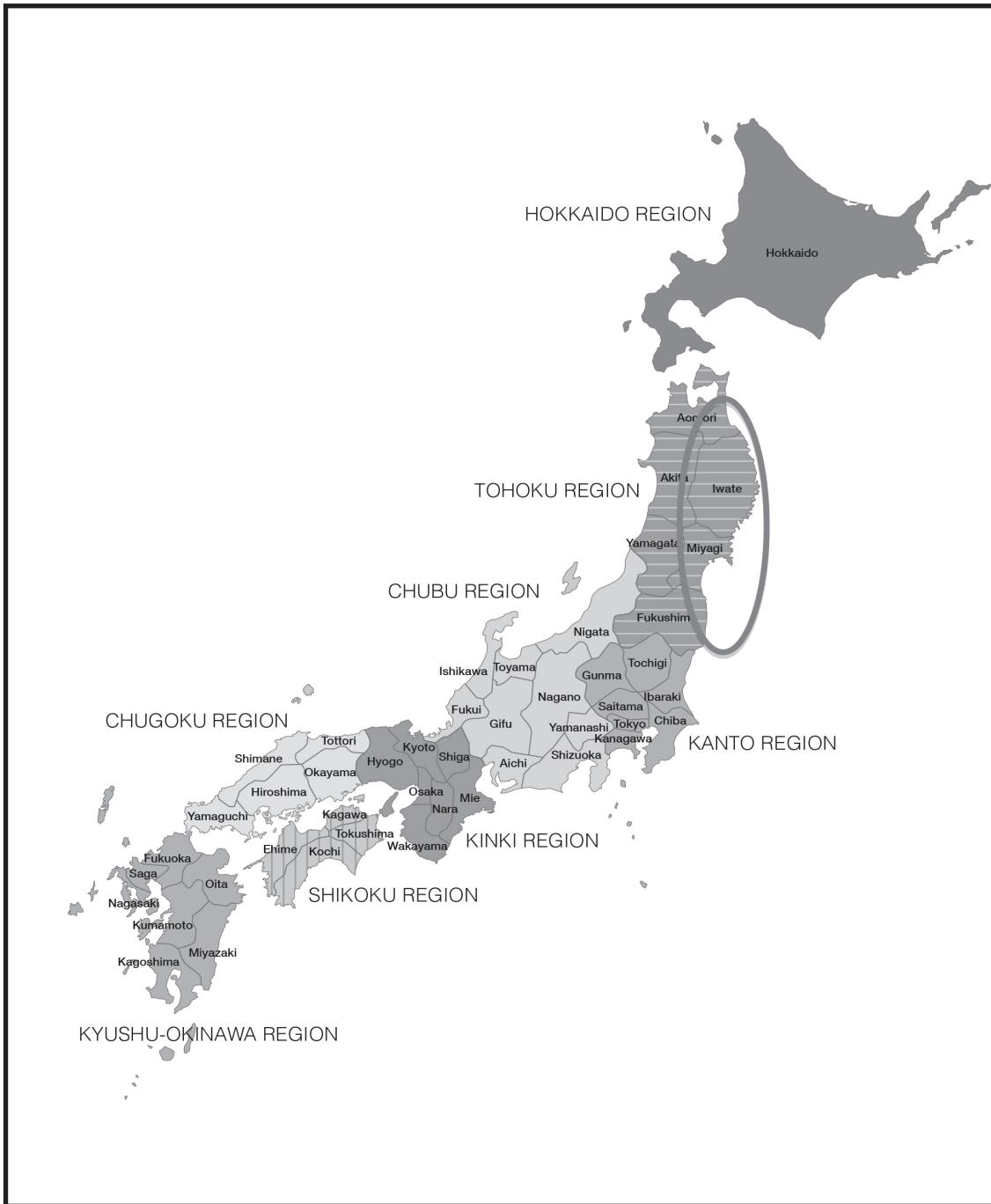
Everyone is expected to present his or her project to the class. Presentations should be clear and well rehearsed.

MARCH 11, 2011, OVERVIEW NOTE-TAKING SHEET

1. Fill in the blank:

On March 11, 2011, Japan was hit by the largest recorded earthquake in its 2,000-year recorded history.

2. Circle the area of Japan that was most affected by the earthquake and subsequent tsunami.



answer key 1

3. How far did the earthquake move Honshu toward the continental United States?
10 feet
4. How tall was the tsunami at its highest?
133 feet
5. How far inland did the tsunami reach?
Six miles
6. How many deaths did the earthquake and tsunami cause?
Up to 19,000
7. Even though the Great Kanto Earthquake of 1923 was not as powerful as the one on March 11, 2011, there were more casualties in 1923. Why?
The building standards were lower in 1923.
8. What are the constantly shifting tectonic plates on which Japan sits known as?
The “Ring of Fire”
9. On average, how many earthquakes does Japan experience every year?
1,500–2,000
10. True or False?:
The Fukushima nuclear disaster has yet to be completely resolved. It will take decades to clean up, decontaminate, and decommission.
True
11. What is one example of how the Japanese cooperated and exhibited a commitment to the national interest in the wake of the March 11, 2011, disaster?
The Japanese people voluntarily accepted a 15 percent reduction in their use of energy—even during the oppressive heat of the Japanese summer, many Japanese citizens turned off their air conditioners or used them only for short periods of time.
12. Did any of the images in the presentation make an impression on you? If so, which ones, and why?
Student answers will vary.
13. What information in this presentation surprised you?
Student answers will vary.

FUKUSHIMA NUCLEAR DISASTER OVERVIEW

1. How was the Fukushima Dai-Ichi Power Station prepared to handle a natural disaster prior to the March 11, 2011, earthquake and tsunami?
As the earthquake hit, the reactors all succeeded in emergency shutdowns. Even though power lines leading to the plant were severed, on-site backup generators kicked in seamlessly.
2. In what ways was the Fukushima Dai-Ichi Power Station not adequately prepared to handle the March 11, 2011, earthquake and tsunami?
Although there was a 10-meter high seawall protecting the plant, it was obliterated by the tsunami, which was well over 12 meters high. As a result, the tsunami succeeded in damaging all the on-site backup power sources.
3. Compare and contrast the Fukushima nuclear disaster to the Chernobyl nuclear disaster of 1986.
 - Both were declared level 7 on the International Nuclear Event Score.
 - Chernobyl released six times more radioactive material than Fukushima.
 - The disaster in Chernobyl resulted from an explosion of an active reactor with no concrete containment vessel.
4. During the Fukushima disaster, seawater was pumped into the reactors in an attempt to cool them. What was a negative consequence of this action?
More than 100,000 tons of water were contaminated, about a tenth of which was released into the ocean by mid-2011.

AFTER THE DARKNESS NOTE-TAKING SHEET

Directions: Answer the following questions as you view the documentary film *After the Darkness*.

1. Fill in the blanks:

This film focuses on the journeys of two people:

- Masahide Chiba, 19 years old, born in Ofunato City, Iwate Prefecture.
- Naomi Fukuda, 19 years old, born and raised in Rikuzentakata.

2. After the earthquake struck, Naomi worried her mother had gone to do what?

She worried her mother had gone to check in on their pets after the earthquake struck, meaning she probably would have been trapped in her car when the tsunami hit.

3. Describe the 2013 landscape of Rikuzentakata as Naomi describes what happened in 2011. Is there a lot of debris? Has everything been rebuilt?

There is a wide expanse of dirt, no buildings, no debris. Not everything has been rebuilt; Naomi shows us where the high school and its surrounding grounds used to be.

4. Who did Masahide lose in the earthquake and tsunami?

Masahide's mother and grandmother both died.

5. How was Naomi feeling two months after the March 11, 2011, disaster?

She was having trouble sleeping, and when she did sleep, she had nightmares. She questioned why she was alive.

6. What is the Tohoku Future Leaders Summit?

The Tohoku Future Leaders Summit is a leadership development program for youth deeply affected by the Great East Japan Earthquake (the March 11, 2011, earthquake).

7. What career path did Naomi decide she wanted to pursue, and why?

Naomi decided she wanted to be a home health-care worker. She felt that by doing so, she could help patients before they became seriously ill, and develop closer relationships with her patients than doctors or nurses could develop with their own patients.

8. What career path did Masahide decide he wanted to pursue, and why?

Masahide decided to study urban planning/city planning. He wanted to make dilapidated towns more beautiful than they originally were (not just for Ofunato, but for the entire Tohoku area).

9. What did you see in the documentary film that shows how Masahide and his family are recovering from the disaster?

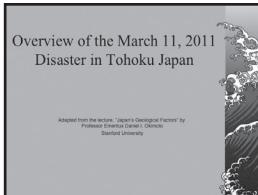
They were in the process of rebuilding their house, playing baseball, etc.

10. What did you see in the documentary film that shows how Naomi and her family are recovering from the disaster?

They were all together in a house (their previous one had been destroyed in the earthquake and tsunami), laughing, discussing Naomi's plans for the future, etc.

MARCH 11, 2011, OVERVIEW*

Directions: Use this presentation script to help guide students through the “March11Overview.ppt” presentation.



Slide 1: Title Slide

On March 11, 2011, Japan was hit by the largest recorded earthquake (9.0 on the Richter scale) in its 2,000-year recorded history.



Slide 2: Japan's Regions

Tohoku, the northern region of Japan, shook violently for 3 to 5 minutes. Tremors were felt throughout Tokyo and farther south.



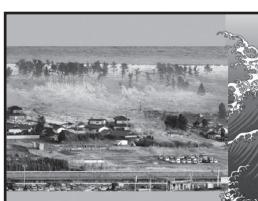
Slide 3: March 11, 2011, Disaster, 9.0 Earthquake

The force of the earthquake was so great that it knocked the global axis off by six inches and moved the main island of Honshu about 10 feet eastward toward the continental United States. There were 400 aftershocks of varying degrees of magnitude.



Slide 4: Tsunami

The earthquake was followed in a few minutes by a massive tsunami, which at its highest crested at 133 feet.



Slide 5: [Untitled]

When the tsunami rolled into the Japanese coastline at speeds of 800 km/hour, it devastated much of the Pacific coastline of Tohoku and areas south of Tohoku.



Slide 6: Destruction

It went as far inland as six miles and had the effect of a bulldozer, destroying homes, buildings, and carrying debris deep into the interior of Japan.

* Adapted with permission from Professor Emeritus Daniel Okimoto's lecture, "Japan's Geological Factors," Stanford University, November 7, 2011.



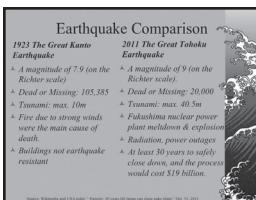
Slide 7: [Untitled]

There were up to 19,000 deaths associated with the natural calamity and 80,000 displaced families.



Slide 8: 7.9 Great Kanto Earthquake, 1923

Of all of the countries in the world, none is more vulnerable to natural disasters than Japan. Earthquakes occur often throughout the course of a year, as well as tsunamis, floods, typhoons, mudslides, and fires. In 1923, Japan experienced the Great Kanto Earthquake (7.9 on the Richter scale), which hit the area of Tokyo.



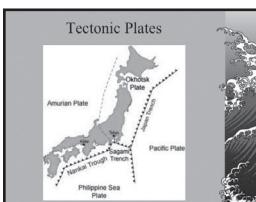
Slide 9: Earthquake Comparison

Because of the lower building standards at that time, the Kanto earthquake led to more than 100,000 deaths and a destruction of the physical infrastructure of the city of Tokyo.



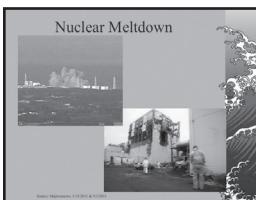
Slide 10: On the “Ring of Fire”

The main reason Japan is prone to such natural disasters is its geology. Japan is an island archipelago; it consists of more than 1,000 islands, and the Japanese reside on four of them: Honshu, Kyushu, Shikoku, and Hokkaido. The islands of Japan sit on top of tectonic plates that are moving constantly, known as the “Ring of Fire.”



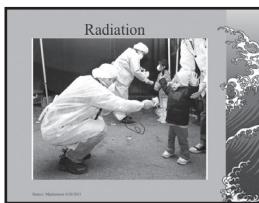
Slide 11: Tectonic Plates

The Tohoku earthquake of March 11 took place above the Pacific Plate, which is moving rapidly toward Japan (approximately 3.5 inches) every year. The movement of these tectonic plates gives rise to slippage and earthquakes. On average, Japan experiences 1,500 to 2,000 earthquakes every year.



Slide 12: Nuclear Meltdown

The March 11 disaster was made even worse by a man-made disaster—the nuclear meltdown of the six reactors located in Fukushima, and in close proximity to the Pacific Ocean. The earthquake shook these facilities and, as they were supposed to, they shut down and the backup generators went into effect. However, the massive tsunami broke down the backup generators and as a result, there was a serious heating problem in the six nuclear reactors.



Slide 13: Radiation

In effect, the meltdown in three of the six nuclear reactors led to hydrogen explosions and the release of radioactivity into the atmosphere. The Fukushima nuclear disaster will take decades to clean up, decontaminate, and decommission.



Slide 14: Cooperation and Reconstruction

However, even in the face of a disaster of this magnitude, the Japanese people displayed resilience and cooperation. For instance, in the aftermath of the disaster, the Japanese people voluntarily accepted a 15 percent reduction in their use of energy—even during the oppressive heat of the Japanese summer, many Japanese citizens turned off their air conditioners or only used them for short periods of time. Despite the magnitude of the March 11, 2011, disaster, values such as obligation, loyalty, cooperation, reciprocity, and a sense of commitment to the national interest brought Japan together in the face of its natural calamity.

TIMELINE AND PRIMARY ACTORS

Simplified Timeline of Events in the Fukushima Dai-Ichi Disaster

March 11, 2011

- 2:46 p.m.: 9.0 earthquake occurs.
- 2:47 p.m.: All reactors lose external power.
- 3:27 p.m.: Tsunami first wave hits.
- 3:35 p.m.: Tsunami second wave hits.
- 3:37 p.m.: Reactors 1, 2, 3 all lose power completely.
- 3:42 p.m.: Nuclear emergency report (Article 10—complete loss of power).
- 4:36 p.m.: Nuclear emergency report (Article 15—emergency cooling inoperative). Prime minister's office establishes nuclear plant disaster headquarters.
- 4:40 p.m.: Reactor 1 core meltdown begins (estimated).
- 6:00 p.m.: Reactor 1 core damaged (estimated).
- 7:03 p.m.: Nuclear emergency declared.
- 8:00 p.m.: Reactor 1 pressure containment vessel damaged (estimated).
- 8:49 p.m.: Backup lights restored to operations centers of Reactors 1 and 2.
- 8:50 p.m.: Evacuation order for 2 km radius around Fukushima Dai-Ichi.
- 9:23 p.m.: Evacuation area expanded to 3 km radius, 3 km–10 km ordered to remain indoors.
- 9:51 p.m.: Radiation levels of Reactor 1 building rising.

March 12

- 12:06 a.m.: Pressure levels of Reactor 1 containment vessel rising.
Plant manager Yoshida orders venting.
- 1:30 a.m.: Prime Minister Kan agrees to vent Reactors 1 and 2.
- 3:12 a.m.: Chief Cabinet Secretary Edano announces venting to press.
- 3:59 a.m.: Major aftershock of 6.6 centered in northern Nagano Prefecture.
- 5:44 a.m.: Prime Minister Kan issues 10 km radius evacuation order.
- 5:46 a.m.: Fire truck begins injection of foam water.
- 6:55 a.m.: METI Minister Kaieda orders TEPCO to vent.
- 7:12 a.m.: Prime Minister Kan arrives in Fukushima Dai-Ichi.
- 8:03 a.m.: Yoshida orders vent procedure to aim for 9:00 a.m.
- 8:05 a.m.: Prime Minister Kan departs Fukushima Dai-Ichi.
- 9:15 a.m.: First group opens vent of Reactor 1 by 25 percent.
- 9:30 a.m.: Second group turns back due to high radiation.
- 10:00 a.m.: TEPCO president arrives at headquarters.
- 11:36 a.m.: Reactor 3 cooling system stops.

teacher information

- 2:30 p.m.: Reactor 1 vessel pressure decreases, judged to be successful venting.
Radiation leaked.
- 3:30 p.m.: Power truck successfully connected to benzene pump.
- 3:35 p.m.: Hydrogen explosion in Reactor 1 building.
- 4:27 p.m.: Emergency alarm from radiation rise; 1,015 mSv per hour recorded.
- 6:25 p.m.: Prime Minister Kan orders 20 km radius evacuation.
- 7:04 p.m.: Fire truck injects seawater into Reactor 1.
- 7:55 p.m.: Prime Minister Kan orders seawater injection.

March 13

- 2:42 a.m.: Reactor 3 high-pressure coolant injector stops.
- 5:10 a.m.: Reactor 3 nuclear emergency report (Article 15—emergency cooling inoperative).
- 7:40 a.m.: Reactor 3 core exposed (estimated).
- 8:35 a.m.: Reactor 3 manually vented.
- 9:24 a.m.: TEPCO determined Reactor 3 vented.
- 10:20 a.m.: Reactor 3 core damaged (estimated).
- 1:12 p.m.: Fire truck begins injecting seawater into Reactor 3.
- 10:10 p.m.: Reactor 3 pressure containment vessel damaged (estimated).

March 14

- 11:01 a.m.: Reactor 3 experiences hydrogen explosion.
Damages Reactor 2 venting circuitry, closes valves.
- 12:30 p.m.: Reactor 2 pressure and temperature rises recorded.
- 1:25 p.m.: Reactor 2 Nuclear emergency report (Article 15—
emergency cooling inoperative).
- 6:00 p.m.: Reactor 2 core exposed (estimated).
- 8:50 p.m.: Reactor 2 internal pressure exceeds maximum specs.

March 15

- 3:00 a.m.: METI Minister Kaieda reports to Prime Minister Kan that TEPCO
wants to evacuate.
- 4:17 a.m.: TEPCO President Shimizu visits prime minister's office.
- 5:26 a.m.: Government-TEPCO accident response joint headquarters announced.
- 5:35 a.m.: Kan arrives at TEPCO headquarters.
- 7:00 a.m.: Reactor 4 building explodes.
TEPCO employees other than direct operations crew evacuate to Dai-Ni.
- 8:46 a.m.: Kan returns to prime minister's residence.
- 11:00 a.m.: Kan issues evacuation order for 20–30 km radius.
- 4:45 p.m.: U.S. Secretary of State Hillary Clinton states that if accident had occurred in
the United States, evacuation zone radius would be 50 miles (80.5 km).

March 16

Fire in building 4. Reactor 3 emits white steam/smoke.

March 17

SDF helicopters and fire trucks begin dousing Reactor 3 with water.

Selected Primary Actors in the Fukushima Disaster Narrative	Position (at the time)
Naoto Kan	Prime Minister (June 2010–Sept. 2011)
Banri Kaieda	METI Minister
Yukio Edano	Chief Cabinet Secretary
Goshi Hosono	DPJ Member, Prime Minister's Aide
Manabu Terada	DPJ Member, Prime Minister's Aide
Tsunehisa Katsumata	TEPCO Chairman
Masataka Shimizu	TEPCO President
Masao Yoshida	TEPCO Fukushima Nuclear Plant Manager
Ichiro Takekuro	TEPCO “Fellow” (former VP of Nuclear Division)
Haruki Madarame	Nuclear Safety Commission (NSC), Chairman

¹ "Nuclear Power in Japan," *World Nuclear Association*, 27 December 2013, <http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/Japan/>.

² Saito, *Nuclear Crisis Economics*.

³ IIC, "Independent Investigation Commission."

⁴ Makoto Saito, *Genpatsu Kiki no Keizaigaku* [The Economics of the Nuclear Crisis] (Tokyo, Japan: Nihon Hyoron Sha, 2011), 97–98.

⁵ Ibid., 22.

⁶ This is a process known as *scram*.

⁷ Saito, *Genpatsu Kiki no Keizaigaku* [The Economics of the Nuclear Crisis]. 22.

⁸ The emergency cooling system was actually not a viable long-term solution, capable of only temporarily cooling the reactor for short periods of time. Ibid.

⁹ Oshika, *Meltdown*, 12–16.

¹⁰ Oshika, *Meltdown*, 570; "Interim Report," ed. Yotaro Hatamura (The Investigation Committee on the Accident at Fukushima Nuclear Power Stations of Tokyo Electric Power Company, 2011). <http://icanps.go.jp/eng/interim-report.html>.

¹¹ This was in accordance with Article 10 of the Nuclear Emergency Preparedness Act (Act on Special Measures Concerning Nuclear Emergency Preparedness), passed in 1999 following a nuclear criticality accident at a nuclear fabrication plant in Tokaimura, operated by JCO. "Interim Report."

¹² This was in accordance with Article 10 of the Nuclear Emergency Preparedness Act (Act on Special Measures Concerning Nuclear Emergency Preparedness), passed in 1999 following a nuclear criticality accident at a nuclear fabrication plant in Tokaimura, operated by JCO. "Interim Report."

¹³ "Interim Report."

¹⁴ "Kinkyuu sengen no okure "Kanshi no Rikai ni Jikan" Kaiedashi shougen Kokkai genpatsu jikochō [The delay in declaring emergency due to "time needed for Kan's understanding/approval," Kaieda's testimony at the Diet Nuclear accident investigation commission]," *Asahi Shimbun*, 18 March 2012.

¹⁵ Oshika, *Meltdown*, 43–44.

¹⁶ Ibid., 48–49; "Interim Report."

¹⁷ *Meltdown*, 48–49.

¹⁸ Ibid. "Fukushima Report."

¹⁹ Ibid., 49; "Fukushima Report," 77.

²⁰ *Meltdown*, 49; "Fukushima Report," 77.

²¹ Ibid. "Fukushima Report."

²² *Meltdown*, 53–54.

²³ His mistrust was not irrational, having gained fame while minister of health and welfare in the mid-1990s for exposing a major scandal in which collusion between ministry officials and a private company that hired retired bureaucrats had covered up a major scandal involving giving untreated, HIV-tainted blood to hemophiliacs and pregnant women.

²⁴ Oshika, *Meltdown*, 60–61.

²⁵ As we note later, the air vents in the reactors did not have air filters to reduce the amount of radioactive material released. These filters were installed in U.S. and European nuclear plants after the 1979 partial nuclear meltdown accident at Three Mile Island in the United States.

²⁶ Oshika, *Meltdown*, 62–63.

²⁷ Ibid., 64–66.

²⁸ Ibid., 81.

²⁹ Ibid., 83–84.

³⁰ To be precise, in its use as fuel-rod casing, the zirconium in part of a compound is called Zircaloy.

³¹ Oshika, *Meltdown*, 81

³² Ibid., 86–88.

³³ Ibid., 88–89.

- ³⁴ Ibid., 93.
- ³⁵ Others, such as METI Minister Kaijeda, also testified to the Diet that communicating with TEPCO was like playing a game of oral note-passing.
- ³⁶ In a blame game that occurred later, in May, some of the popular press were misled to believe that Kan had ordered a halt of seawater injections, which was carried through and contributed substantially to the disaster. *Yomiuri Shimbun*, the daily newspaper with the largest circulation in Japan, even ran the story as a headline. Only two months later, when plant manager Yoshida spoke up and revealed that he had disobeyed TEPCO orders to stop seawater injections, did it become clear that it was TEPCO's Takekuro who ordered the halt, rather than Kan.
- ³⁷ Ibid., 108–10.
- ³⁸ Ibid., 120–21; *Prometheus*, 262–63.
- ³⁹ *Meltdown*, 123–29; "Kaijeda's Testimony."
- ⁴⁰ "Fukushima Report," 85; *Prometheus*, 263.
- ⁴¹ *Meltdown*, 126.
- ⁴² Ibid., 129–30; "Fukushima Report."
- ⁴³ *Meltdown*, 131–33; *Prometheus*.
- ⁴⁴ "Fukushima Report."
- ⁴⁵ Oshika, *Meltdown*, 145.
- ⁴⁶ "Fukushima Report."
- ⁴⁷ *Meltdown*, 152.
- ⁴⁸ "Fukushima Report," 88.
- ⁴⁹ William Kremer and Claudia Hammond, "Hikikomori: Why are so many Japanese men refusing to leave their rooms?" *BBC News Magazine*, 4 July 2013. <http://www.bbc.co.uk/news/magazine-23182523?print=true> [Accessed 31 January 2014]
- ⁵⁰ Tuukka Toivonen, Ph.D., "Japanese Youth After 3.11: From Underdogs to Change-makers," *Wochi Kochi Magazine*. <http://www.wochikochi.jp/english/relayessay/2012/03/311haisha%20.php> [Accessed 1 February 2014]
- ⁵¹ William Kremer and Claudia Hammond, "Hikikomori: Why are so many Japanese men refusing to leave their rooms?" *BBC News Magazine*, 4 July 2013. <http://www.bbc.co.uk/news/magazine-23182523?print=true> [Accessed 31 January 2014]
- ⁵² Michael J. Green, "Crisis as Opportunity: The Future of Japan After 3-11," *Statement Before the House Foreign Affairs Committee, Subcommittee on Asia and the Pacific*, 24 May 2011. http://csis.org/files/ts110524_Green.pdf [Accessed 1 February 2014]
- ⁵³ Ibid.
- ⁵⁴ Tuukka Toivonen, Ph.D., "Japanese Youth after 3.11: From Underdogs to Change-makers," *Wochi Kochi Magazine*. <http://www.wochikochi.jp/english/relayessay/2012/03/311haisha%20.php> [Accessed 1 February 2014]
- ⁵⁵ Tomoki Fukae, "Young Returnees Aiding Post-Disaster Tohoku," *The Japan Times*, 23 July 2013. http://newslookup.com/cached.php?ref_id=263&siteid=2203&id=2603389&t=1374590664#.UvVuQM2KP3l [Accessed 2 February 2014]
- ⁵⁶ May Masangkay, "3/11 Students Vow Leadership Roles," *The Japan Times*, 13 March 2013. <http://www.japantimes.co.jp/news/2013/03/13/national/311-students-vow-leadership-roles/#.UvVuOs2KP3l> [Accessed 3 February 2014]