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Paper:

Damage and Reconstruction at Okushiri Town Caused by the 1993 Hokkaido Nansei-Oki Earthquake Tsunami

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The Hokkaido Nansei-Oki Earthquake Tsunami that struck Okushiri Island off western Hokkaido, Japan's northeasternmost island in 1993 killed about 200 in Okushiri Town, which had a population of less than 4,000. Damage totaling over ¥66 billion was a severe blow to the community, which had an annual budget of only ¥5 billion. The tsunami was caught by the island and struck the Aonae district on the southern tip from both the west and east. Based on an experience from tsunami in 10 years earlier, it was thought that a tsunami would arrive more slowly than this one did, which increased the human toll. Fire caused by the tsunami increased losses. Among reconstruction efforts, remarkable are an artificial ground and cordial assistance based on monetary donation.

Keywords: tsunami, fire, loss of lives, reconstruction after tsunami

1. Introduction

Okushiri Island, located about 30 km west of Hokkaido, stretches 11 km from east to west and 27 km from south to north, and is 84 km in circumference. As of 2005, the island had a population of 3,726 comprising 1,721 households. Its chief industries are fisheries and sightseeing, and the island has been known as "dream island," "treasure island," "unexplored region in Hokkaido" (Okushiri town, 2005 [3]).

Although the tsunami caused by the Hokkaido Nansei-Oki Earthquake influenced all shores of the Japan Sea, Okushiri Town, located near the epicenter, suffered damage from both the earthquake, which caused widespread landslides on the island – a hotel beneath a cliff, for example, was immediately destroyed, costing the lives of 29 guests –, and the great tsunami which struck the island soon after and wreaked terrible destruction, especially in Aonae.

Focusing mainly on the Aonae district, we detail the results of tsunami destruction and the reconstruction that followed.

Fig. 1. Location of epicenter.

2. Characteristics of the Striking Tsunami

The epicenter of an earthquake of Ms 7.8 at 22:17 on July 12, 1993, off southwestern Hokkaido was located less than 100 km offshore (in **Fig. 1**). It originated in a fault stretching from the south to the north that partially underlies Okushiri Island. Maximum subsidence of 80 cm was observed on the southern part of the island. The tsunami caused by this fault movement hit not only Hokkaido but all areas on the Japan Sea. The tsunami's first surge reached the west coast of Okushiri Island, which was nearest the epicenter, in 4 or 5 minutes.

Measured tsunami heights around Okushiri Island are shown in **Fig. 2** (Shuto and Matsutomi, 1995 [4]). The maximum tsunami run-up height exceeding 30 m was recorded in a narrow valley near Monai on the west coast.

The tsunami came around also to the back of the is-

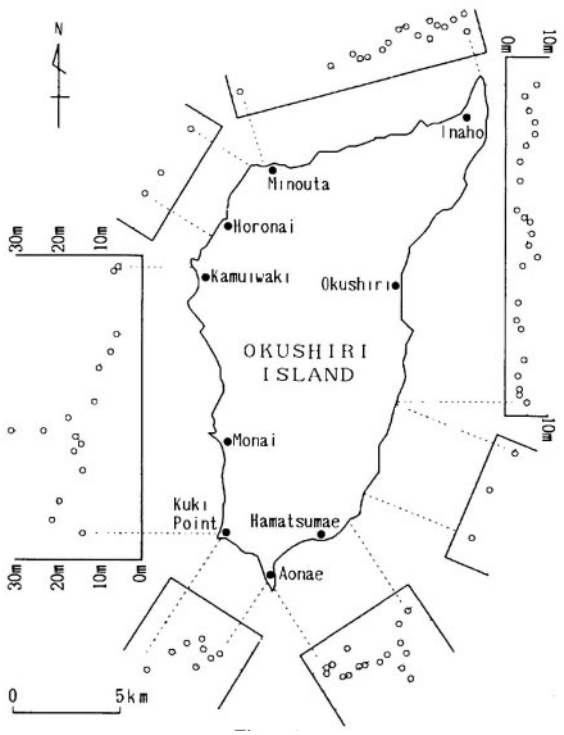

Fig. 2. Tsunami heights on Okushiri Island.

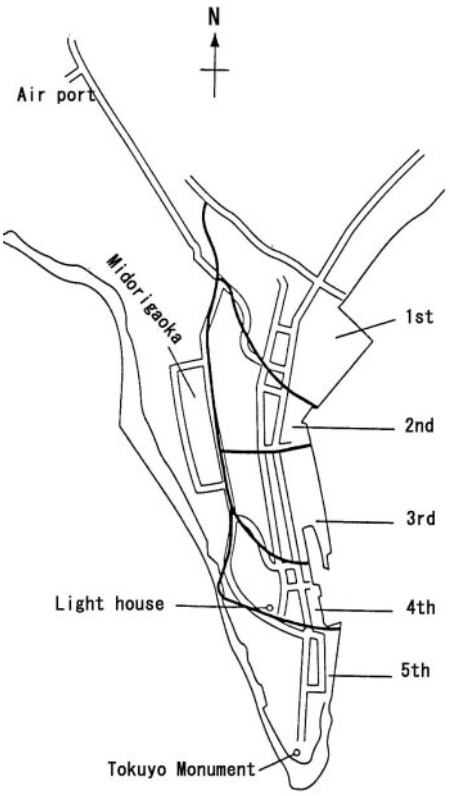

Fig. 3. Aonae district.

land. Particularly by effects of diffraction and refraction on the Okushiri Spur well developed at the southern side of the island, the tsunami, originally coming from the west, swung around even to Hamatsumae, which should have been shielded from the tsunami, increasing damage due to the local focusing effect.

3. Damage to Aonae

3.1. Geographical Features of Aonae

Aonae, in Okushiri town, is located on and at the foot of hills 17-18 m high, stretching to the southern tip of Okushiri Island. It consists of 1 to 5 divisions in plain (**Fig. 3**) and 6 to 7 divisions on higher ground. Aonae division 5 is on a sandbar at the southern tip of the island, open to the sea both to the east and west. Divisions 1 to 4 are along the east coast beneath the hills. Division 4 is the site of a fishing port employing many residents. The high ground is the site of a lighthouse, an airport, and the Midorigaoka apartment.

3.2. Tsunami Damage to Aonae

About 5 minutes after the earthquake, the first tsunami, estimated to be 11 m high, struck from the west, surging sea walls 4.5 m high and washing 90 buildings, including housing and warehouses, in Aonae division 5 in seconds. Some 12 to 13 minutes after the first surge, a second surge from the east, inundated Aonae divisions 1 to 4 up to the east road, one of the two running through the divisions from south to north, destroying and washing away housing on the seaside of the east road. This second surge was supposed to be refracted by Okushiri Spur southward, changed direction, and struck Aonae district from the southeast, flooding the area indicated by solid lines in **Fig. 4**.

Asterisks in the figure show the heights of tsunamis above sea level in m. Figures in parentheses along the seawall and breakwater show the height of each structure above sea level (Shuto and Matsutomi, 1995 [4]).

3.3. Fire (Murosaki, 1994 [2])

Fire breaking out following the earthquake and tsunamis originated in at least 4 locations (flame marks in **Fig. 4**), 2 within the fishing port and 2 ashore.

At about 22:25, immediately after the first surge, fire started in two fishing boats moored inside the breakwater. Although the cause is unknown, it is assumed that fishermen preparing for fishing the next morning were heating or cooking, and the tsunami's impact sparked these fires.

The first fire of the 2 fires in town broke out at about 22:35 at a house within the tsunami inundation to the right of the place noted as "Burned" in **Fig. 4**. It was probably caused by a kerosene stove used for heating in the house, knocked over by the earthquake movement or tsunami. Okushiri Island is cold enough that kerosene stoves are used even in summer. Because the temperature at the time of the earthquake was 19°C, many households presumably were using kerosene stoves.

Table 1. Human and housing damage at Aonae.

	Households	Population	Housing totally destroyed	Deaths
Aonae division 1	87	242	71	10
Aonae division 2	74	218	74	21
Aonae division 3	59	174	59	1
Aonae division 4	56	167	28	3
Aonae division 5	77	214	77	78
Total	353	1015	309	113

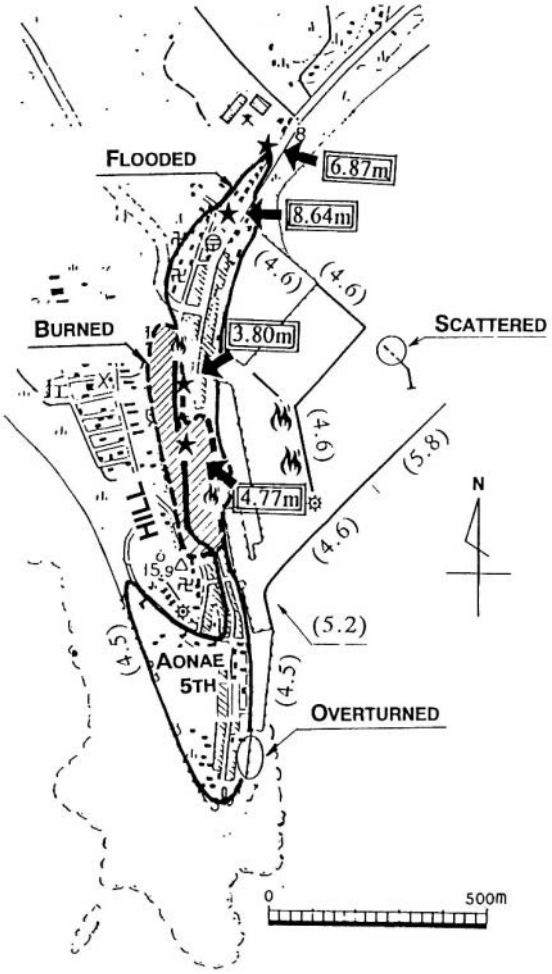

Fig. 4. Damage from flooding and fire in Aonae district.

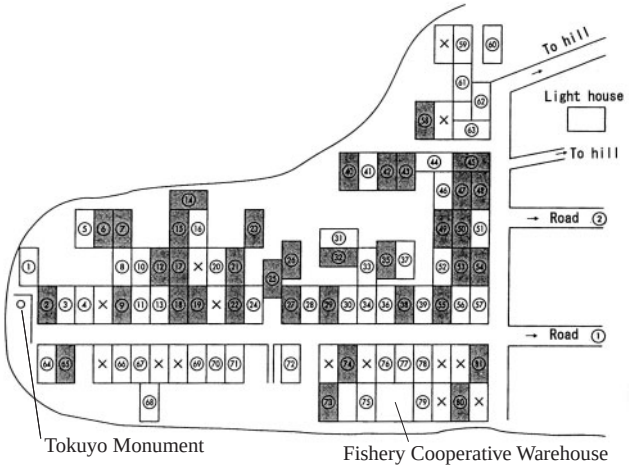

Fig. 5. Human damage occurrence households at Aonae division 5.

The second fire (to the right of "Hill" in **Fig. 4**) is estimated to have broken out at 0:15 the next morning, possibly due to one of 3 causes – the burning ship in the carried into the town by the tsunami, a kerosene leakage in subsequent flooding set afire by flying sparks, or shorted electrical circuit. Given the fact that the burned boat remained nearby this outbreak and due to eyewitness accounts, this appears to be the most likely possibility, but no other decisive evidence exists.

Areas burned are indicated by slanted lines surrounded by broken lines in **Fig. 4**.

3.4. Human Death and Destruction

Table 1 shows damage to Aonae divisions confirmed by Hiroi (1994) [1].

Figure 5 is his detailed survey for Aonae division 5, which was stricken by the tsunami 4 or 5 minutes after the earthquake. Black squares in the figure indicate households in which someone died, open squares households where all residents were safe, and squares marked with "×" households whose residents were elsewhere at the time. Aonae division 5 is a small community on a flat sandbar and residents had the possibility of escaping to higher ground via the two roads noted as "To hill" in the figure. Roads ① and ② run northward along the eastern edge of higher ground. While near the southern tip of the sandbar 400 m from high ground some households suffered no fatalities, others suffered deaths despite being near high ground.

Hiroi summarized 4 major causes of death based on his survey.

The first cause involved those who could not or did not evacuate because (1) they were elderly or handicapped, or (2) they did not expect a tsunami.

The second cause involved those who delayed evacuating because (1) the tsunami arrived earlier than expected, or (2) they were trying to help family members or neigh-

Fig. 6. Aonae division rebuilt by ground fill.

bors. Just 10 years earlier, in May, 1983, a tsunami from the Nihonkai Chubu Earthquake off Akita Prefecture had struck this division some 30 minutes after the earthquake, giving those who experienced the earlier earthquake the hope that there would be enough time for an evacuation.

The third cause involved those evacuating on foot or by car whose evacuation was too slow. They could not reach high ground before arrival of the tsunami. Even among those using cars, some departed too late, or were involved in traffic jams on the way.

The forth cause involved those who evacuated but returned home to turn animals loose, to pick up a forgotten purse, or for other reasons and were caught in the tsunami. Such losses were particularly frequent in Aonae divisions 1, 2, and 5.

4. Reconstruction of Okushiri Town (Okushiri Town, 2005 [3])

4.1. Development of Disaster-Resistant Town

Okushiri Town suffered ¥66.4 billion in damage – a severe blow to a town with an annual budget of only ¥5 billion. In addition to money from the Japanese government, Hokkaido, and Okushiri Town itself, contributions were collected from elsewhere for reconstruction.

Okushiri Town established a Disaster Reconstruction Measures Office on October 1, 1993, and put together projects involving assistance from the Japanese government and Hokkaido. It decided the basic reconstruction plan shown in **Table 2** which was not simply reconstruction but intended also to meet objectives in the third stage of the Okushiri Town development plan.

This basic reconstruction plan consists of "lifestyle reconstruction", "disaster-resistant town development" and "regional advancement". In summary, it intends to reconstruct immediate lifestyles based on advancements focusing on the future town, and make the town disaster-resistant. It was planned for completion in fiscal 1997 and implemented.

Typical of reconstruction was ground fill, named "artificial ground", used in developing a "disaster-resistant town". Aonae division 5, originally located on a sandbar and totally destroyed by the first tsunami, was relocated en masse to high ground. Ground around Aonae divisions 1 to 4 was raised nearly 6 m to be higher than tsunami height and divisions were reconstructed there. **Fig. 6** shows Aonae division 4 from the south. This is the first time in Japan that a community was reconstructed by raising ground so widely and extensively.

4.2. "Disaster Reconstruction Fund"

Scenes of the hotel buried under a landslide immediately after the earthquake and the Aonae district burning after the tsunami crowded media outlets nationwide, triggering contributions from all over the country. Based on some ¥9 billion, the "Disaster Reconstruction Fund" was created.

Its use ranged over 8 types of application involving 73 items.

First was "independent restoration for residents," including 10 items ranging from providing interest on disaster relief funds for lifestyle stabilization to subsidies for housing acquisition.

Second was restoration assistance for agriculture, forestry, and fisheries, including improvement of damaged fishing boats.

Third was restoration assistance for commerce, industry, and tourism.

Fourth was disaster-prevention restoration assistance and subsidies for improvement of evacuation routes and sites.

Fifth was restoration assistance for town development.

Sixth was restoration assistance for residents' activities.

Seventh was restoration assistance for parks, including the cost of constructing the Tsunami Materials Center, which was opened in May, 2001.

Eighth was other restoration assistance ranging from the provision of special educational funds for the stricken schoolchildren to construction of the Tsunami Victims Memorial and preparation of disaster documentary records.

Table 2. Basic Okushiri town reconstruction plan.

Item		Contents
Lifestyle reconstruction		
1. Housing reconstruction	a. Construction of public housing	Construction of public disaster-relief housing
	b. Construction of private housing	Subsidies for reconstruction of private housing
2. Basic industries reconstruction	a. Reconstruction of fisheries and agriculture	Improvement of fishing boats, fishing implements, cooperative facilities, etc.; improvement of drainage, agricultural machinery, cooperative facilities, etc.
	b. Reopening of sightseeing	Improvement of stricken sightseeing routes, sightseeing sites, shops, lodging facilities, etc.
	c. Fostering of successors	Settlement of young worker
3. Stabilization of lifestyle and establishment of social life foundation	a. Stabilization of lifestyle	Subsidies for interest on funds, subsidies for purchasing kerosene
	b. Improvement of social life foundation	Improvement of medical health facilities, educational facilities, social welfare facilities
Development of disaster-resistant town		
1. Development of town divisions	Formation of a new community	Reorganization and quality use of land, relocation to high ground
2. Evacuation measures	a. Settling on evacuation plans	Settling on plans and preparation of disaster prevention handbooks
	b. Improvement of evacuation facilities	Improvement of evacuation routes, evacuation sites, shelters, etc., and lifeline security
3. Strengthening of arrangements for disaster prevention activities	Formation of disaster prevention arrangements	Reinforcement of management, notification, organization for disaster related informations and improvement of facilities
Regional advancement		
1. Advancement of fisheries	a. Reconstruction of fishermen's cooperative	Promotion to merge 8 cooperatives within Hinoeyama jurisdiction
	b. Improvement of fisheries foundation	Creating of fishing grounds, improvement of fish reef, support for strengthening and training of management
	c. Advancement of farming fisheries	Increase in resources (establishment of new aquaculture) Introduction of production technology
	d. Measures for effective use of local resources	Development of currency routes, construction of Process Center, improvement in angling facilities
2. Advancement of agriculture	Advancement of land-utilizing type agriculture	Furtherance of the Comprehensive Improvement Project for Farmland Furtherance of the Agricultural Land Preservation Project
3. Advancement of sightseeing	a. Improvement in sightseeing resources	Construction of the Tsunami Research Materials Center Improvement in the Mt. Kannon Memorial Park
	b. Improvement in sightseeing facilities	Strengthening of sightseeing function Promotion of construction of larger lodging facilities
	c. Promotion of sightseeing events	Use of Three Big Okushiri Festivals Promotion of hometown rediscovery activities Implementation of reconstruction PR
	d. Year-round sightseeing	Development of original Okushiri Island foods
4. Expansion of art and culture	a. Enlightenment of cultural awareness	Participation in cultural activities
	b. Preservation of public-entertaining arts	Activation and preservation of local culture
	c. Promotion of creative activities	Promotion of autonomous creative activities

5. Conclusions

Okushiri town damaged severely from the earthquake and tsunami was so rapidly restored that the town assembly declared total restoration in March, 1998. This was possible because Okushiri Town, with a population of less than 4,000, was supported from all side. Although all the Japanese seaside towns have the risk of being stricken by tsunamis, the reconstruction achieved in Okushiri Town cannot, unfortunately, be anticipated for all such towns.

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