Ōtsuchi 大槌

On a tax map probably made in 1730, Ōtsuchi's houses line a road between bayside paddies and the district magistrates' office. To the southwest, smoke rises from kilns.

Approximate north

Ōtsuchi magistrates stationed here, in a government office building (*o-yakuya* 御役屋), sent a report on the 1700 tsunami to Morioka castle. A later Ōtsuchi magistrate prepared a summary from which a Japanese earthquake historian would learn of the 1700 tsunami by 1943 (p. 62).

The kilns may mark the area of salt evaporators reportedly damaged by the 1700 tsunami. Notes below kilns identify recipients of rice-tax revenues.

Yokkamachi Paddies Yōkamachi

Ōtsuchi's main street probably escaped flooding by the 1700 tsunami and also by the 1960 tsunami. Lining the street were neighborhoods named for their market days. The 1677 tsunami, of nearby source, entered 20 houses in the eighth-day neighborhood, Yōkamachi.

THE PICTURE MAP, conserved at Morioka-shi Chūō Kōminkan (p. 44), is probably tied to tax records from about 1730, according to Konishi Hiroaki, the Kōminkan documents librarian (interviewed 1999). Text beside kilns describes division of 74 *koku* (about 13,000 liters) of rice among Morioka-han (21 koku) and three samurai (17, 6, and 29 koku). In the fourth-day neighborhood (四日町 Yokkamachi), market days ended in four (4th day, 14th day, 24th day); likewise in the eighth-day neighborhood (八日町 Yōkamachi), markets were open on the 8th, 18th, and 28th.

ŌTSUCHI STATISTICS for 1803: 1465 persons, 273 houses, 42 boats (Takeuchi, 1985a, p. 172).

Main points

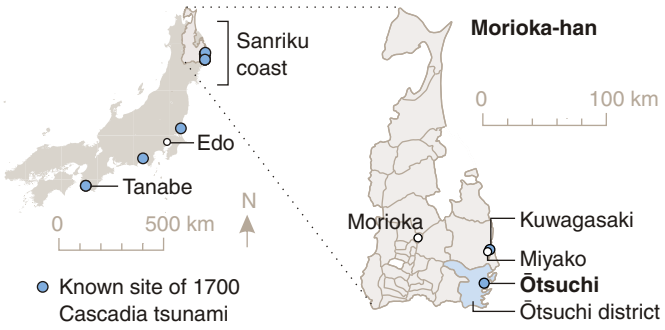
The sea invaded Ōtsuchi the same date and hour as it did 30 km to the north, in Kuwagasaki (p. 43, 72).

The flooding damaged paddies, two houses, and two salt-evaporation kilns (p. 60). This damage, though small, was reported to Edo, perhaps to help justify financial relief from the Tokugawa shogunate (p. 61).

An earthquake historian included this flooding in an earthquake catalog issued in 1943 (p. 62).

The flooding in 1700 probably stopped short of Ōtsuchi's main Edo-period street. The 1751 Chile tsunami reportedly crossed this street, but the 1960 Chile tsunami did not (p. 64).

Because of puzzling regional subsidence, places covered by the 1700 tsunami in Ōtsuchi may now stand a meter lower, relative to the sea, than they did in 1700 (p. 65).



Setting

Nestled between hills and bayside paddies, Edo-period Ōtsuchi stretched along a road between two river mouths. Houses flanked both sides of the street. In a side valley stood the office of a magistrate, or magistrates, who administered the Ōtsuchi district of Morioka-han.

Documents

Morioka-han "Zassho" provides the main account of the 1700 tsunami in Ōtsuchi. Like the entry about the tsunami in Kuwagasaki (p. 36), it is based on a report from coastal magistrates (p. 44). The report from Ōtsuchi probably reached Morioka castle the day after the report on Kuwagasaki arrived from Miyako (p. 60).

The 1700 tsunami killed no person or horse in Ōtsuchi, according to "Ōtsuchi kokon daidenki," a chronological record of the Ōtsuchi magistrates' office. A secondary source, "Daidenki" contains material from 1596 to 1796 that was compiled and edited in Ōtsuchi by Ogawa Magobei Yoshiyasu (1735-1820). The oldest surviving version was copied from Ogawa's compilation. The compiler or the copyist wrote the 1700 tsunami's month and hour but neglected its day. Before earthquake historians found the "Zassho" account, this omission in "Daidenki" obscured the link between the 1700 tsunami in Ōtsuchi and the flooding of similar character in Tanabe (p. 62).

Sanriku ō-tsunami
Sanriku great tsunamis

dekishisha seirei
drowned-persons' souls

kuyōtō
monument for prayer

A tsunami memorial, for victims in 1896 and 1933, stands in the cemetery of Kōganji Temple, Ōtsuchi.

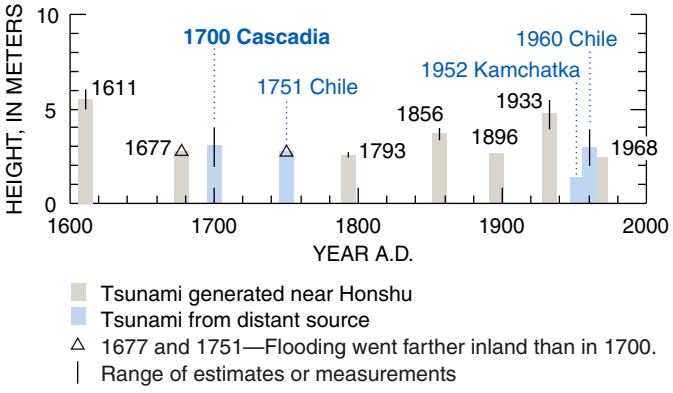
Other tsunamis

Tsunamis generated off northeast Honshu devastated Ōtsuchi in 1611, 1896, and 1933. Deaths from the 1611 waves totaled about 800 in Ōtsuchi and vicinity. In the town of Ōtsuchi alone, the 1896 and 1933 tsunamis took 600 and 61 lives, respectively. An inscription on the back of a memorial stone, above, further states that the town lost more than 600 houses to each of these latter tsunamis.

Lesser near-source tsunamis reached heights of several meters in Ōtsuchi in 1677, 1793, 1856, and 1968. The 1677 tsunami covered the floor in 20 of 60 houses in the Yōkamachi neighborhood along the town's main street.

Among tsunamis of remote origin, 1751 Chile may have reached the farthest into Ōtsuchi. It entered both the Yokkamachi and Yōkamachi neighborhoods, flooding a dozen houses. The 1960 Chile tsunami approached 4 m in height along the bayshore south of town. Its crest descended onshore to the tsunami's limit near the 2 m topographic contour, seaward of the main Edo-period street (p. 64-65).

NOTABLE TSUNAMIS IN ŌTSUCHI SINCE 1600



TSUNAMI MEMORIAL mapped on page 65.

TSUNAMI HEIGHTS and deaths: **1611**, Hatori (1995, p. 60, 62). **1677**, Tsuji and Ueda (1995, p. 102). Height excludes correction for tectonic change in land-level (p. 65). **1700**, our pages 64-65. **1751**, height by analogy with 1677. On flooding in 1751, see Ninomiya (1960, p. 20) and Watanabe (1998, p. 217-218). **1793**, **1856**, **1896**, and **1933**, Tsuji and Ueda (1995, p. 103). Deaths in 1896, Yamashita (1997, p. 113). Deaths and 5.5 m height in 1933, Watanabe (1998, p. 115, 118). **1952**, The Central Meteorological Observatory (1953, p. 46). **1960**, our page 65. **1968**, Kajiura and others (1968, p. 1373).

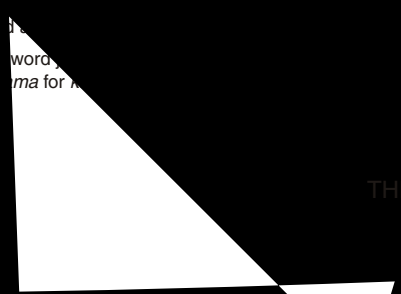
and *hyō*, see page 71).

n Morioka

ation recorded by Morioka-han for 1695 (Mori,

ion of sankin kōtai. He lists a shortfall of 100,000
ufu) commonly helped daimyo domains after
ommon type of assistance took the form of loans [that
u could be relied on for aid" (Bolitho, 1991, p. 202).

ns, and maps see Naitō and Hozumi (1982; 2003, p.
stood on a
two hectares.



Report to Edo 江戸への報告

Why forward, to the shogun's capital, the particulars of minor damage to a minor port?

SEVERAL REPORTS of the 1700 tsunami make their immediate purpose clear. Magistrates justify an allocation of rice and a request for wood in Kuwagasaki. Other magistrates certify the sinking of 28 tons of rice off Nakaminato. A headman wonders about stealth waves in Miho. A mayor in Tanabe expresses concern about the flooding of a nearby storehouse that belongs to a branch of Japan's ruling Tokugawa family.

Left unstated, in column 4 at left, is why samurai in Morioka castle forwarded to Edo—the shogun's bustling capital—details on small losses from a natural disturbance to a remote shore. We speculate that officials of Morioka-han kept track of natural disasters in hopes of financial relief from the Tokugawa shogunate.

Morioka-han spent heavily to comply with Tokugawa edicts. Through most of the Edo period, the shogunate required daimyo—some 260 land barons, including the distant Nambu governor of Morioka-han—to reside alternate years in Edo. This required residence consumed over half the tax income of Morioka-han. The Nambu governor would journey between Morioka and Edo, 546 km by road, with a showy entourage of some 250 persons and 100 horses. While in Edo, he would reside in a mansion near the shogun's castle (map, lower right).

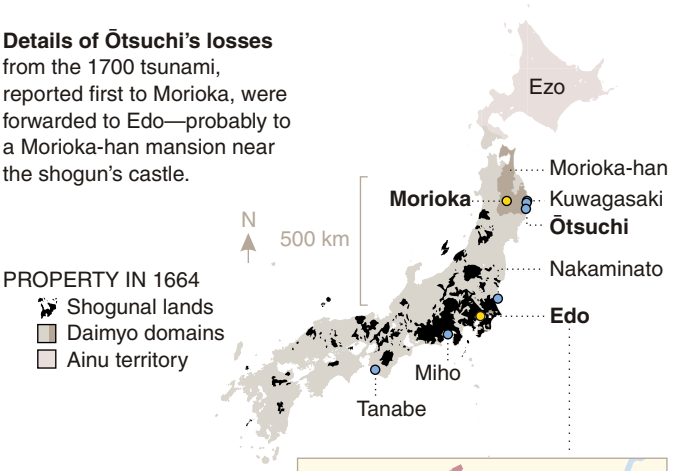
The shogunate allowed Morioka-han to cancel this journey after poor harvests in 1695. Reportedly starving that year were 34,000 people—ten percent of the domain's population. The domain's next famine, in progress at the time of the 1700 tsunami, resulted from frost and rain during the 1699 growing season. The domain's records state that 27,186 people suffered from hunger that year. Such circumstances may have spurred domain officials to document natural disasters as minor as the 1700 tsunami in Ōtsuchi.

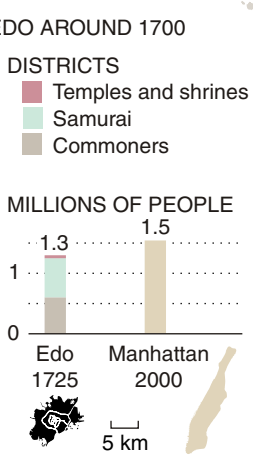
THE NUMBER OF DAIMYO DOMAINS, or han, stood at 241 in 1688 and reached 262 by 1720 (Bolitho, 1991, p. 201). Each han had an expected annual production worth at least 10,000 koku of rice (on *koku* and *hyō*, see page 71).

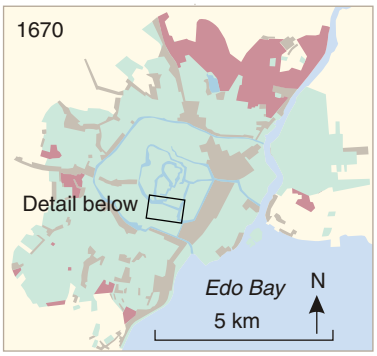
IN MORIOKA-HAN, according to figures for internal use (*naidaka*; Tsukahira, 1966, p. 82), the expected yield was 241,922 koku (Mori, 1963, p. 921) on the basis of surveys in 1666-1683 (Kambun 6 to Ten'na 3). For the required residence in Edo (*sankin kōtai*), the governor's entourage journeyed 139 *ri* between Morioka and Edo (Hosoi, 1988, p. 79). The domain's yearly costs of sankin kōtai in the 17th century have been estimated conservatively as 46,500 *ryō* (Hanley and Yamamura, 1977, p. 130-131). To help cover these expenses, Morioka-han levied special taxes on its samurai (1.5 ryō per 100 koku of stipend) and on its commoners (total yearly revenues about 8,300 ryō).

THE 34,000 REPORTEDLY STARVING after the 1695 harvest compares with 334,887, the commoner population recorded by Morioka-han for 1695 (Mori, 1963, p. 642). Mori (1972, p. 125) associates the poor harvest in 1695 with this famine and with the cancellation of sankin kōtai. He lists a shortfall of 100,000 hyō in 1695 and 77,320 hyō in 1699. At 0.4 koku per hyō, the shortfall in 1699 amounts to nearly 31,000 koku, or about one-eighth the domain's naidaka. The Tokugawa shogunate (the *bakufu*) commonly helped daimyo domains after disasters: "By far the most common type of assistance took the form of loans [that were] reserved for the emergencies of which Tokugawa Japan seemed to produce an inordinate number. [W]henever a crop was ruined, a castle damaged, or an Edo mansion destroyed, the bakufu could be relied on for aid" (Bolitho, 1991, p. 202).

Details of Ōtsuchi's losses from the 1700 tsunami, reported first to Morioka, were forwarded to Edo—probably to a Morioka-han mansion near the shogun's castle.







Earth's most populous city in 1700, Edo was as crowded, on average, as modern Manhattan.

CENTRAL EDO IN 1684

Map area 1 km wide

Nambu crest (p. 45)

Daimyo mansions, here marked by family crest, adjoined moats of central Edo. A corner of the shogun's castle grounds is at upper left.

LANDHOLDINGS IN 1664 from Totman (1967, map 4). The Ainu, native people, held most of Ezo (now Hokkaido) until 1800 (Walker, 2001).

ON EDO population, mansions, and maps see Naitō and Hozumi (1982; 2003, p. 104, 108, 117, 178). The main mansion (*kami-yashiki*) of Morioka-han stood on a five-acre estate—a parcel of 6013 *tsubo* (Mori, 1963, p. 360), or two hectares. The lower map is a detail from "Eiri Edo ōezu" (p. 106), courtesy of East Asian Library, University of California, Berkeley.

Collected writings 史料集

Modern recognition of the 1700 tsunami in Japan began with a teacher's mimeographed anthology of historical earthquakes.

MUSHA KINKICHI (1891-1962), an educator and geographer, collected accounts of historical earthquakes on behalf of the Earthquake Research Institute in Tokyo. He began this work in 1928 and continued it into the 1940s.

Because his mandate included events possibly related to earthquakes, Musha noted reports of high water at Ōtsuchi and Tanabe from the year 1700. Musha summarized them side-by-side in a collection brought out first as a wartime mimeograph and printed later as one of the green hardbound volumes at right.

Most other accounts of the 1700 tsunami went undiscovered until the 1970s and 1980s, when a new generation of earthquake historians began mining Japan's old documents. A project led by Usami Tatsuo and Ueda Kazue produced a 16,812-page anthology, "Shinshū Nihon jishin shiryō" ("Newly collected materials on historical earthquakes in Japan;" photo, p. 123). Its first 21 volumes appeared between 1981 and 1994.

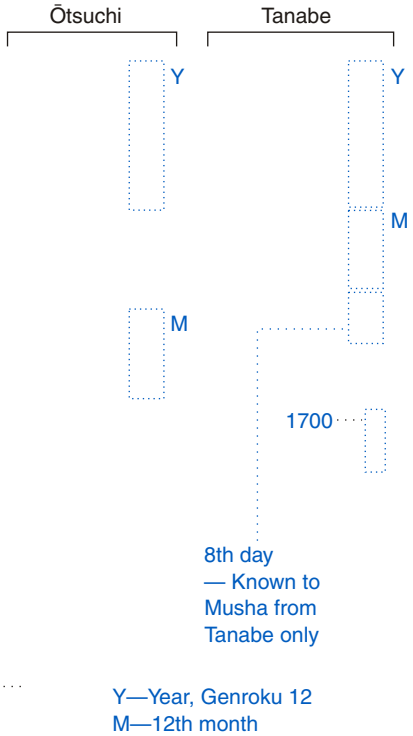
The Musha and "Shinshū shiryō" anthologies together identify 45,698 Japanese earthquakes from the years A.D. 416 to 1872. Most date from the Edo period (1603-1867), when record-keeping first flourished outside the nation's capitals (graphs, facing page). Coincidence with the Edo period thus helped the 1700 tsunami enter written history.

MUSHA KINKICHI AND HIS ANTHOLOGY

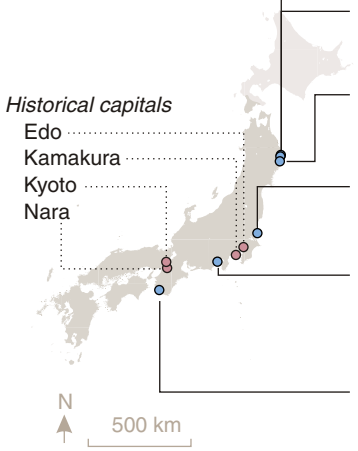
Contents first published

1949 1943-1941

MUSHA'S SUMMARY OF ACCOUNTS OF THE 1700 TSUNAMI



MODERN DISCOVERY OF THE ORPHAN TSUNAMI OF 1700



1993 **Kuwagasaki** "Shinshū Nihon jishin shiryō" quotes Morioka-han "Zassho" (p. 38-39).

1983-2004 **Tsugaruishi** A regional historican transcribes the Moriai-ke "Nikki kakitome chō" account in 1983. The transcription is quoted ten years later in "Shinshū Nihon jishin shiryō." In 2004, earthquake historians view the 18th-century source and confirm a copyist's error (p. 50-53).

1943-1993 **Ōtsuchi** Musha Kinkichi, in his anthology from 1943, cites "Ōtsuchi kokon daidenki," which omits the day of the flooding (above). This missing detail survives in Morioka-han "Zassho" (p. 60), as quoted in "Shinshū Nihon jishin shiryō" in 1993.

1943-2002 **Nakaminato** A prefectural fisheries association prints the Nakaminato account in 1943. Earthquake historians cite this secondary source In 1996. In 2002, Satake traces the account to a family's collection of documents on Edo-period shipwrecks (p. 66).

1982-1998 **Miho** "Miho-mura yōji oboe" contains an entry on the earthquake and tsunami of 1703 alludes to the 1700 tsunami as "Rabbit Year waves" (p. 76-77). This flashback, collected by Tsuji in 1982, appears in a 1989 volume of "Shinshū Nihon jishin shiryō." Ueda, in 1998, notices that the preceding entry in "Miho-mura yōji oboe" describes the 1700 waves in detail (p. 78-79).

1943-1993 **Tanabe** Musha's 1943 anthology summarizes the account in "Tanabe-machi daichō" (above; full text on our page 86). In 1981, a parallel account from "Mandaiki" (p. 84) appears in an earthquake anthology. The 1993 volume of "Shinshū Nihon jishin shiryō" also contains the "Mandaiki" version.

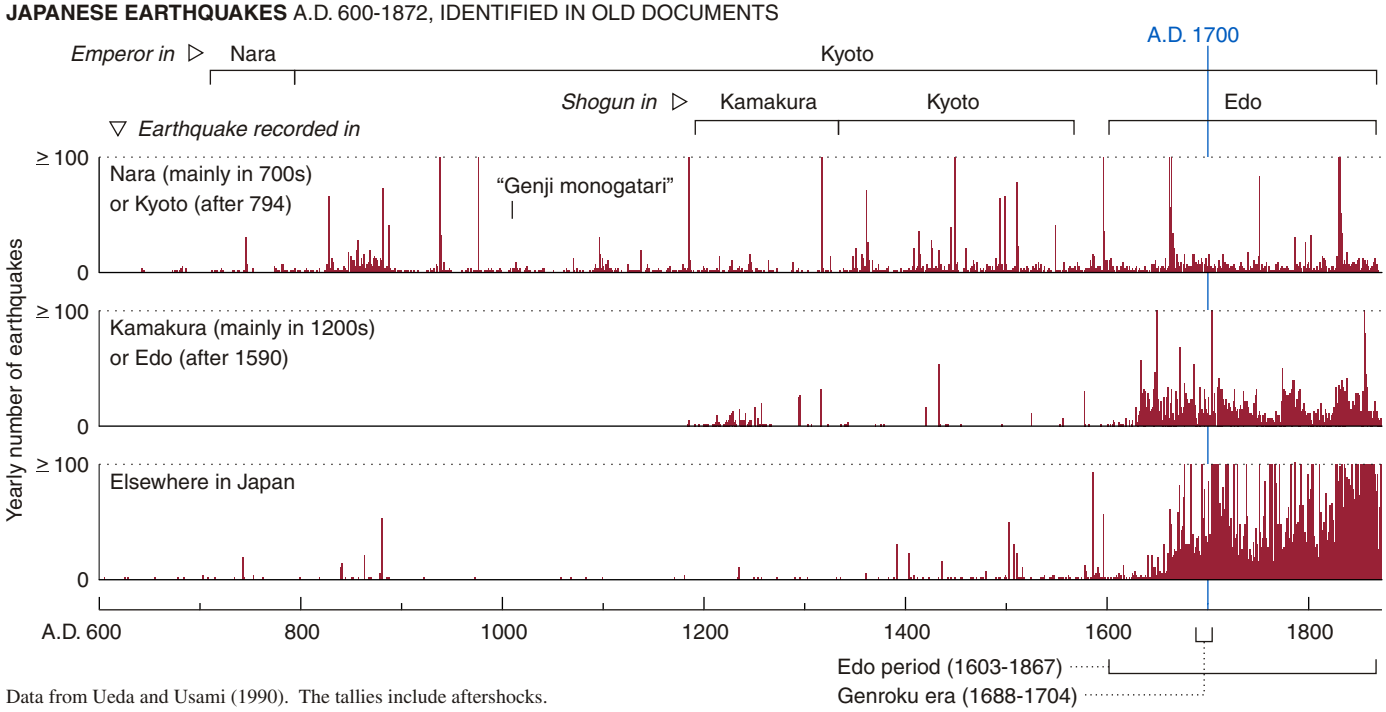
DURING THE FIREBOMBING of Tokyo in 1945, the manuscript for Musha's 1949 volume awaited war's end in a galvanized box 3 m underground. Musha worked for the military geology branch of the U.S. occupation forces from 1949 to 1960. His collection of earthquake accounts built on previous work, much of it by Tayama Minoru, who issued a two-volume anthology in 1904 (Usami, 1979a, b).

USAMI (1996) summarizes descriptions of more than 300 earthquakes that struck Japan between 416 and 1872. A parallel summary for tsunamis was compiled by Watanabe (1998). Tsuji and others (1998, p. 2-4) trace the origins of accounts of the 1700 tsunami.

A PREFECTURAL FISHERIES ASSOCIATION published the Nakaminato account in a volume edited by Ōuchi (1943).

THE COLUMNS OF JAPANESE TEXT above are excerpted from Mombushō Shinsai Yobō Hyōgikai (1943, p. 25; see also our page 112). The photo of Musha Kinkichi, undated, was provided by his family through Matsu'ura Ritsuko.

JAPANESE EARTHQUAKES A.D. 600-1872, IDENTIFIED IN OLD DOCUMENTS



Data from Ueda and Usami (1990). The tallies include aftershocks.

元禄 Genroku

THE CULTURAL PEAK of the Edo period is known as Genroku 元禄, the era name for 1688-1704 (p. 42). The Genroku society that kept prodigious records also produced literary innovations, popular titles, and scholarly tomes.

Genroku innovations include haiku—poems of seventeen syllables in three unrhymed lines. These were refined and popularized by Matsuo Bashō (1644-1694). In a posthumous collection he tells how to focus verse so brief: "You should put into words the light in which you see something before it vanishes from your mind."

Bashō's contemporary, Ihara Saikaku (1642-1693), introduced realistic description of the lives of urban merchants and samurai. His novels and collections of short stories include "The life of an amorous man" (1682), "Five amorous women" (1686), "The great mirror of love between men" (1687), "The Japanese family storehouse" (1688), and "Reckonings that carry men through the world" (1692).

The playwright Chikamatsu Monzaemon (1653-1725) popularized puppet theater and wrote dance dramas (*kabuki*) as well. Some of his works treat turmoil in the houses of land barons; others, beginning in 1703, tell of lovers driven to suicide by social obligation and financial difficulty.

Genroku publishers issued thousands of commercial books. A book-dealers' catalog from 1696, in 674 pages, listed 7,800 titles. The books in print included how-to manuals for home use by the young. "Onna chōhōki" (1692) instructed young women; "Otoko chōhōki" (1693), for young men, provided lessons on calligraphy, Chinese and Japanese poetry, tea ceremony, and letter writing. "Shōbai ōrai" ("Merchants' manual," ca. 1694) exhorted merchants' children to practice writing and arithmetic "from infancy." "Nōgyō zensho" ("Encyclopedia of farming," 1697) advised peasants to "lay up stores of money and grain" as precautions against "the very great risk of dying of starvation in bad years."

An early cookbook, "Ryōri monogatari" ("Story of cooking," 1643), alludes in its title to the classic novel from A.D. 1000, "Genji monogatari" ("The tale of Genji"). "Edo ryōri-shū" ("Collection of Edo cuisine," 1674) filled six volumes.

The shogun throughout the Genroku era, Tokugawa Tsunayoshi (1646-1709), was more scholar than soldier. He is said to have lectured on the "Yiching," an ancient Chinese book of wisdom and divination, no fewer than 240 times between 1693 and 1700.

"Honchō tsugan" ("General history of our State"), completed by 1680, filled 310 volumes. Attributed to the founder of a competing historical project, "Dai-Nihon shi" ("The history of greater Japan"): "In writing one must be true to fact, and the facts must be presented as exhaustively as possible. An excess of detail is preferable to excessive brevity."

Fiction, Kato (1979a, p. 85-112; Bashō quote, p. 102) and Totman (1993, p. 215-220). **Catalog** ("Shojaku mokuroku taizen") and "chōhōki," Shively (1991, p. 720, 731); "Shōbai," Seeley (2000, p. 130); "Nōgyō," Totman (1993, p. 264). **Cookbooks**, Nishiyama (1997, p. 167). **Tsunayoshi**, Bolitho (1976). **Histories**, Tsunoda and others (1964, p. 344-345, 362-364); quotation attributed to Tokugawa Mitsukuni (1628-1700).

Tsunami size 津波の高さ

The 1700 tsunami crested several meters high at the edge of Ōtsuchi Bay.

1700 tsunami

EVIDENCE, HEIGHTS **A** AND **B**

ryōshi no fishermen's

tokoro place

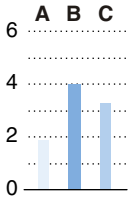
ni-ken two houses

shiogama salt kilns

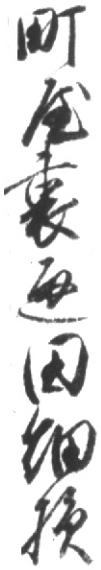
ni-kō two sets

hason damaged

INFERRED HEIGHT OF TSUNAMI AT BAY SHORE, IN METERS



EVIDENCE, HEIGHTS **B** AND **C**



machiya commercial district

uradōri back street,

tahata paddies and fields

sonsu were damaged

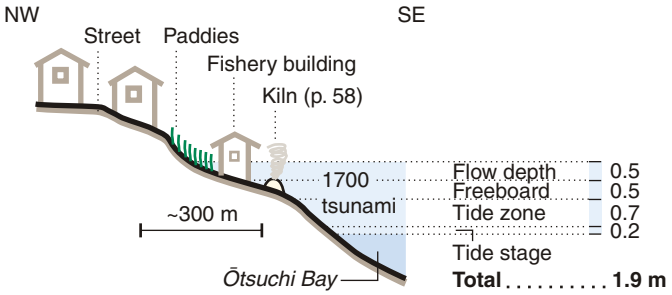
WHILE DAMAGING BUILDINGS AND KILNS near the bay shore in front of Ōtsuchi or nearby, the 1700 tsunami approached or exceeded 2 m above tide (**A**).

Maximum tsunami heights of 3-4 m are likely if, like the 1960 Chile tsunami, the 1700 tsunami descended inland to a limit near Ōtsuchi's Edo-period street (first option in **B**). The 1960 tsunami crested 3.6-4.0 m at the bay shore but stopped short of the 2-m contour a few hundreds meters inland (top map, facing page). Independently, maximum tsunami heights of 3-4 m in 1700 can be estimated by assuming that Ōtsuchi has subsided 1-2 m since 1700 (**C** and second option in **B**).

The 1700 tsunami probably crested lower in Ōtsuchi than did the 1677 and 1751 tsunamis, for these flooded houses along the town's main street (p. 59). Unlike estimate **B**, the published height for the 1677 tsunami in Ōtsuchi (2.8 m) lacks correction for an onshore decrease in tsunami height; and unlike estimate **C**, it neglects land subsidence since 1677.

Height **C** from Tsuji and others (1998). Height estimate for 1677 tsunami (p. 59) from Tsuji and Ueda (1995, p. 102).

A Minimum height, inferred from bayside damage



ASSUMPTIONS

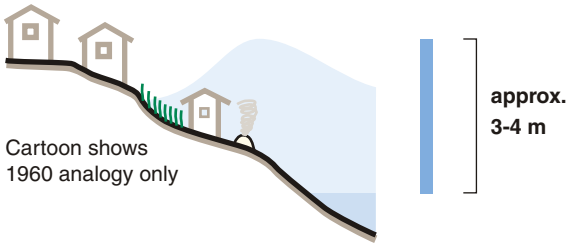
Flow depth 0.5 m where fishermen's sheds damaged.

Freeboard To have floors above swash during storms—and perhaps with the 1677 tsunami in recent memory—villagers sited these sheds at least 0.5 m above high astronomical tides.

Tide zone Highest astronomical tide in 1700 was 0.7 m above mean sea level, by analogy with modern tides at Kamaishi.

Tide stage 0.2 m above mean sea level; computed for midnight arrival of high water (p. 83).

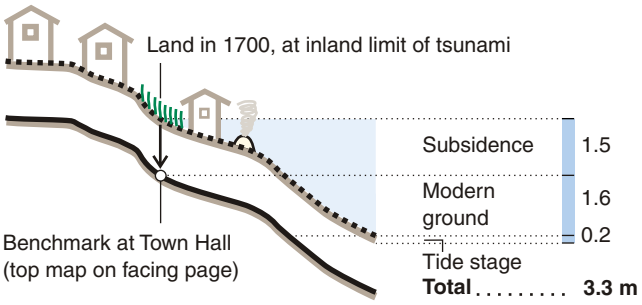
B More realistic height, inferred either of two ways



Inferred with 1960 analogy The 1700 and 1960 tsunamis both went about the same distance inland. Thus, the 1700 tsunami probably reached heights at the shore similar to those of the 1960 tsunami, in the range 3.6-4.0 m (top map, opposite).

Inferred from subsidence Paddies overtopped by the 1700 tsunami, now at least 1.2 m above mean sea level (brown points on map), may have stood 1.5 m higher in 1700 because of chronic subsidence (estimated in **C**, below).

C Modern land level, adjusted for tectonic subsidence since 1700

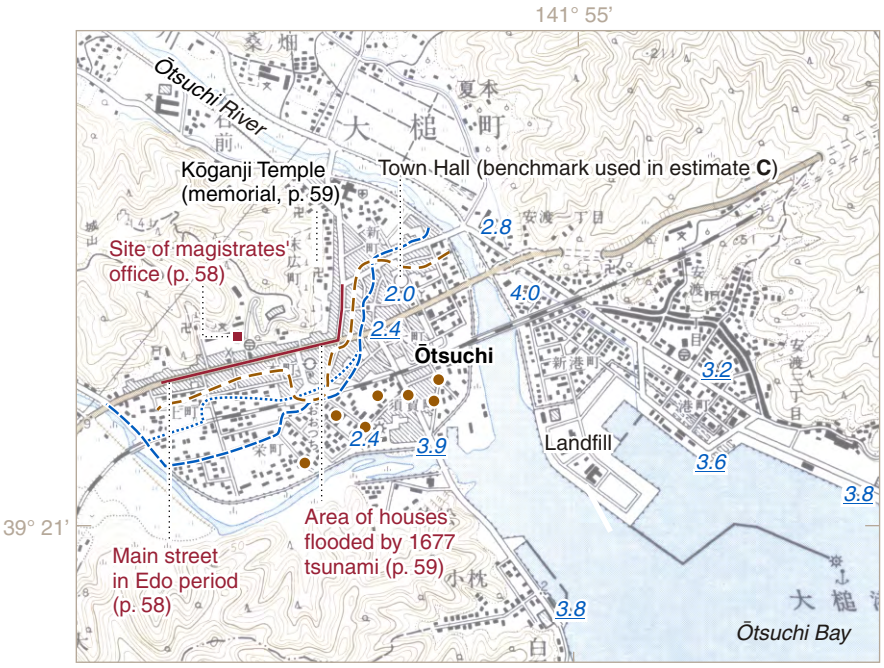


Subsidence 1.5 m since 1700 (extrapolated tide-gauge trend, right).

Modern ground Maximum height of 1700 tsunami approximated by benchmark 1.6 m above TP.

Tide stage 0.2 m below 1700 mean sea level (p. 83).

1960 tsunami



Inland limit of 1960 tsunami Estimates differ between sources "a" and "b"

a

b

Height of 1960 tsunami

3.9 a

2.8 b

Topography mapped in 1975

2-m contour

Elevation 1.2 m in former rice paddy

All heights in meters above TP, a datum near mean sea level

Scale 1:25,000

0 1 km

N

a, Omote and Komaki (1961); b, Ōtsuchi-chō Kyōiku I'inkai (1961)

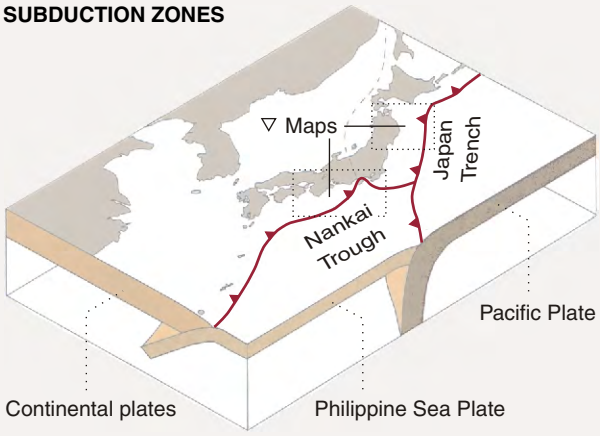
Base map from Kokudo Chiri'in (Geographical Survey Institute), Ōtsuchi 1:25,000 quadrangle, 1996. Contour interval 10 m.

Land-level changes since 1700

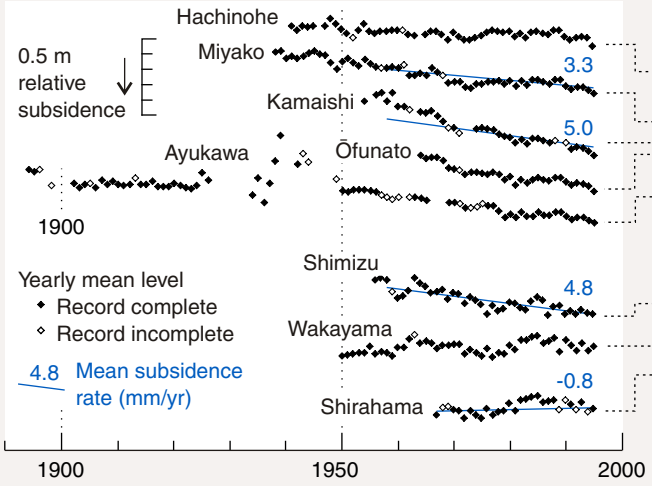
THE DESCENDING PACIFIC PLATE dragged land downward along the Japan Trench through the last half of the 20th century. If such subsidence persisted through the last 300 years, northern sites flooded by the 1700 tsunami stood 1.0-1.5 m higher than now—as assumed in the **C** estimates on pages 48, 57, and 64. The assumption is doubtful because (1) 20th-century sea-level rise explains part of the apparent subsidence, (2) stability prevailed at Ayukawa early in the 20th century, and (3) long-term uplift has raised the region's coast in the past 125,000 years.

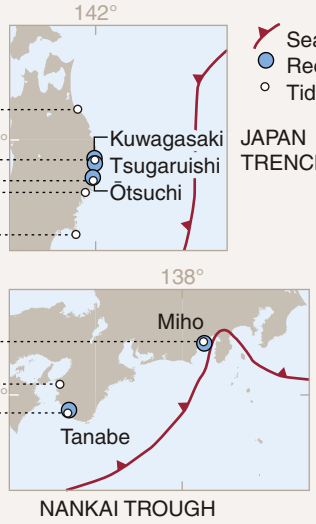
The coast farther south has a history of cyclic land-level changes related to historical subduction earthquakes on the Nankai Trough (p. 91).

SUBDUCTION ZONES



TIDE-GAUGED TRENDS, LAND LEVEL RELATIVE TO THE SEA





Block diagram modified from Earthquake Research Committee (1998, p. 22). Tide-gauge data from Coastal Movements Data Center (1996); periods of record vary. The mean rates, for 1958-1995, are from Ozawa and others (1997). They include 2 mm/yr of global sea-level rise (Cazenave and Nerem, 2004; Heki, 2004, p. 15). Ota and Omura (1991) infer long-term uplift; Kato (1979b) and Sawai and others (2004) assess historical subsidence.