

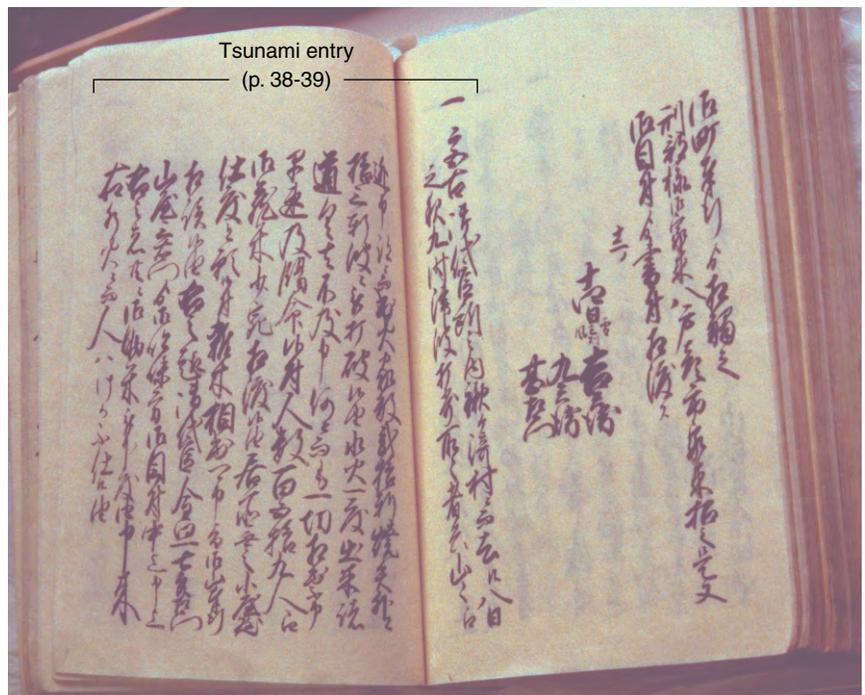
Kuwagasaki 鋤ヶ崎



The port of **Kuwagasaki** was administered from Miyako by district magistrates of a feudal domain, Morioka-han. Administrative records in a volume of Morioka-han "Zassho," compiled by samurai in the domain's castle, mention the 1700 tsunami in Kuwagasaki.

KUWAGASAKI had 281 houses a decade or two before 1700 (Takeuchi, 1985a, p. 321, citing Morioka-han "Zassho" for the years 1681-1691). It was then a major port for Morioka-han, as recounted by Iwamoto (1970, p. 116, 119) and implied by a shipping route on the shogunal map from 1702 (dull red line, p. 33).

THE ABOVE VIEW of the village and its surroundings comes from a 1739 map of the Miyako district (p. 44). The tax office arose beside the port in 1701. Its map label reads *jūbun no ichi o-yakuya* ("ten-percent office") because Morioka-han levied a ten-percent tax on non-agricultural goods (Hanley and Yamamura, 1977, p. 129; Iwamoto, 1970, p. 49).



Main points

A nighttime flood and ensuing fires destroyed one tenth of the houses in Kuwagasaki. In response, officials issued food and sought wood for emergency shelters (p. 38-39).

An account of these events, probably written in 1700, calls the flood a “tsunami”—a term used in no other account of the 1700 tsunami in Japan (p. 40-41).

The reported hour of the tsunami in Kuwagasaki, identical to that reported from Ōtsuchi, 30 km to the south, pinpoints the 1700 Cascadia earthquake to the North American evening of January 26, 1700 (p. 42-43).

A regional government run by samurai produced the main account of the 1700 tsunami in Kuwagasaki (p. 44-45).

People went to high ground during the 1700 tsunami, as they did centuries later during the tsunami from Chile in 1960 (p. 46-47).

Waves of the 1700 tsunami directly destroyed 13 houses in Kuwagasaki. The damage in Japan helps define the size of the 1700 earthquake (p. 48-49).

Setting

From the nation’s capital in Edo, later renamed Tokyo, the Tokugawa shoguns and their retainers ruled Japan between 1603 and 1867, the Edo period. Under their authority, the Nambu clan controlled much of the northeast part of the nation’s main island, Honshu.

The Nambu domain, Morioka-han, included several coastal districts. One of these districts was administered from Miyako. The village of Kuwagasaki, 1 km east of Miyako, adjoined the district’s main harbor. The village contained close to 300 houses in 1700.

Other tsunamis

Tsunamis of nearby origin caused deaths in Kuwagasaki in 1611, 1896, and 1933. A lesser near-source tsunami, in 1677, swept away five houses, flooded rice paddies, and damaged salt-evaporation kilns.

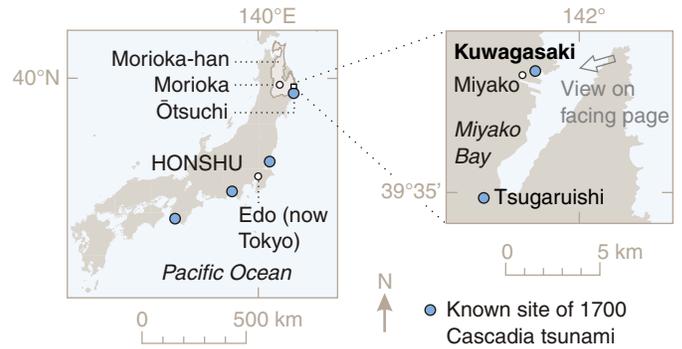
Aside from the 1700 event, no tsunami of remote origin is known to have damaged Edo-period Kuwagasaki. The 1960 Chile tsunami entered 14 houses but destroyed none (p. 49).

Documents

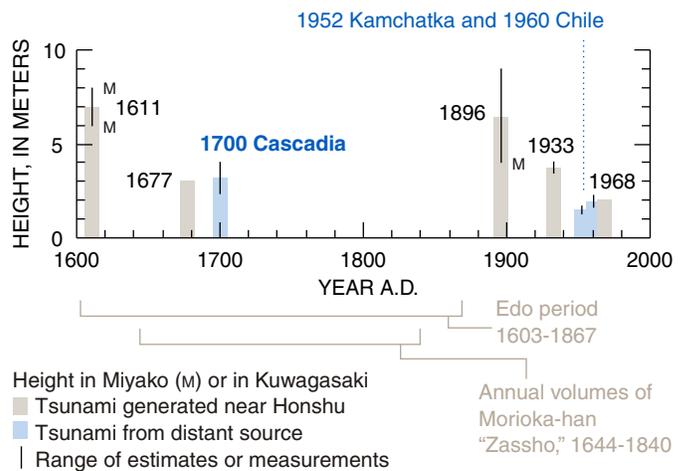
Morioka-han “Zassho,” an administrative diary compiled in Morioka castle, contains the main account of the 1700 tsunami in Kuwagasaki. The news originated with district magistrates in Miyako. Their report reached Morioka six days after the tsunami (p. 44).

An independent report of the tsunami, dispatched from Ōtsuchi, reached Morioka a day later (p. 60). A merchant’s account of the 1700 tsunami in Tsugaruishi mentions, as hearsay, the house fires in Kuwagasaki (p. 52, columns 3-5).

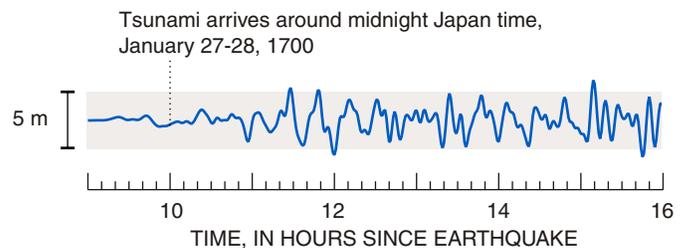
MORIOKA-HAN “ZASSHO,” in the volume at left, contains records from the 12th year of the Genroku era (defined p. 42). Each page is 30 cm (12 inches) long; the book weighs 1.26 kg (2.7 lb).



NOTABLE TSUNAMIS IN KUWAGASAKI AND MIYAKO SINCE 1600



SIMULATED WAVES OF THE 1700 TSUNAMI IN KUWAGASAKI



MEASURED HEIGHTS of the **1952 and later** tsunamis are from The Central Meteorological Observatory (1953, p. 20-22, 46), The Committee for Field Investigation of the Chilean Tsunami of 1960 (1961, p. 178), Unoki and Tsuchiya (1961, p. 258), and Kajiura and others (1968, p. 1370). The 1964 Alaska tsunami, not shown, crested 0.14 m above tide (map, p. 95). The graphed heights of most of the earlier tsunamis were inferred from descriptions of flooding and damage (Hatori, 1995, p. 60; Tsuji and Ueda, 1995, p. 96-97; Usami, 1996, p. 189; pages 48-49 of this report). The **1611** tsunami caused about 100 deaths in Miyako and Kuwagasaki (Hatori, 1995, p. 64; Tsuji and Ueda, 1995, p. 96). In Kuwagasaki alone, the **1896** tsunami killed 125 (Yamashita, 1997, p. 113) and the **1933** tsunami, 24 (Usami, 1996, p. 189).

THE SIMULATED WAVES are those from sea-floor deformation during a magnitude-9 earthquake at the Cascadia subduction zone (p. 98). The wave train lasts more than a day (p. 74-75), like the gauged Chilean tsunami of 1960 (p. 19). The modeled earthquake occurs about 9 p.m. local time on January 26, 1700 (p. 43). Diagram from Satake and others (2003).

Account in Morioka-han “Zassho” 盛岡藩『雑書』の記述

TWELVE CURSIVE COLUMNS in Morioka-han “Zassho” provide an official description of the 1700 tsunami and its aftermath in Kuwagasaki. The tsunami arrived at night (column 2). Villagers fled to high ground (2-3). The water destroyed 13 houses outright (4) and set off a fire that burned 20 more (3). In response, magistrates in nearby Miyako

issued rice to 159 persons (6-7) and sought wood for shelters (8-9). They kept others in the han government informed of these emergency efforts (9-12).

The columns contain symbols of Chinese origin (*kanji*) and a few, simpler symbols from Japanese syllabaries (*kana*). The writer applied these symbols with a brush. In gray we

12 (last)	11	10	9	8	7
					
<i>migi</i> At right	<i>migi no</i> At right	Yamaya Yamaya	<i>sōdan sōrō</i> consulted,	<i>tsukamatsuri</i> <i>tashi to</i> want to build,	<i>o-kuramai</i> stipend rice
<i>suika</i> flood and fire	<i>monodomo</i> villagers	San'emon San'emon	<i>yoshi</i> it was reported.	<i>negai sōrō</i> request	<i>sukoshi</i> a little
<i>nite</i> because of,	<i>ni</i> to,	<i>yori</i> from,	<i>migi no</i> At right	<i>ni tsuki</i> for this reason	<i>zutsu</i> to
<i>hito</i> people	<i>o-tasukemai</i> relief rice	<i>go-ginmigata</i> inspecting section	<i>omomuki</i> matter,	<i>zōki</i> low-grade wood	<i>ai watashi</i> <i>sōrō</i> supplied,
<i>wa</i> as for, <i>kega</i> injury	<i>kudasaretaki</i> want to be provided,	<i>o-metsuke</i> <i>chū</i> officials	<i>o-daikan</i> the magistrates	<i>ai dashi</i> release	<i>yoshi</i> it was reported.
<i>tsukamatsura-</i> <i>zu sōrō</i> did not receive,	<i>yoshi mōshi</i> <i>kitari</i> request was made.	<i>made</i> to, <i>mōshiageru</i> petitioned.	Kindaichi Kindaichi	<i>mōsu beki</i> request	<i>kyosho</i> Housing
<i>yoshi</i> it was reported.			Shichirō- zaemon Shichirō- zaemon	<i>mune</i> in summary	<i>kore naku</i> lost,
				<i>o-yamabugyō</i> forest magistrate	<i>koyagake</i> temporary shelter

12, *kega tsukamatsura-zu sōrō*—Language reflects the villagers' status below that of the writer.

Formal language—*mōsu* (3, 5, 8), *sōrō* (4, 6-8, 12), *mōsa-zu* (5), *mōshi* (11).

Sound change at word juncture—*doki* for *toki* (2), *domo* for *tomo* in *monodomo* (2), *nijikken* for *nijūken* (3), *gen* for *ken* in *jūsan-gen* (4), *issai* for *ichisai* (5), *gata* for *kata* in *go-ginmigata* (10).

NOTES, LIKE THE COLUMNS, BEGIN AT RIGHT ON THE FACING PAGE.

yamabugyō commonly worked in the finance office (*kanjōsho*) and reported directly to deputy governors (*karō*) (Totman, 1989, p. 91).

9-10, *Kindaichi*...*San'emon*—During Genroku 12, the year of the 1700 tsunami (p. 42), four magistrates served in Miyako. Among them were Kindaichi Shichirōzaemon and Yamaya San'emon (Miyako-shi Kyōiku I'inkai, 1991, p. 554).

10, *go-ginmigata*—*go-*, honorific like *o-* in column 1.

8, *tsukamatsuri*—Humble language for addressing a person of higher status. Such deference is shown also by *mōshiageru* (10).

8, *zōki*—*zō*, miscellaneous; *ki*, tree or timber. Probably the writer would have used *mokuzai* had the wood been suitable for fine buildings and furniture.

8, *o-yamabugyō*—Literally, person in charge (*bugyō*) of hills (*yama* as in column 2). In Edo-period domains, senior forest officials called

add Roman letters as a guide to the spoken Japanese (rules, p. v). Literal translations follow in blue.

The columns proceed from right to left. Matter already mentioned therefore appears “at right” (9, 11, 12). Verbs end sentences, some of which are punctuated further by “ink breaths,” where bold lines of a newly inked brush start the

next sentence (clear example: 右 *migi*, column 9). Nouns follow all their modifiers; prepositions follow their objects.

COLUMN 1 (first)

<p>6</p>  <p><i>sassoku</i> Soon after,</p> <p><i>katsumei ni oyobi sōrō</i> became famished</p> <p><i>ni tsuki</i> thereby</p> <p><i>hitokazu</i> number of people,</p> <p><i>hyaku-gojūkyū-nin</i> 159 people</p> <p><i>e</i> to,</p>	<p>5</p>  <p><i>dōgu</i> belongings</p> <p><i>wa</i> as for,</p> <p><i>mōsu ni oyoba zu</i> needless to say</p> <p><i>nani nitemo</i> everything</p> <p><i>issai</i> at all</p> <p><i>ai-dashi</i> save</p> <p><i>mōsa-zu</i> could not.</p>	<p>4</p>  <p><i>jūsan-gen</i> 13 houses</p> <p><i>nami</i> waves</p> <p><i>ni</i> by</p> <p><i>uchiyaburare sōrō</i> were destroyed,</p> <p><i>yoshi</i> it was reported.</p> <p><i>suika</i> Flood and fire</p> <p><i>ichi-do</i> at the same time</p> <p><i>shuttai</i> happened.</p> <p><i>sho</i> Various</p>	<p>3</p>  <p><i>nige mōsu</i> escaped.</p> <p><i>ato nite</i> Afterwards</p> <p><i>shukka</i> started fire</p> <p><i>iekazu</i> number of houses</p> <p><i>niji-kken</i> 20 houses</p> <p><i>shōshitsu</i> burned.</p> <p><i>hoka ni</i> In addition,</p>	<p>2</p>  <p><i>no</i> of</p> <p><i>yoru</i> night</p> <p><i>kokonotsu-doki</i> hour of nine,</p> <p><i>tsunami</i> tsunami</p> <p><i>uchiyose</i> came.</p> <p><i>shosho no</i> Here and there,</p> <p><i>monodomo</i> villagers</p> <p><i>yamayama</i> hills</p> <p><i>e</i> to</p>	<p>一</p>  <p>[start of entry]</p> <p>Miyako Miyako</p> <p><i>o-daikansho</i> district magistrate's office</p> <p><i>no uchi</i> within,</p> <p><i>Kuwagasaki-mura</i> Kuwagasaki village</p> <p><i>nite</i> in,</p> <p><i>saru</i> past</p> <p><i>yōka</i> eighth day</p>
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6, *katsumei ni oyobi*—*katsu*, thirst; *mei*, life; *ni oyobi*, approach.

7, *o-kuramai*—Rice (*mai*) collected as tax, kept in government storehouses (*o-kura*), and distributed as stipends for samurai. An *o-kura* adjoined the Miyako magistrates' office in 1692 (Hanasaka, 1974, p. 26-27); the rice in 1700 may have come from this building. The 1700 tsunami entered another *o-kura*, near Tanabe (p. 86, 88).

2 and 6, *e*—Pronounced and written *e*, means "to."

3, *kken*—The house counter *ken* (like "sheets" in "seven sheets of paper") here follows a slight pause transcribed as a doubled Roman consonant. This same counter changes sound to *gen* in column 4.

5, *ai-dashi*—*ai* adds only emphasis or cadence.

5 and 12, *wa*—Topic marker, written *ha*.

6, *nin*—Counter for people.

← NOTES. Column 1, *Miyako o-daikansho no uchi*—In the district administered from the Miyako magistrates' office (p. 44; office location, p. 36, 49).

1, *o-daikansho*—Honorific *o-* here and in 7-11.

2, *kokonotsu-doki*—Around midnight (p. 43).

2, *monodomo*—Commoners.

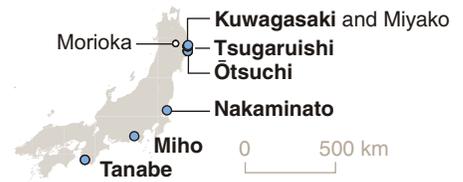
2, *yamayama*—More than one hill (*yama*).

Second *yama* denoted by "repeat" symbol, ㄹ

Words for waves 「津波」を表すことば

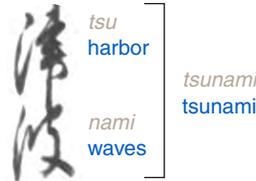
In each primary account, the orphan tsunami has a different alias.

SUDDEN SLIP on a submarine fault initiates a typical tsunami while also setting off an earthquake (cartoon, opposite; see also p. 10, 99). Feeling no precursory earthquake (p. 54), several Japanese writers called the 1700 tsunami a high tide. Only the writer of the Kuwagasaki account uses 津波 *tsunami* without questioning the term.



Tsunami 津波

A *tsunami* flooded Kuwagasaki at midnight on January 27-28, 1700, according to the entry in Morioka-han “Zassho” for February 2, 1700. The writer, inland at Morioka (p. 44), was probably paraphrasing a report from coastal magistrates in Miyako. He wrote tsunami with the same pair of symbols used today: 津 *tsu* (harbor) and 波 *nami* (waves).



Morioka-han “Zassho,” entry dated Genroku 12.12.14 (February 2, 1700) [p. 39, column 2].

High tide 大塩

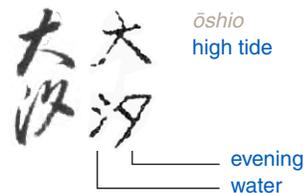
“High tide” denotes the 1700 tsunami in Tsugaruishi. The symbols mean “big” (大 *ō*) and “salt” or “tide” (塩 *shio*); in context, they connote “high tide.” The report states that the flooding was not associated with a felt earthquake.



Moriai-ke “Nikki kakitome chō,” 18th-century copy. From error in copying, event misdated to Genroku 12.11.8 [p. 52, column 1; 53].

High tide 大汐

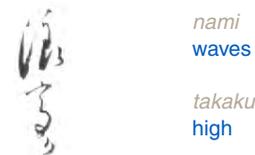
In an entry dating to February 3, 1700, Morioka-han “Zassho” uses a different *ōshio* for waters that damaged Ōtsuchi at midnight on January 27-28, 1700. The *ō*, again 大 for “big,” modifies 汐 *shio* composed of symbols for water and evening. This same *ōshio* represents the 1700 tsunami in an independent summary of Ōtsuchi magistrates’ documents, as later compiled in the printed symbols at right.



Left, Morioka-han “Zassho,” entry dated Genroku 12.12.15 [p. 60, column 1]. Right, Hand-printed synopsis of “Ōtsuchi kokondaidenki” (Mombushō Shinsai Yobō Hyōgikai, 1943, p. 25) [p. 62, 112].

High waves 浪高久

Nami takaku held a rice boat offshore Nakaminato on January 28, 1700. The waves were probably described as such by the crew; 浪高久 appears in a petition from the captain. At right, the version in a probably 18th-century copy of an accident certificate issued February 12, 1700.



Ōuchi-ke “Go-yōdome,” certificate originally dated Genroku 12.12.24 (p. 70) [p. 69, column 3].

Tsunami? 徒奈三?

The headman of Miho village puzzled over what to call the waves in 1700. He described them as “high water” (*mizu takaku*) and as “something like high tides” (*michishio nado no yōni*). He knew and used the term *tsunami* (which he wrote phonetically) but expressed wonder as to why no preceding earthquake was felt in his village or nearby.



“Miho-mura yōji oboe,” [p. 78, column 10]. The symbols 徒 *tsu*, 奈 *na*, and 三 *mi* are *hentaigana*—variant kana omitted from the simpler, modern syllabaries adopted in the 20th century (46-character hiragana and katakana; Seeley, 2000, p. 143, 153-154).

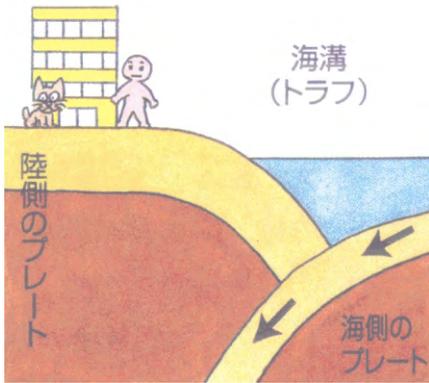
Unusual seas あびき

A Tanabe municipal record from 1700 introduces the tsunami as あびき *abiki*—unusual seas from tides, storms, winds, or tsunami. The same record also calls the tsunami a “tide” (潮 *shio*). This *shio* contains a radical for morning, while the one for Ōtsuchi contains “evening”—in accord with times when the tsunami was first noticed (p. 43).

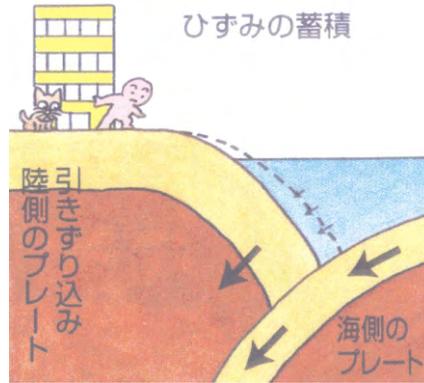


“Tanabe-machi daichō” [p. 86, columns 1, 3, 5]. The *abiki* can be read as hiragana. On *abiki*’s meanings, see “Nihon kokugo daijiten” (comparable to the Oxford English Dictionary) and a footnote on our page 86. Page 47 tells the story behind the first use of “tsunami” that the OED records.

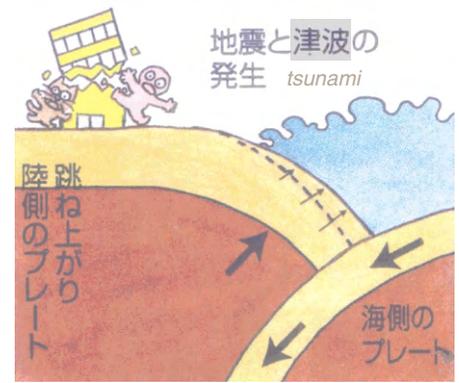
1 One tectonic plate descends beneath another at a subduction zone.



2 Subduction gradually drags the upper plate downward.



3 Suddenly released during an earthquake, this plate springs back, making a tsunami.

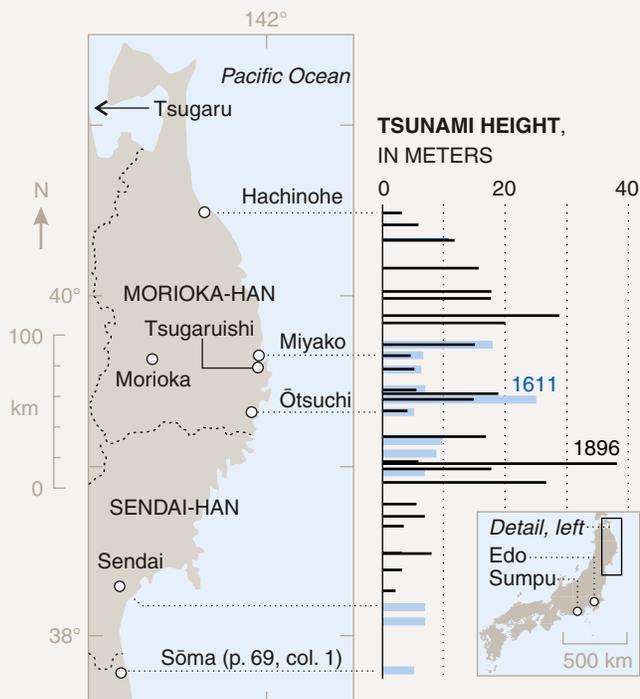


From a public-safety booklet by Jishin Yochi Sōgō Kenkyū Shinkōkai Jishin Chōsa Kenkyū Sentā (undated)

The first “tsunami”

AN OFFICIAL DIARY from 1612 contains what is probably the earliest extant example of 津波 *tsunami*. The writer was an aide to Tokugawa Ieyasu (1542-1616), the first of 15 shoguns to rule Japan from Edo. The document, “Sumpuki,” provides a record of Ieyasu's years at Sumpu, near Miho (p. 76), in the last decade of his life.

A tsunami spawned off northeast Honshu took thousands of lives there on December 2, 1611. Among the dead were 100 persons in Miyako, 150 in Tsugaruishi, and 800 in Ōtsuchi. In height the 1611 waves rivaled those of Japan’s most disastrous tsunami, which caused 22,000 fatalities in northeast Honshu in 1896.



Hatori (1995) compiled the heights and 1611 deaths; Yamashita (1997, p. 113), deaths from 1896. For a printed “Sumpuki” see Anonymous (1995).



In Sumpu castle a diarist wrote 津波.

Detail from 1687 map on page 26. East Asian Library, University of California, Berkeley.

The tsunami entry in “Sumpuki,” written in January 1612, begins by noting a gift from Date Masamune (1566-1636), daimyo of Sendai-han. From northeast Honshu Masamune has sent *hatsu tara*, the season’s first cod.

Aides then tell of the 1611 disaster. A so-called tsunami (*yo ni tsunami to yu’u*) has drowned 5,000 people in the territory of Masamune and 3,000 persons and horses (*jimba*) in the Nambu clan’s domain (Morioka-han) and in adjoining Tsugaru. Along with this news comes a story about a samurai who survived the tsunami by faithfully serving his daimyo:

Masamune wants fish. Two samurai receive the order. They round up fishermen. The fishermen balk because the sea has a strange color and the skies look ominous. One of the samurai insists on obeying the daimyo’s order. All set out in a boat. Soon it meets the tsunami, which drives it inland into the crown of a pine tree. The waves also sweep away entire villages along the shore. Later, after the water recedes, the men clamber down from the tree. Scanning the shore, they realize that they too would have been swept away had they not gone fishing for Masamune. The two samurai return to Masamune, who bestows a gift upon the one who had insisted on following orders.

The story, as recounted in “Sumpuki,” concludes with a moral voiced by Ieyasu: If you follow orders, you may escape disaster and receive gifts.

Converting time 時間の換算

The orphan tsunami came ashore in Japan on January 27 and 28, 1700.

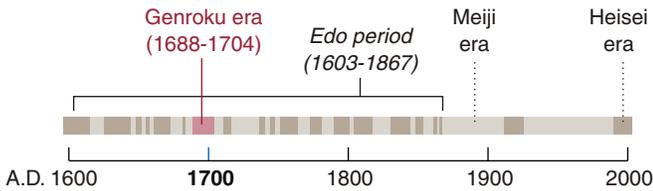
YEARS ON "ZASSHO" COVER



Genroku jūni
Genroku 12

tsuchinoto
younger brother of earth
u
fourth zodiac sign;
rabbit

JAPANESE ERAS



TWO CALENDARS date the 1700 tsunami in Morioka-han "Zassho." The year was the twelfth of the Genroku era—one of 35 eras in the period of Tokugawa rule from Edo. Genroku 12 was also a "Year of the Rabbit" in a 60-year zodiacal cycle of Chinese origin.

By either name, the year lasted 384 days; it contained a leap month, between the 9th and 10th month. Each month started on the new moon and lasted 29 or 30 days. The usual 12-month sum came to 354 days—eleven days short of a solar year. Therefore a leap month was inserted every few years, as happened in Genroku 12.

The 1700 tsunami came ashore on the 8th and 9th days of the 12th month of Genroku 12. This final month of Genroku 12 coincides with January and February of 1700. In the Julian calendar, the 1700 tsunami in Japan spans January 17 and 18; in the Gregorian calendar, adopted by Spain in 1582 and England in 1752, the equivalents are January 27 and 28.

CHINESE SIXTY-YEAR CYCLE

JIKKAN	CELESTIAL STEM		JŪNI-SHI EARTHLY BRANCH											
	Element	Brother	ne mouse	ushi bull	tora tiger	u rabbit	tatsu dragon	mi snake	uma horse	hitsuji sheep	saru monkey	tori rooster	inu dog	i boar
kinoe	wood	elder	1		51		41		31		21		11	7
kinoto	wood	younger		2		52		42		32		22		12
hinoe	fire	elder	13	9		3		53		43		33		23
hinoto	fire	younger		14	10		4		54		44		34	24
tsuchinoe	earth	elder	25		15	11		5	1		55		45	35
tsuchinoto	earth	younger		26		16	12		6	2		56		46
kanoe	metal	elder	37		27		17	13		7	3		57	47
kanoto	metal	younger		38		28		18	14		8	4		58
mizunoe	water	elder	49		39		29		19	15		9	5	59
mizunoto	water	younger		50		40		30		20	16		10	6

Year in cycle Year in Genroku era

JAPANESE YEARS AND MONTHS

Genroku 12 (leap year; 384 days)



Genroku 13 (354 days)

Winter solstice: Genroku 12.11.1 = December 21, 1699 Gregorian

WESTERN YEARS AND MONTHS



1699 Gregorian (365 days)

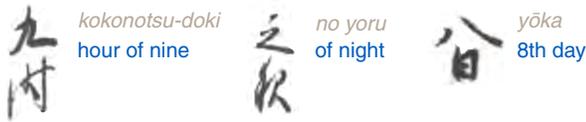
1700 Gregorian (365 days)



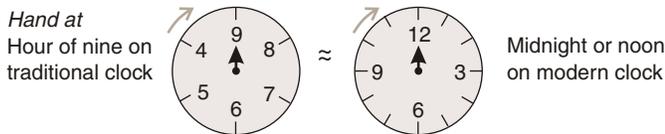
1699 Julian (365 days)

1700 Julian (leap year; 366 days)

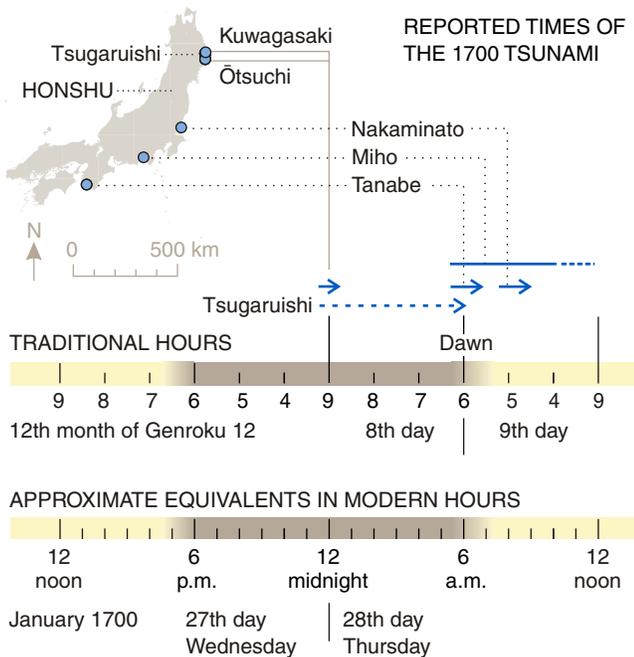
Morioka-han “Zassho” records the tsunami’s midnight arrival at Kuwagasaki and Ōtsuchi as the hour of nine on the 8th day (p. 39, columns 1 and 2):



The writer here refers to traditional Japanese timekeeping that divided a day into two series of six parts. These “hours,” each 120 minutes on average, were counted down, starting at midnight and again at noon, from nine to four:



Because the traditional numbered day began at dawn, the 1700 tsunami’s midnight arrival in Kuwagasaki and Ōtsuchi refers unambiguously to the 8th day. In Tsugaruishi the flooding reportedly began on the 8th and continued to the 9th. At Nakaminato and Miho, unusual seas were first noticed on the 9th day, in the first hours after dawn. The Tanabe account says “since about dawn of the 8th day”—either near the start of the 8th day or, interpreted for agreement with the other reports, near the start of the 9th.

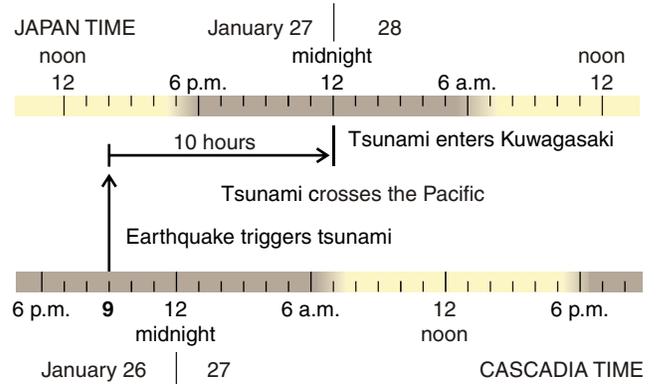


ON CALENDARS AND CLOCKS see Uchida (1975, p. 432), Chamberlain (1905, p. 476-477), Morris (1971, p. 377-382), Nelson and Haig (1997, p. 1251-1256), Parise (1982, p. 294-297), and Steel (2000, p. 2-3).

THE TRADITIONAL HOUR OF SIX coincided with the beginning of dawn and the end of dusk. Its time therefore varied with season, longitude, and latitude. Tsuji and others (1998, p. 9) reckoned that Genroku 12.12.9 dawned in Miho at 6:13 a.m. and in Tanabe ten minutes later.

The 1700 tsunami probably originated in the Cascadia region of North America in response to warping of the seafloor during an earthquake (p. 94, 99). From there, crossing the Pacific Ocean at jetliner speed, the tsunami front needed about ten hours to reach northern Honshu—the arrival simulated on the front cover and on page 75.

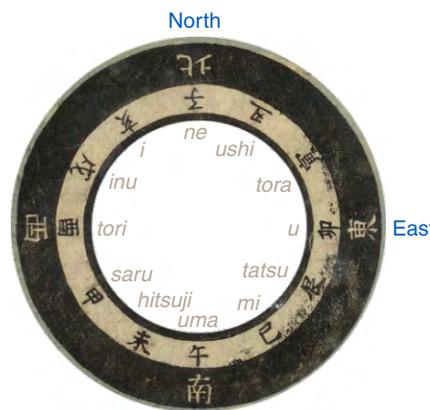
Suppose a Cascadia earthquake therefore preceded Kuwagasaki’s midnight waves by ten hours. Also allow for a 105-degree difference in longitude (a 17-hour difference in modern time zones). Then the earthquake’s local time becomes 9 p.m. Cascadia time on Tuesday, January 26, 1700:



THE TIMELINES above show how Satake and others (1996, 2003) dated the 1700 Cascadia earthquake to about 9 p.m. of January 26. The earthquake may have occurred a few hours earlier if the midnight flooding in Kuwagasaki and Ōtsuchi was from large waves that lagged the tsunami front. Such a lag, between one and two hours long, appears in a simulation of the 1700 tsunami at Kuwagasaki (p. 37) and in Japanese tide-gauge records of the 1960 Chile tsunami (p. 46, 73).

BECAUSE A TSUNAMI’S SPEED in the deep ocean depends solely on ocean depth, a tsunami from Cascadia should take about as much time to reach Japan as does a tsunami that follows a similar path in the reverse direction. Tsunamis from northern Honshu in 1896 and 1933 reached California in 11 hours. Similarly, tsunamis from southern Honshu in 1854 and 1946 reached California in 12-13 hours (box, p. 91; Lander and others, 1993, p. 120, 126, 130, 178).

TWELVE HOURS OR MORE is the likely duration of the 1700 tsunami in Japan. A single train of waves most simply explains the overlap among reported tsunami times (graph at left; p. 72-73). A long train appears in simulations of the 1700 tsunami (snapshots, p. 74-75; graph, p. 37). The 1960 tsunami excited Japanese harbors for days (p. 46, 73).



The Chinese zodiac gave the name *u no toshi* (Rabbit Year) that led historians to Miho’s full account of the 1700 tsunami (p. 62, 77). Zodiac signs also denoted time of day (“hour of the snake,” p. 44) and compass directions (left). The rabbit 卯, as the fourth of twelve signs, faces east 東.

All symbols face outward; 卯 rotates to 辰. From “Nihon kaisan chōriku zu” (p. 30), East Asian Library, University of California, Berkeley.

Samurai scribes 藩の右筆

Military men in a castle town documented their peacetime rule of a feudal domain.

HEADNOTE



jūyokka
14th day

Yuki minokoku kaze
Snow; wind at the hour of the snake
[about 10 a.m.]

Kichibe'e Kyūbe'e Jinzaemon
Kichibe'e, Kyūbe'e, Jinzaemon
[right] [left]

AS SNOW FELL on the inland town of Morioka six days after the 1700 tsunami, officials in the administrative wing of Morioka castle received the Miyako magistrates' report about the losses and relief measures in Kuwagasaki. Samurai employed as scribes drafted a synopsis. After review by senior ministers (*karō*, listed above), they entered the final version into the pages of Morioka-han "Zassho" (p. 36).

In similar fashion, officials compiled over 100,000 pages of administrative records in yearly volumes of "Zassho" from 1644 to 1840. One hundred eighty-nine of the yearbooks survive in the air-conditioned attic of Morioka-shi Chūō Kōminkan, a community center.

MORIOKA-HAN "ZASSHO"

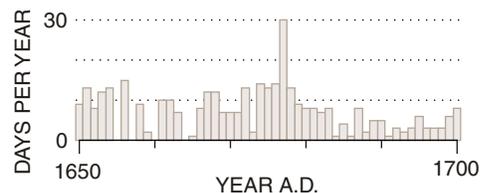


Earliest volume, 1644

MORIOKA-HAN "ZASSHO" was kept in Morioka castle until 1874, when the castle was torn down and the "Zassho" volumes entered a storehouse of the Nambu clan. A typeset version has been prepared by Morioka-shi Kyōiku Iinkai and Morioka-shi Chūō Kōminkan (1986-2001). On the han's history and administration see Mori (1972), Hosoi (1988), and Hanley and Yamamura (1977). THE HEADNOTE dates to six days after the tsunami's midnight arrival in Kuwagasaki on Genroku 12.12.8 (p. 42-43). The year Genroku 12 appears on the volume cover (p. 42); the month is introduced on an interior page.

THE SENIOR MINISTERS, named in full in the year's first "Zassho" entry, were among seven *karō* who served Nambu Yukinobu (opposite) between 1693 and 1702 (Hoshikawa and Maezawa, 1984-1985; Yoshida and Oikawa, 1983-1992). Nakano Hiroyasu (ca. 1658-1745) served as *Kichibe'e* in 1690-1713. He inherited the post as an adopted son of the preceding *karō* *Kichibe'e*. Kita Yoshitsugu(?) (1670-1732) succeeded his own father as *Kyūbe'e* in 1696. He held that post for seven years and later returned to it, after the death of his son, for another six. Urushido Shigetada (1640-1709), born in Edo, was *Jinzaemon* in 1691-1700.

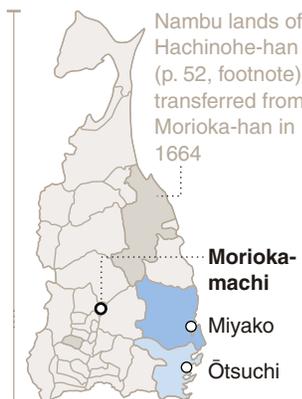
"ZASSHO" EARTHQUAKES



Morioka-han "Zassho" abounds in incidental facts. Headnotes summarize daily weather, which we use to confirm an error in the orphan tsunami's dating (p. 52-53) and to rule out storms as the cause of flooding (p. 72). Graphed above are the yearly number of days when "Zassho" scribes noted an earthquake or earthquakes. The years 1650-1700 included 366 such earthquake days.

Official papers of Morioka-han also include large picture maps (*ōezu*). The one being unfolded below, from 1739, shows one of the domain's 33 administrative districts. The maps aid in envisioning the bygone villages and fields that were flooded in 1700 (p. 36, 50, 56, 58).

DISTRICTS OF MORIOKA-HAN



Scale bar 240 km = length of Pacific coast of Washington state (p. 8)

MORIOKA
-han, feudal domain
-machi, castle town
-shi, modern city

PICTURE MAP OF MIYAKO DISTRICT, 1739



EARTHQUAKES recorded in Morioka-han "Zassho" were tabulated by the Ōfunato City Museum in a well-attributed list of earthquakes and tsunamis in northeast Honshu (Ōfunato Shiritsu Hakubutsukan, 1990). The graph above was compiled from pages 9-29 of that list, in the manner described by Satake (2002). The peak of 30 earthquake days in 1677 results from aftershocks of the earthquake whose tsunami washed away five houses in Kuwagasaki and flooded the main street in Ōtsuchi (p. 37, 59).

THE MAP OF HAN DISTRICTS (*tōri*; with sound change at word juncture, *dōri*) is from Morioka-shi Chūō Kōminkan (1998, p. 26). The *ōezu* of Miyako-dōri, conserved at the Kōminkan, dates to Genbun 4 (1739).

The scribes of Morioka-han “Zassho” resided in Morioka-machi, a castle town zoned by class. As samurai, they probably lived nearer the castle than did artisans and merchants—commoners whose neighborhoods ringed the town. A census in 1700 identified 14,209 commoners in Morioka-machi, out of a total of 343,499 in Morioka-han.

The scribes worked in the *ninomaru*, an administrative center that adjoined the keep of Morioka castle. They may have trained at a military school just north of the castle grounds.



CASTLE TOWN

Commoners' neighborhood
Merchants and artisans

Samurai neighborhood
Individuals' names are plotted.

Morioka castle White box, area of detail below

Temple or shrine



CASTLE GROUNDS

School (site) Founded by 1672, moved elsewhere in 1740

Ninomaru Administrative center where Morioka-han “Zassho” was written and stored

Honmaru Castle keep

Castle wall



A monument stone in a city park now marks the site of the *ninomaru* of Morioka castle, demolished in 1874.

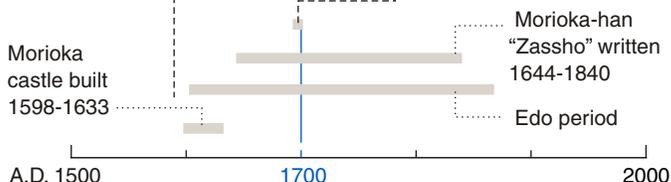
IN CASTLE TOWNS of Edo-period Japan, samurai typically resided nearest the castle (Sakudō, 1990, p. 149). The census figures come from Mori (1963, p. 641-643, 688-692); the 1736 map, from Morioka-shi Chūō Kōminkan (1998, p. 2); the 1770 map, from a visitors pamphlet for Morioka-shi Chūō Kōminkan. Nagaoka (1986, p. 81-82) locates the school, *Han go-shinmaru go-keikojo*, which probably began as a military institute for the sons of high-ranking samurai.

DAIMYOS



Nambu Nobunao Subdued opposition in the 1590s

Nambu Yukinobu Ruled in peacetime 1693-1702



Scribes in Morioka castle and district magistrates in Miyako served the Nambu clan. The Nambu wrested control over the region while Japan was emerging from centuries of civil war. Nambu rule then continued for more than 250 years under Tokugawa shoguns, throughout the Edo period.

This Nambu authority initially depended on Toyotomi Hideyoshi, who gained hegemony over Japan’s warlords in the 1580s and 1590s. In July 1590, Hideyoshi granted much of northeast Honshu to Nambu Nobunao on condition that he survey taxable land and subjugate its owners. Nobunao faced a farmer’s rebellion a few months later and an attempted coup the following March. Hideyoshi sent an army to his aid in August 1591.

Morioka castle, begun under Nobunao in 1598, became the domain’s headquarters in the 1630s. By then, power had passed from Hideyoshi to the Tokugawa shogunate, and Nambu retainers were attending to peacetime administration. Their successors, under the daimyo Nambu Yukinobu, documented the 1700 tsunami.

Nambu family crest

A pair of cranes symbolizes the clan that controlled Morioka-han throughout the Edo period.



PORTRAITS AND CREST courtesy of Morioka-shi Chūō Kōminkan. Totman (1993, chap. 4) outlines pacification under Hideyoshi and Ieyasu. Han were reorganized into today’s prefectures after 1871 (Beasley, 1982, p. 126).

High ground 高台へ

In 1700, Japanese villagers used a timeless tactic for surviving tsunamis.

1700 tsunami

A curling wave chases a fleeing figure on roadside signs in Washington, Oregon, and California. In Sumatra in 2004, how many lives would such signs have saved?



In Japan in 1700, tsunami-savvy villagers fled to high ground during a tsunami that originated not far from where the North America signs stand. Going to hills probably prevented casualties at Kuwagasaki; all its villagers escaped injury despite a sea flood that destroyed 13 houses and set off a fire that burned 20 more. Miho's headman advised the elderly and children to go to a shrine on the area's highest ground.

THE HIGHWAY SIGN, designed in Oregon in the late 1990s, was adopted as an international symbol in 2003 (<http://ioc3.unesco.org/itic/contents.php?id=71>). QUOTES are from Morioka-han "Zassho" (p. 38-39, columns 2-3) and "Miho-mura yōji oboe" (p. 79, columns 6-7).



1960 tsunami

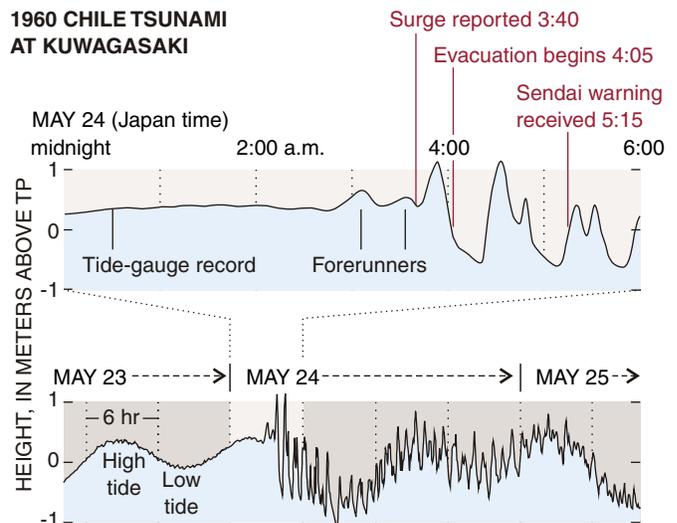
As a precaution against the incoming tsunami from Chile, local police and firemen began evacuating low-lying parts of Kuwagasaki at 4:05 a.m. on May 24, 1960. This action anticipated, by an hour, a tsunami warning from the regional headquarters of the Japan Meteorological Agency, in Sendai. The local officials used tips like these, which weather observers received at JMA's station in Kuwagasaki:

- 3:30....Chilean tsunami in Hawaii (*source*: radio news)
- 3:40....Surge at Norinowaki (fishermen's association)
- 3:49....High water in Ōtsuchi (town officials)
- 3:55....High water near Kuwagasaki (local resident)

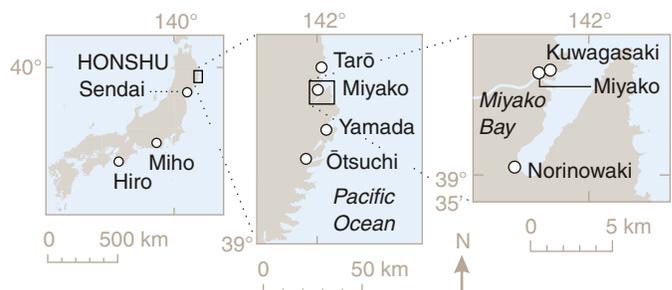
Soon after 4:13 sunrise, with the local evacuation underway, JMA observers in Kuwagasaki saw the sea withdraw. By then, they had received a further inquiry from the fishermen's association and official calls from Miyako and Yamada. By 4:30, the sea had flooded a pier in Kuwagasaki and a wave had been reported from Tarō.

Forerunner waves prompted the 3:40 report from Norinowaki. Such advance notice of the 1960 Chile tsunami registered on 27 Japanese tide gauges. Did forerunners similarly warn of the 1700 Cascadia tsunami in Japan?

MIYAKO WEATHER STATION in 1960 stood on low ground in Kuwagasaki (map, p. 49). The station report is in Japan Meteorological Agency (JMA) (1961, p. 232-233). JMA Sendai had authority to issue a warning; JMA Miyako did not. THE MARIGRAM was recorded by the Miyako tide gauge, Kuwagasaki (JMA, 1961, p. 271; map, p. 49). There, 1960 mean sea level stood 0.1 m above a national vertical datum, TP (Tokyo Peil). Though the marigram shows the tsunami cresting 1.2 m above TP (JMA, 1961, p. 34), a high-water line 2.4 m above TP was observed on a warehouse near the gauge (p. 49). For details on forerunner waves of the 1960 tsunami, see Nakamura and Watanabe (1961); on damping of tsunamis by tide gauges, Satake and others (1988).



The tsunami began off Chile nearly 24 hours before reaching Japan.



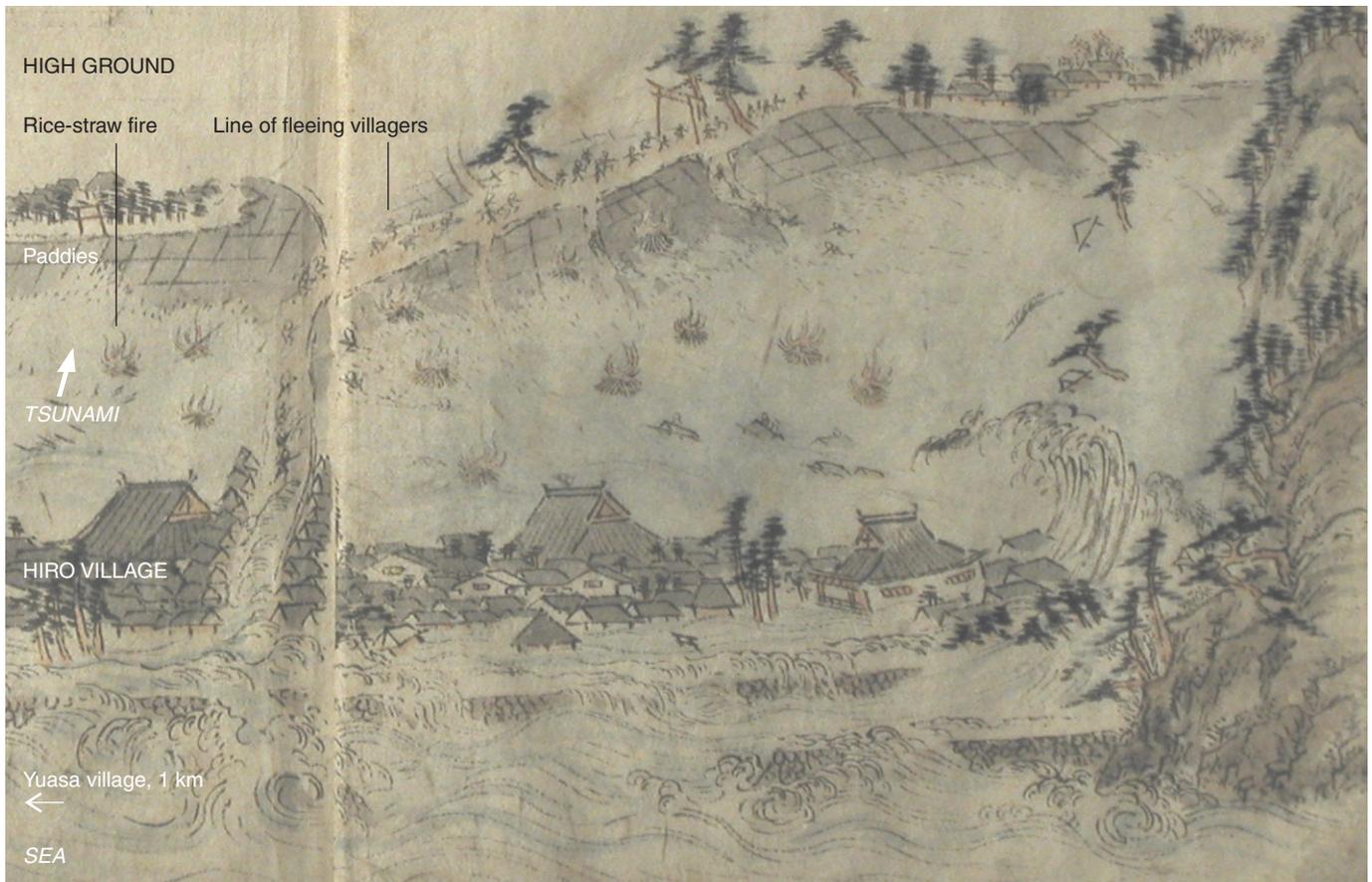
1854 tsunami

Hamaguchi Gohei, a village elder, knows “all the traditions of the coast.” One autumn evening, high above the seaside village that he heads, the old man feels an earthquake “not strong enough to frighten anybody.” Soon the sea withdraws in a “monstrous ebb.” As unknowing villagers flock to the beach, Gohei torches his rice harvest—“most of his invested capital.” The villagers rush uphill to fight the fire. Their headman’s selfless ruse has saved them from a tsunami.

As “Inamura no hi” (“The rice-sheaf fire”), this story first appeared in a Japanese grade-school reader in 1937 (p. 113) and later appeared in video (p. 115-121). As “The Wave,” an American children’s book, the tale similarly became a video sent to hundreds of schools in the 1990s for tsunami education in British Columbia, Washington, Oregon, and California. As public art inscribed in stone in Seattle, a “true story” tells of “an old farmer in Japan who saved an entire village from destruction by a tidal wave.”

The story, timeless as a cautionary tale about natural tsunami warnings, originated in 1897 as “A living god” by Lafcadio Hearn. Hearn blended two 19th-century disasters: Honshu’s giant waves of 1896 (p. 41), whose parent earthquake was weak; and a tsunami evacuation a half century earlier in the southwest Honshu village of Hiro. On the night of December 24, 1854, 34-year-old Hamaguchi Goryō lit rice-straw fires in Hiro during a tsunami that shortly followed a violent earthquake of estimated magnitude 8.5. Lost that night in Hiro were 36 lives and 158 of 374 houses. Goryō himself nearly drowned.

Hamaguchi Goryō’s rice-straw fires in Hiro village beckoned villagers well-rehearsed in seeking high ground. As a precaution against tsunamis, Hiro had already evacuated twice in 1854—after earthquakes on July 9 and December 23. Goryō’s beacons on December 24, depicted below, are said to have guided nine persons to safety.



HAMAGUCHI GORYŌ, who founded Hiro’s first public school in 1852, underwrote the village’s recovery from the 1854 disaster (Tsumura, 1991; Shimizu, 1996). Drawing on proceeds from his family’s soy-sauce business (today’s Yamasa brand), he employed villagers to rebuild 50 houses and to replace the seawalls being overwashed in the painting, above. His wall, still standing, rises 5 m and extends 0.6 km. Hiro village is now the town of Hirogawa.

THE PAINTING above, courtesy of Yōgen temple in Hirogawa, portrays Goryō’s fires as numerous and widely dispersed in rice paddies being covered by the tsunami of December 24, 1854. The artist, Furuta Shōemon (also known as Furuta Eisho), witnessed the tsunami in adjoining Yuasa village (Shimizu, 2003).

ELIZA RUHAMAH SCIDMORE, in the September 1896 *National Geographic*, reported that people shouted “*Tsunami!*” as they ran to high ground during the 1896 disaster (<http://ngm.nationalgeographic.com/1896/09/japan-tsunami/scidmore-text>). Hearn’s (1987) “A living god,” quoted above, contains the earliest use of *tsunami* cited in the Oxford English Dictionary.

“INAMURA NO HI” remained, until 1947, in a national reader for students 10-11 years old (p. 113). Nakai Tsunezō, a grade-school teacher, wrote this adaptation. Hodges (1964) similarly made “A living god” into “The wave.” Ellen Ziegler, with a 1987 grant from the Seattle Arts Commission, inscribed the tale on tablets fronting Jefferson Park fire station.

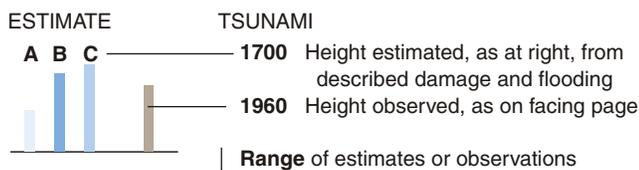
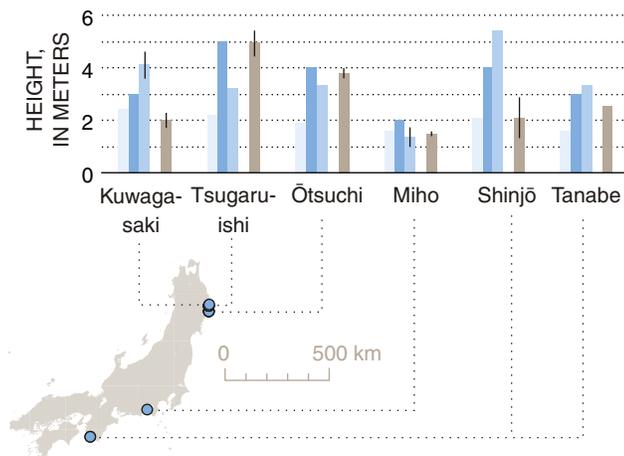
Tsunami size 津波の高さ

Kuwagasaki's losses in 1700 suggest a tsunami several meters high.

WRITTEN RECORDS of flooding and damage by the 1700 tsunami imply tsunami heights in the range 2-5 m in Japan. The heights, graphed in blue below, are central to the conclusion that the Cascadia subduction zone can produce earthquakes of magnitude 9 (p. 98-99).

The height estimates vary with assumptions about the recorded damage and flooding, illustrated for Kuwagasaki in the cartoons at right. In an estimate that is probably low (A), the 1700 tsunami crested 2½ m high when it destroyed 13 houses in Kuwagasaki. The estimate increases to 3 m under moderate assumptions (B), and it reaches 4 m if it includes a generous assumption about land-level changes since 1700 (C; p. 65).

Summary of tsunami heights, 1700 and 1960



ON TSUNAMI HEIGHTS in 1700, see also pages 56-57, 64-65, 82-83, and 88-91. **A** and **B**, “low” and “medium” height estimates of Satake and others (2003); **C**, estimate by Tsuji and others (1998). TP, datum near sea level (p. 46, footnote). AT THE MIYAKO GAUGE, high tide averaged 0.6 m above mean sea level for the years 1954-1959; the highest tide in 1937-1995 was 1.0 m above 1995 mean sea level (Japan Meteorological Agency, 1960, p. 402; 1996, p. 253). WHERE THEY DESTROYED wooden Edo-period houses in Japan, tsunamis commonly ran at least 1.0-1.5 m deep (Tsuji, 1987).

Estimates of 1700 tsunami height in Kuwagasaki

REPORTED DAMAGE

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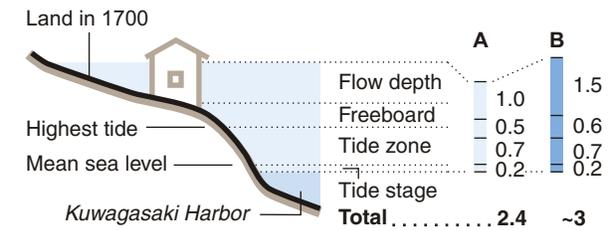
jūsan-gen
 13 houses

nami ni
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uchiyaburare
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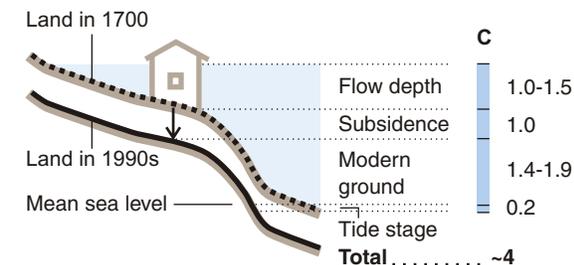
Morioka-han “Zassho”
(p. 39, column 4)

HEIGHT ESTIMATES, IN METERS ABOVE TIDE



ASSUMPTIONS

- Flow depth** Tsunami flowed 1.0-1.5 m deep where it destroyed houses (1.0 m assumed in **A**, 1.5 m in **B**, 1.0-1.5 m in **C**).
- Freeboard** To escape storm waves—and perhaps with the 1677 tsunami in mind (p. 37)—villagers built their houses at least 0.5 m above highest astronomical tide (0.5 m in **A**, 0.6 m in **B**).
- Tide zone** The highest astronomical tide in 1700 was 0.7 m above mean sea level, by analogy with modern tides in Kuwagasaki Harbor (Miyako gauge; location on facing page). Used in **A** and **B**.
- Tide stage** Tide stood 0.2 m below mean sea level when houses were destroyed (**A**, **B**, and **C**; supporting details, p. 83).
- Modern ground** The ground surface, surveyed in 1971-1995, was 1.4-1.9 m above TP in probable area of 1700 destruction (**C**).
- Subsidence** Relative to the sea, land at Kuwagasaki has subsided about 1 m since 1700 (**C**; p. 65).

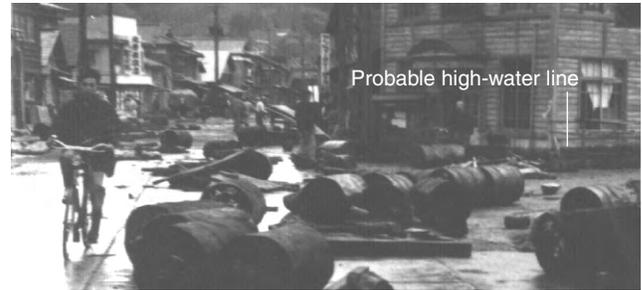


1960 tsunami

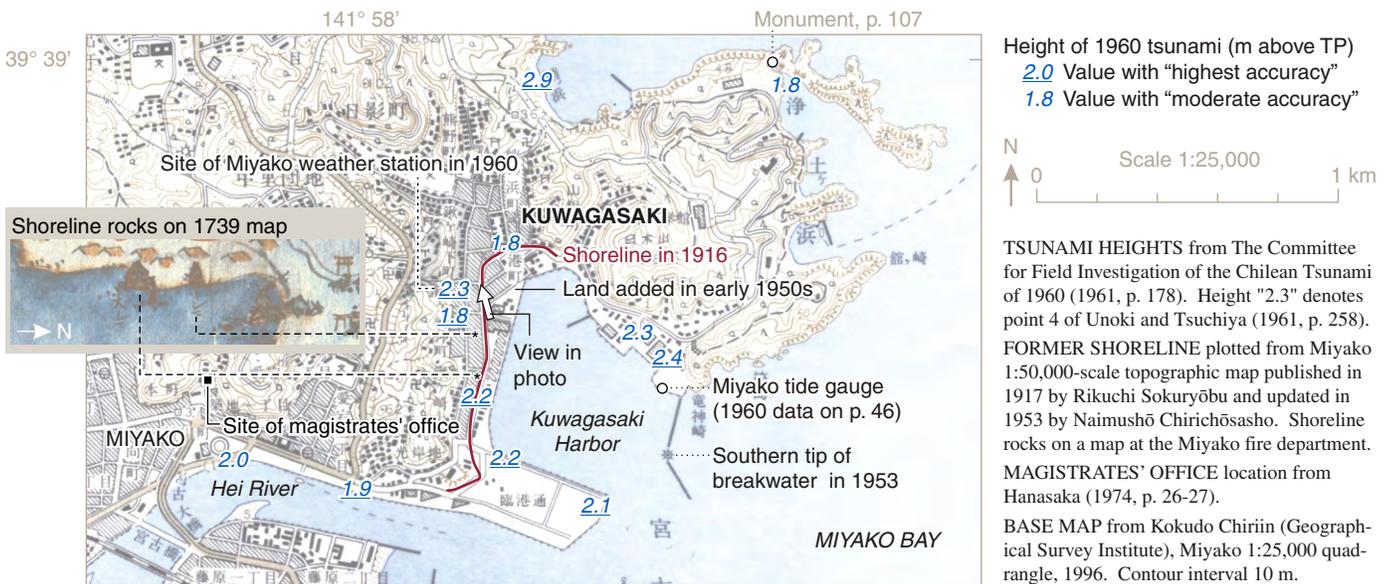
In Japan, the 1700 tsunami probably attained about the same size as the 1960 tsunami (summary graph, opposite)—the trans-Pacific waves that began in Chile (p. 10-11, 19).

In Kuwagasaki, where the 1700 tsunami probably reached heights of 2-3 m, the 1960 tsunami crested about 2 m high. The range of 1960 heights is 1.8-2.3 m above a datum near mean sea level (map, below). This range corresponds to 1.7-2.2 m above tide because the 1960 tsunami crested when the tide was about 0.1 m above this datum (p. 46, tide-gauge record). The 1960 tsunami in Kuwagasaki wetted floors of 14 houses without destroying any buildings. In the photo at right, shallow flooding by the tsunami has littered a street with empty petroleum barrels.

EFFECTS OF SHALLOW FLOODING IN 1960

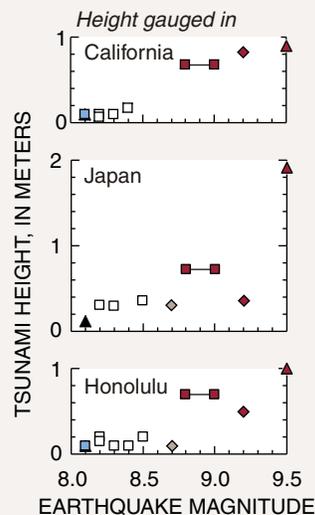
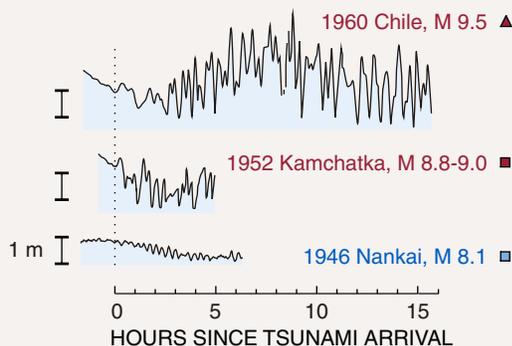


VIEW northward from tip of arrow on map below. At left, in a grocery, the 1960 tsunami crested about 0.3 m above a street-level floor (Atwater and others, 1999, p. 9). Photo from Japan Meteorological Agency (1961, p. 351).



Tsunami height and earthquake size

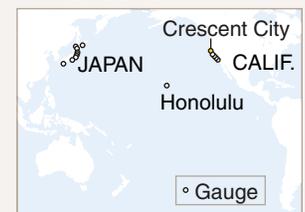
IN RELATING TSUNAMI DAMAGE in Japan to earthquake size at Cascadia, we assume that the height of a far-traveled tsunami increases with the size of the parent earthquake. The graphs at right show this tendency among 14 subduction-zone earthquakes of magnitude 8.1-9.5 between 1933 and 1974 (p. 98). Below, a similar trend among tide-gauged tsunamis at Crescent City, California.



EARTHQUAKES



TIDE GAUGES



MARIGRAMS from Lander and others (1993, p. 178, 181, 193). SCATTER PLOTS show maximum heights among gauges at least 1,000 km from the tsunami source (Abe, 1979, p. 1562). On size of the 1952 Kamchatka earthquake, see Johnson and Satake (1999).