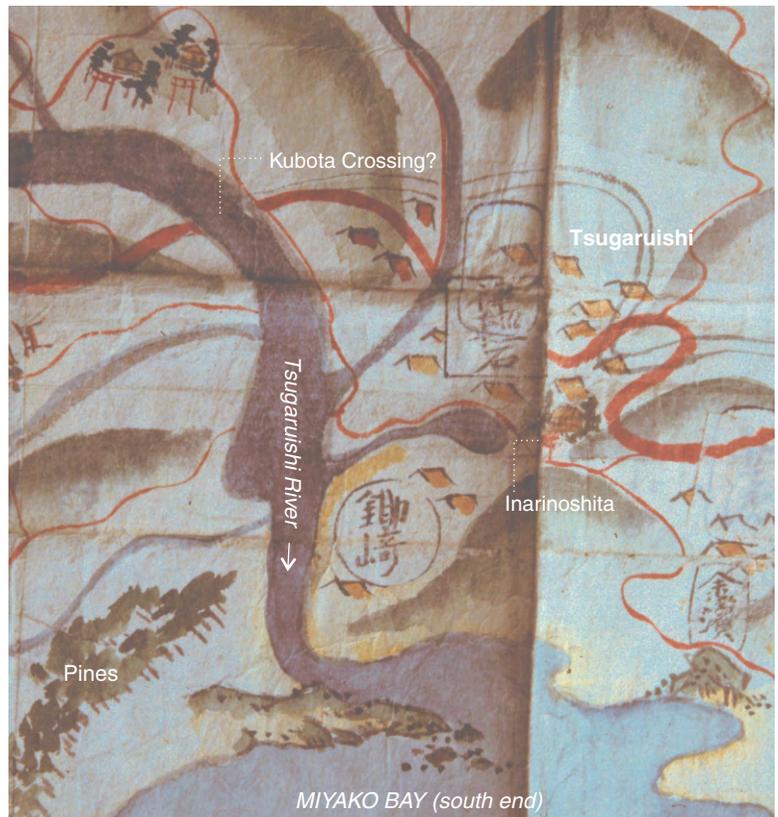
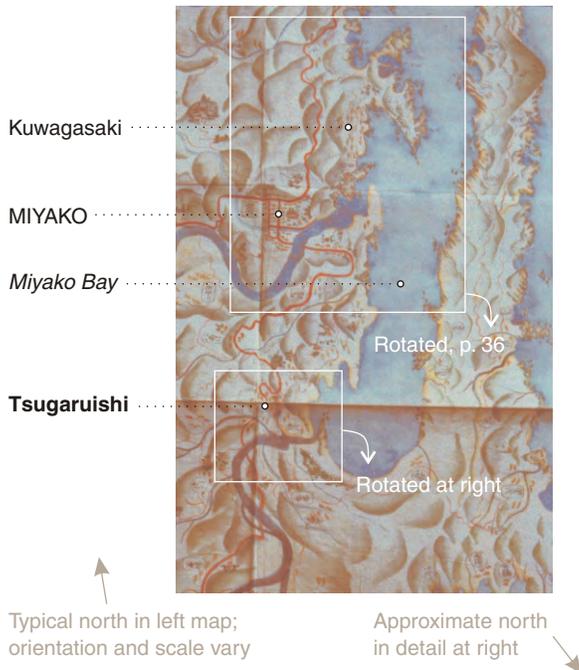


Tsugaruishi 津軽石



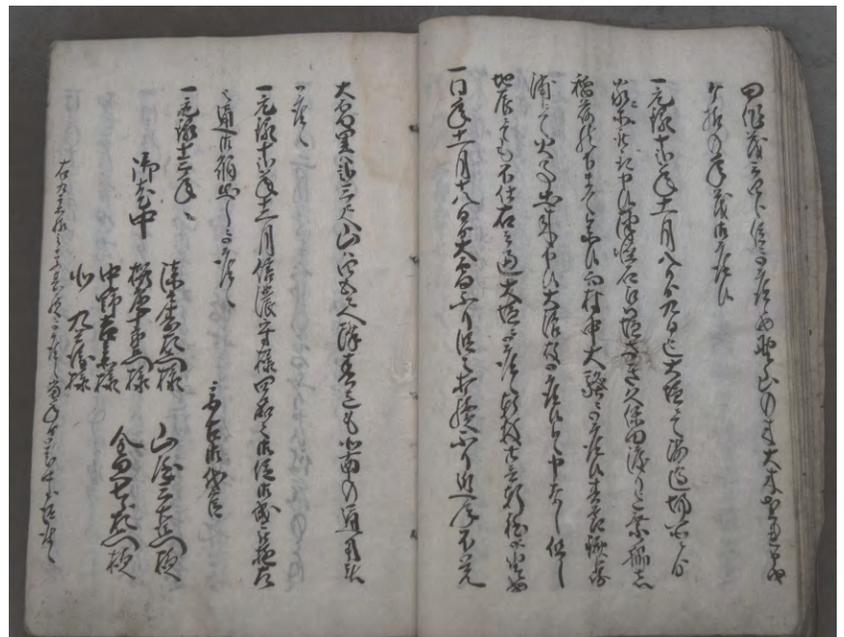
The south end of Miyako Bay, 7 km from Kuwagasaki, flanked Edo-period villages near the mouth of a river known for its salmon. The largest village, Tsugaruishi, adjoined the river 1 km upstream from the bay.



2004



Moriai-ke “Nikki kakitome chō,” a Tsugaruishi family’s notebook for the years 1696-1703, mentions the 1700 tsunami as high water that swept away houses along the bayshore, went inland to Inarinoshita and Kubota Crossing, and reportedly caused a related fire in Kuwagasaki. “Nikki” further states that there was no accompanying earthquake.



Entries about

Heavy snow

Tsunami (p. 52)

Both events misdated by exactly one month (p. 53)

UPPER VIEWS from the 1739 map of Miyako-dōri (unfolding, p. 44). Scale varies from place to place on the map, as does perspective shown by brown rooftops and red shrine gates (additional examples, p. 36, 56).

Main points

High water at the south end of Miyako Bay washed away houses and entered Tsugaruishi village, 1 km inland.

The same event set off a fire that burned “about 21 houses” in Kuwagasaki (p. 52; compare p. 39, col. 3).

The flooding happened without an earthquake (p. 54).

The water went upvalley to “Kubota Crossing”—perhaps as far as did the 1960 Chile tsunami, which ran 2 km inland from the south shore of Miyako Bay. Therefore the 1700 tsunami may have attained heights like those of the 1960 tsunami—about 5 m at the bayshore (p. 56-57).

The Tsugaruishi account originated with a merchant family that built a local financial empire in the 18th century (p. 53).

Setting

Tsugaruishi village, today as in 1700, occupies alluvial fans 1 km south of Miyako Bay. East of the village a farmed plain extends northward to a pine-covered beach ridge near Akamae. Pines also bordered this part of Miyako Bay in 1739 (detail, opposite; mapped also on p. 56).

Edo-period Tsugaruishi belonged to the Miyako district of Morioka-han (p. 44). In the 1680s the village contained 183 houses—about 100 fewer than Kuwagasaki.

Other tsunamis

Tsunamis from earthquakes along the coast of northeast Honshu took lives at the south end of Miyako Bay in 1611, 1896, and 1933. A lesser near-source tsunami in 1677 swept away 13 houses in Kanahama and ten houses in Akamae while damaging 70 hectares of rice paddies near Tsugaruishi.

The 1960 Chile tsunami resonated in Miyako Bay. Just 2 m high along the Pacific coast, the waves rose inside the bay and crested about 5 m high at its south end (p. 55). From there the waters ran past Norinowaki and Tsugaruishi to a limit 2 km inland (p. 56).

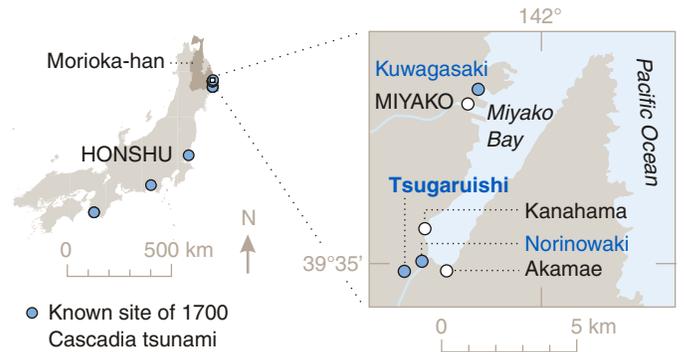
Documents

Earthquake researchers learned of the 1700 tsunami in Tsugaruishi through a 1983 transcription by a noted regional historian, Mori Kahei. In 1993 they quoted this transcription in the earthquake anthology “Shinshū Nihon jishin shiryō” (p. 62, 123).

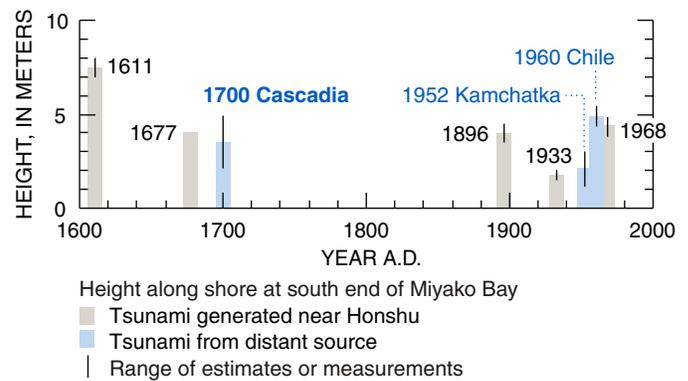
In 2004 we viewed Mori’s source document in the home of the Moriai family of Tsugaruishi (home interior, p. 53). That source is a Moriai family notebook for the years 1696-1703 (opposite). Because of a copyist’s error, the notebook dates both the orphan tsunami and a subsequent snowstorm exactly one month early (p. 52-53)

THE 17TH-CENTURY STATISTICS on Tsugaruishi can be found in Iwamoto (1970, p. 11) and Takeuchi (1985a, p. 507).

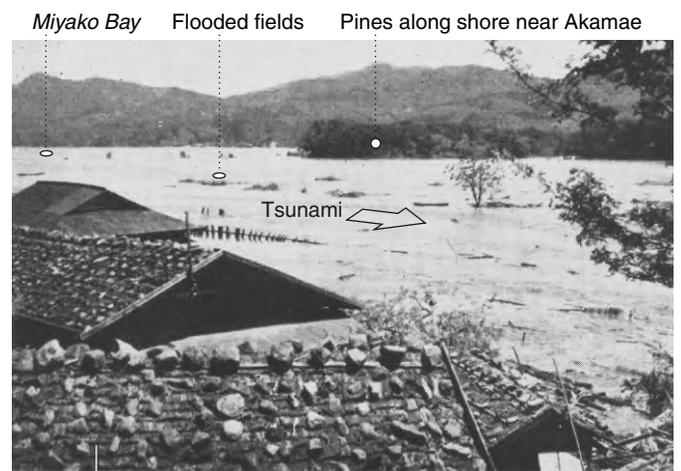
MORI KAHEI reviewed accounts of tsunamis of northeasternmost Honshu (Mori, 1983, p. 155-175). His transcription of the “Nikki” account (p. 161) contains a small error in transcribing “Norinowaki” (footnote, p. 52). For the quote in “Shinshū,” see Tokyo Daigaku Jishin Kenkyūsho (1993, p. 146).



NOTABLE TSUNAMIS IN TSUGARUISHI SINCE 1600



1960 CHILE TSUNAMI



Roofs of Norinowaki, weighted against typhoons

THE GRAPHED HEIGHTS of the 1952 and later tsunamis were measured soon after each event (The Central Meteorological Observatory, 1953, p. 22, 46; The Committee for Field Investigation of the Chilean Tsunami of 1960, 1961, p. 178-179; Kitamura and others, 1961a, p. 239; Kajjura and others, 1968, p. 1370, 1374). The graphed heights of earlier tsunamis are inferences from descriptions of flooding and damage (Hatori, 1995, p. 64; Tsuji and Ueda, 1995, p. 97; our pages 56-57). The 1611 tsunami caused about 150 deaths near the south end of Miyako Bay (Hatori, 1995, p. 60; Tsuji and Ueda, 1995, p. 96). Sixteen died in 1896 (Yamashita, 1997, p. 113), three in 1933 (Usami, 1996, p. 189). Katō and others (1961) describe amplification of the 1960 tsunami in Miyako Bay.

THE 1960 PHOTO, from Japan Meteorological Agency (1961, p. 339), shows a view east-northeast from the site plotted on page 56. The Akamae pines, in which people survived the 1960 tsunami, are probably similar in location to the pines shown in the picture map from 1739 (facing page).

Account in Moriai-ke “Nikki kakitome chō” 盛合家『日記書留帳』の記述

A “DIARY MEMO NOTEBOOK” of Tsugaruishi’s Moriai family recounts flooding at the south end of Miyako Bay, relates it to a nearby fire, and notes the lack of an earthquake.

The water swept away houses along the bayshore and went as far inland as Kubota Crossing (columns 1-2). It

caused panic in Tsugaruishi by reaching Inarinoshita, an area below Inari shrine (3). The related fire, in Kuwagasaki, destroyed about 21 houses according to hearsay (3-5). The account’s author probably suspected a tsunami, for he noted that no earthquake accompanied the event (4-5).

5	4	3	2	COLUMN 1 (first)
 <p><i>jishin nite mo</i> earthquake</p> <p><i>tsukamatsurazu</i> did not occur</p> <p><i>migi no tōri</i> mentioned at right</p> <p><i>ōshio ni</i> the high water</p> <p><i>goza sōrō</i> was.</p> <p><i>kensū</i> Number of houses</p> <p><i>nijūi-kken</i> twenty-one houses</p> <p><i>hodo</i> about</p> <p><i>goza sōrō yoshi</i> were reported.</p>	 <p><i>ura</i> small port</p> <p><i>nite</i> at</p> <p><i>kaji</i> fire</p> <p><i>shuttai mōshi sōrō</i> broke out.</p> <p><i>ōnami yue ni</i> The high water because of</p> <p><i>goza sōrō</i> was</p> <p><i>to mōshi tatematsuri sōrō</i> it is said.</p> <p><i>tadashi</i> However,</p>	 <p><i>Inarinoshita</i> Inarinoshita</p> <p><i>made up to</i></p> <p><i>mairi sōrō</i> reached,</p> <p><i>nite and so mura-jū</i> villagers</p> <p><i>ōsawagi ni goza sōrō</i> panicked.</p> <p><i>sono setsu</i> At that time,</p> <p><i>Kuwagasaki</i> Kuwagasaki</p>	 <p><i>ie nado</i> houses and so on</p> <p><i>torare mōshi sōrō</i> were swept away.</p> <p><i>Tsugaruishi e wa</i> Tsugaruishi at,</p> <p><i>shiosaki</i> salt water</p> <p><i>Kubota watari</i> Kubota crossing</p> <p><i>made up to, Norinowaki</i> Norinowaki</p> <p><i>wa</i> at,</p>	 <p>[start of entry] <i>Genroku</i> Genroku</p> <p><i>jūni-nen</i> 12th year</p> <p><i>jūichi-gatsu</i> 11th month</p> <p><i>yōka yori</i> 8th day from</p> <p><i>kokonoka made</i> 9th day to</p> <p><i>ōshio</i> high tide</p> <p><i>nite</i> because of,</p> <p><i>umibe</i> on the coast</p> <p><i>basho ni yori</i> here and there</p>

5, *migi no tōri* (as at right)—Refers to material stated previously, in a column to the right (as in columns 9, 11, and 12 on p. 38).

5, *nijūi-kken hodo* (approximately 21 houses)—The houses that burned in Kuwagasaki (p. 39, column 3). Reported as hearsay.

Formal language—*mōshi sōrō* (2, 4), *mairi sōrō* (3), *goza sōrō* (3-5), *tsukamatsurazu* (5).

Sound change at word juncture—*mura-jū* for *mura-chū* (3), *nijūi-kken* for *nijūichi-ken* (5).

1, *basho ni yori*—Not fully translated. Literally, “depending on the place.”

2, *ie nado*—The *nado* (“and so on”) makes the *ie* plural: “houses.”

2, *Norinowaki* 法之脇—Village (maps, p. 51, 56). Probably includes the area of the houses in the foreground of the photo on p. 51. In transcribing Moriai-ke “Nikki kakitome chō,” Mori (1983, p. 161) read *nori* 法 as *nori* 乗, “to ride,” and he inserted a comma after this 乗. Thus in Mori’s transcription, salt water “rode” to Kubota Crossing.

← NOTES. Column 1, *jūichi-gatsu* (11th month)—A mistake in copying *jūni-gatsu* (12th month). The writer repeated this mistake for a heavy snow that fell ten days after the orphan tsunami (facing page). This snowfall is securely dated in Moriokahan “Zassho” and in Hachinohe-han “Han nikki.” In the latter, the heavy snow was noted independently by the *metakesho* (inspection bureau) and by its *kanjōsho* (finance office) (Hachinohe Komonjo Benkyō-kai, 1994, p. 203).

Human error 写しまちがい

A Tsugaruishi writer miswrote the orphan tsunami's month.

ONE LUNAR MONTH separates two reported dates for a fire that destroyed some 20 houses in Kuwagasaki during a sea flood late in the year Genroku 12. Morioka-han “Zassho” dates this unusual event to the 8th day of the 12th month (p. 39, column 1); “Nikki kakitome chō,” to the 8th and 9th days of the 11th month (p. 52, column 1; excerpt, right).

Errors in compiling “Nikki” probably explain this discrepancy and an adjoining one. The next entry in “Nikki kakitome chō” (p. 50), nominally for the 18th day of the 11th month, tells of heavy snow (right). Morioka-han “Zassho,”



however, reports fair skies on that day and snow exactly one month later. Similarly in Hachinohe, snow fell not on 11/18 but heavily on 12/18 (first footnote, opposite). Miswriting the month of this storm, the “Nikki” compiler similarly misdated the orphan tsunami.

DATED EXACTLY ONE MONTH EARLY

SNOWSTORM

一日
十一月十八日
雪

dō nen
same year

jūichi-gatsu
11th month

jūhachi-nichi
18th day

SEA FLOOD AND FIRE

一元
十二月八日
津波と火

Genroku
Genroku

jūni-nen
12th year

jūichi-gatsu
11th month

yōka
8th day

Social status 士農工商

A merchant family that chronicled the orphan tsunami later attained samurai rank.

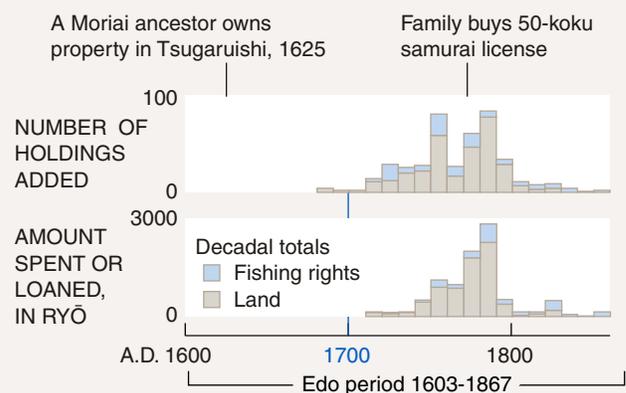
THE FOUNDING WARRIORS of Edo-period Japan decreed a hereditary social order that ranked samurai above farmers, farmers above artisans, and nearly everyone above merchants. However, the samurai-led governments commonly ran up debts (p. 61), which some daimyo domains partly covered by selling samurai status to merchants. Thus in 1774 Morioka-han issued, to a prosperous merchant family from Tsugaruishi, a license that elevated them to samurai with the surname Moriai.

The family's commercial ascent began in the 1680s with loans secured by land and fishing rights. Holdings grew as borrowers failed to repay. By 1776 the Moriai held timber and shipping interests in Kuwagasaki and sake breweries in Miyako and Ōtsuchi.

The family's first samurai, Moriai Chūzaemon, reviewed records from this era of financial growth. He assembled in 1777 most of the transactions graphed at right. In that same year he annotated “Nikki kakitome chō,” a “diary memo notebook” that probably originated with his grandfather, Mitsutatsu, who headed the family between 1690 and 1730.



Moriai Mitsunori headed the main branch of the Moriai family in 2004. His ancestors tracked their gains in lands and fishing rights, below.



A MORIAI ANCESTOR, Wakasa, held property in Tsugaruishi in 1625. His descendants purchased for 410 ryō, in 1774, samurai status that included an annual stipend of 50 koku and official use of the family name Moriai. Iwamoto (1970, p. 98-130) describes this purchase and tabulates the family's financial records; in a later book (1979) he relates additional Moriai history. One ryō (cash) would buy about 1 koku (180 liters) of dry hulled rice (p. 71).

EIGHTEENTH-CENTURY ENTREPRENEURS paid cash to Morioka-han for “samurai status and often the rights to conduct their commerce on a restrictive basis.” In 1783 “the domain issued a ‘price list’ for the various ranks of samurai status and privileges... [T]he right to wear swords and use a surname was 50 ryō; a promotion...to a bona-fide samurai was considerably more expensive at 620 ryō” (Hanley and Yamamura, 1977, p. 140).

Foreign waves 外国からの津波

Occasionally, a tsunami that damages Japan comes from afar.

NO EARTHQUAKE WARNED of the 1700 tsunami in Japan. No account mentions associated shaking, and two accounts note the lack of seismic warning (right).

Such orphan waves intrigued Ninomiya Saburo of the weather station in Miyako (p. 46). Soon after the 1960 Chile tsunami he matched three Edo-period tsunamis with South American earthquakes—from 1687, 1730, and 1751.

Ninomiya found no parent for the 1700 tsunami. It would remain an orphan until the 1990s (p. 93-94).

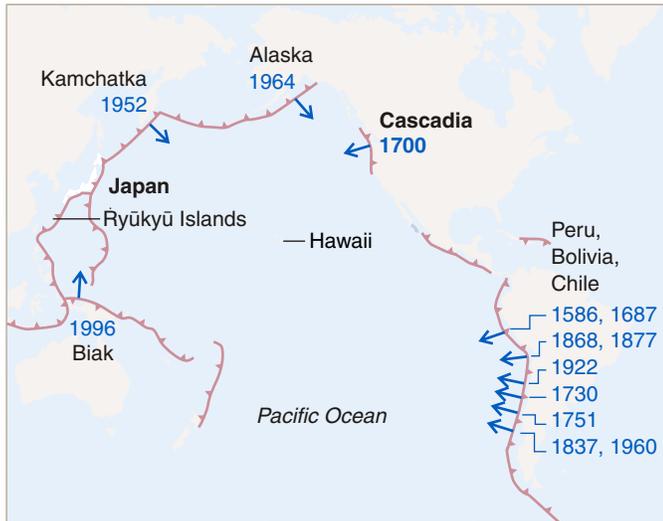
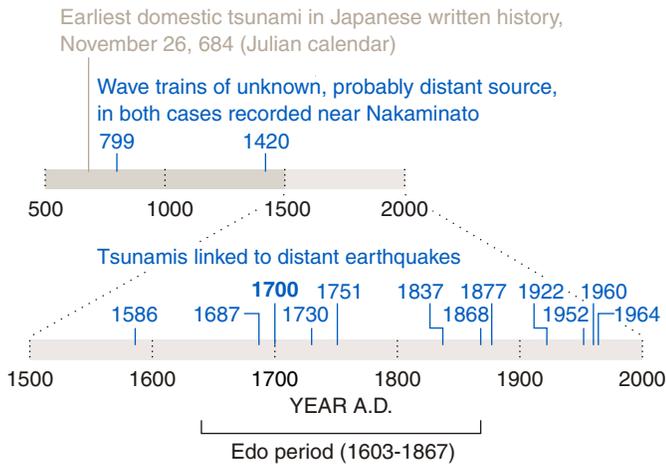
TSUGARUISHI

如存すも石住
jishin nite mo earthquake
tsukamatsurazu did not occur

MIHO

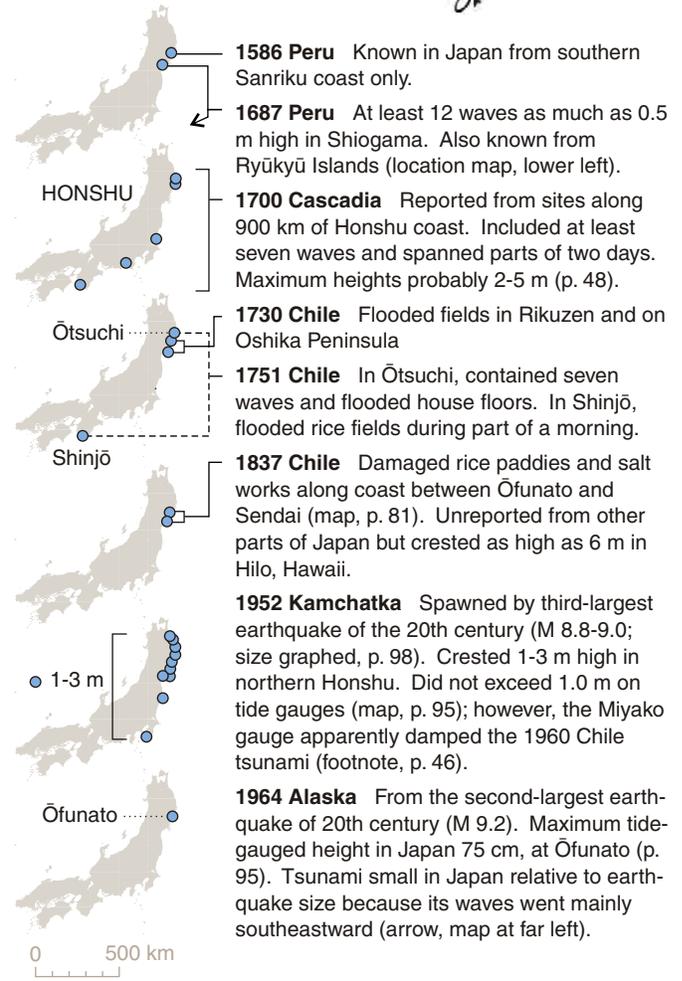
地震も
jishin earthquake
mo any
goza naku sōrō did not happen

Foreign tsunamis in Japan



1952 Tsunami recorded in Japan Arrow points toward distant shores that face broad side of the tsunami's source area. Where far from its source, a tsunami tends to be largest on such shores (simulation, p. 74-75 and 99).

Subduction zone Low-angle fault between tectonic plates (p. 8, 77). Line shows upper edge; teeth point down dip. Tsunamis on map originated along subduction zones.



QUOTES at top from pages 52 and 78.

ON FAR-TRAVELED TSUNAMIS see The Central Meteorological Observatory (1953, p. 39, 45-58), Ninomiya (1960), Takahashi and Hatori (1961, p. 23), Hatori (1965), Pararas-Carayannis and Calebaugh (1977), Lockridge (1985), Ōfunato Shiritsu Hakubutsukan (1990), Usami (1996), and Watanabe (1998). Perusing “Mandaiki” (p. 84) in 2002, Satake noticed a description of flooding in Shinjō, on Hōreki 1.5.2, that matches the expected arrival time of the 1751 tsunami. On tsunami directivity see Ben-Menahem and Rosenman (1972) and, for Cascadia, our pages 74-75 and 99.

JAPAN’S 684 TSUNAMI, according to the ancient chronicle “Nihongi” (or “Nihonshoki”), was “an overflowing rush of sea-water” that sank “many of the ships used for conveying tribute” (Aston, 1972, p. 366).

1960 Chile tsunami



Ōfunato, 1960
The Chilean tsunami drove ashore the “Dai jūsan kaiun maru” (“Luck bringer no. 13”).

Asahi Shimbun

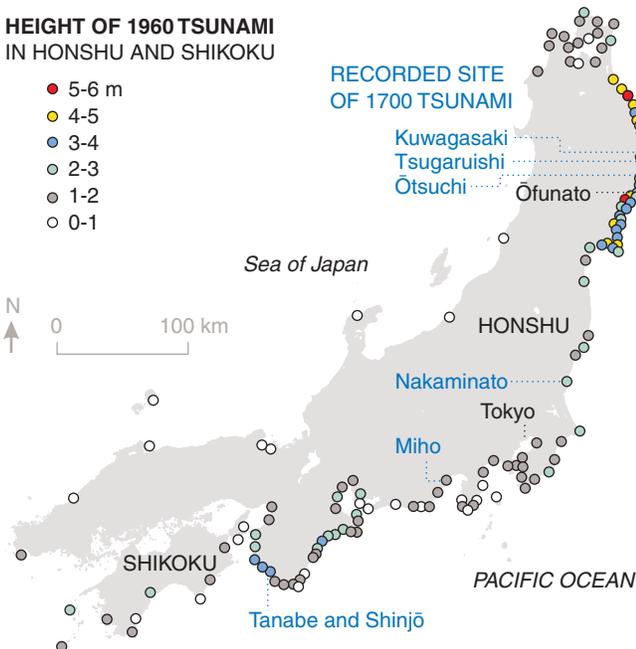
Few of Japan’s foreign tsunamis rival the 1700 event. In its documented Asian extent, it exceeds all other foreign tsunamis before 1868 with the exception of the South American waves of 1687 and 1751.

Japan’s most ruinous foreign tsunami originated with the largest earthquake ever measured—the 1960 Chile shock of magnitude 9.5 (p. 10-11). The waves took nearly 24 hours

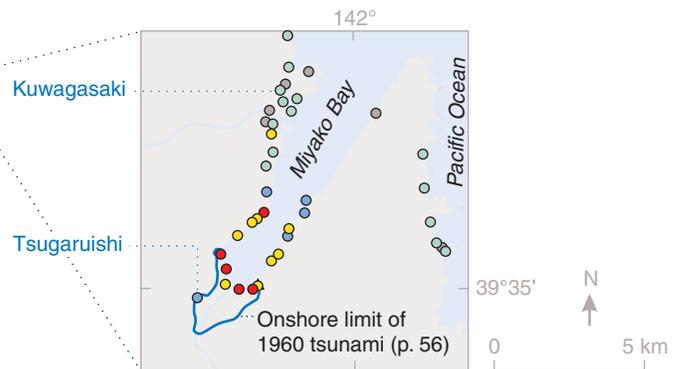
to reach Japan. The largest waves arrived a few hours after high tide in northern Honshu and at high tide to the south (p. 46, 83). They widely reached heights of 2-4 m and, where amplified in bays, locally crested at 5-6 m (map below). The waves caused 52 fatalities in Ōfunato (above and p. 81) and 71 deaths elsewhere in northeast Honshu. None of these losses occurred in areas of documented flooding in 1700.

HEIGHT OF 1960 TSUNAMI IN HONSHU AND SHIKOKU

- 5-6 m
- 4-5
- 3-4
- 2-3
- 1-2
- 0-1



INCREASE IN 1960 TSUNAMI HEIGHT IN MIYAKO BAY BETWEEN KUWAGASAKI AND TSUGARUISHI



IN POST-TSUNAMI SURVEYS, Japanese teams made hundreds of height measurements of the 1960 Chile tsunami. Most were compiled in books by the Japan Meteorological Agency (1961) and by The Committee for Field Investigation of the Chilean Tsunami of 1960 (1961)—sources for the overview map at left and most details above. The height estimate for Tsugaruishi is based on tsunami limits identified by eyewitnesses interviewed in 1999 (p. 56-57).

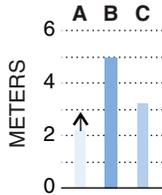
Tsunami size 津波の高さ

The 1700 tsunami probably grew to heights of five meters in Miyako Bay.

EVIDENCE FROM "NIKKI KAKITOME CHŌ"

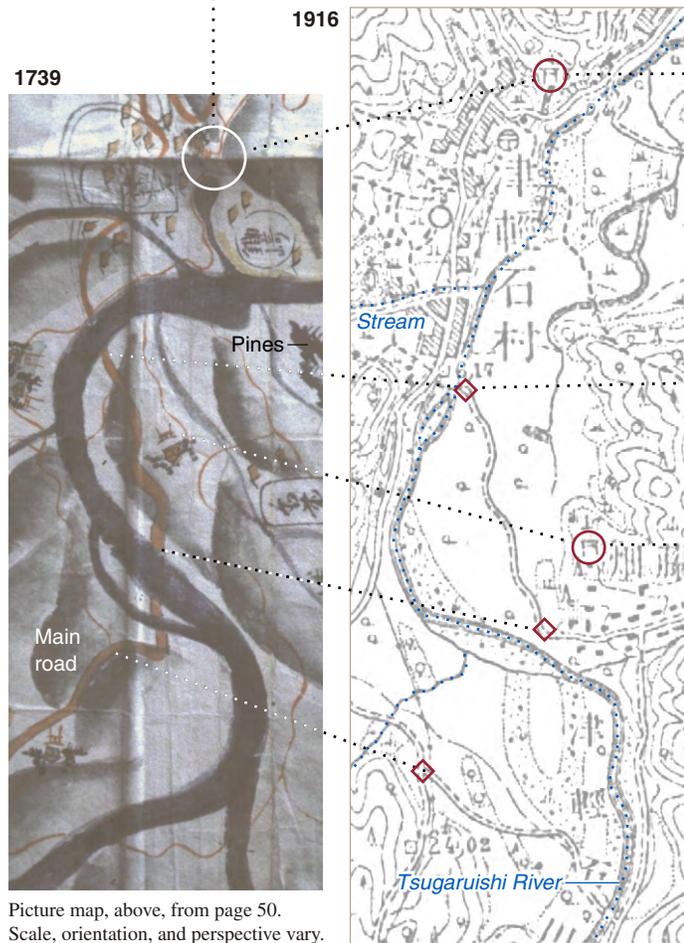
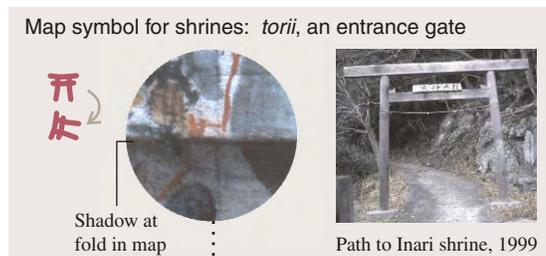
<p>Inari-no-shita Inari-no-shita made up to</p>	<p>Kubota watari Kubota crossing made up to</p>	<p>ie nado houses and so on torare were swept away</p>
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INFERRED HEIGHT OF TSUNAMI AT BAY SHORE

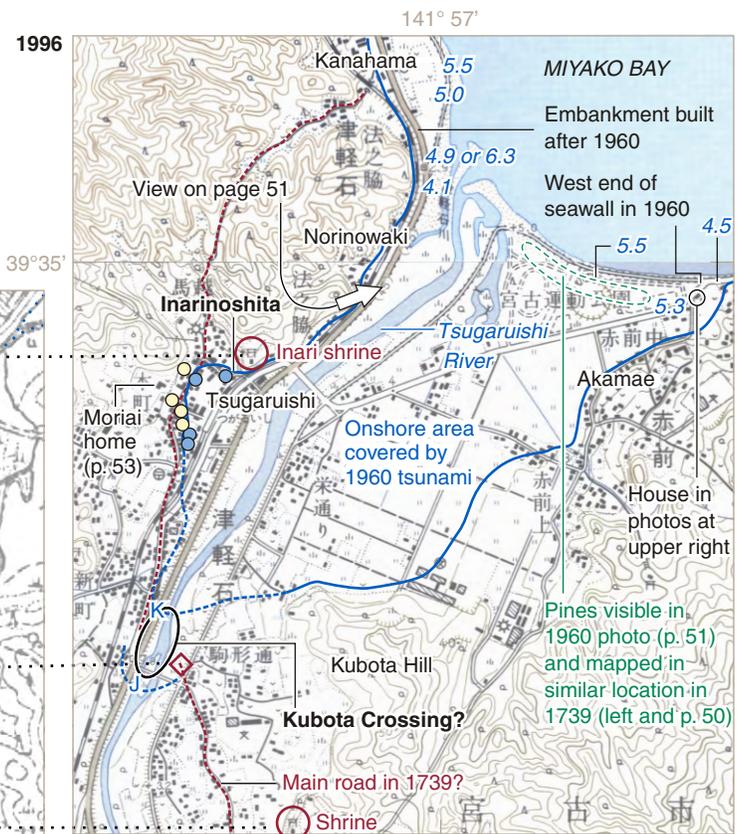


AS IT SWEEP AWAY HOUSES between Kanahama and Akamae, the 1700 tsunami rose more than 2 m above the ambient tide (estimate **A**). Its reported limits at Kubota Crossing and Inarinoshita imply greater heights (**B** and **C**), especially by analogy with the 1960 Chile tsunami. The 1960 tsunami went 2 km up the Tsugaruishi River (map below), entered Tsugaruishi village (photo in **C**, opposite). Because the 1700 tsunami probably did likewise (quotes at left), it probably attained heights like those in 1960—about 5 m along the bay shore (**B**).

SETTING OF THE 1700 TSUNAMI, AND OBSERVED LIMITS AND HEIGHTS OF THE 1960 TSUNAMI



Picture map, above, from page 50. Scale, orientation, and perspective vary.



5.3 Height of 1960 tsunami (m above TP)
Landward limit of 1960 tsunami—Dashed where sources differ (J and K, below). Control points from interviews in 1999: ○ above limit, ● below limit

Scale 1:25,000

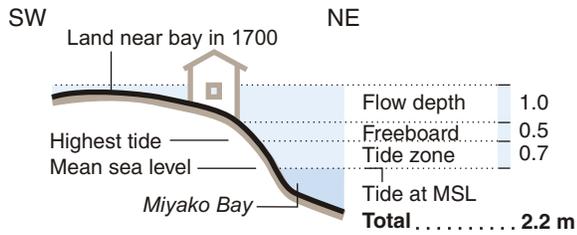
1 km

Contour intervals 10 m (1996) and 20 m (1916)

1960 TSUNAMI heights from The Committee for the Field Investigation of the Chilean Tsunami of 1960 (1961, p. 178-179) and Japan Meteorological Agency (1961, p. 119). TP, Tokyo Peil, a datum near mean sea level (p. 46). Landward limits: K, Kon'no (1961, p. 22) and Kitamura and others (1961a, p. 239); J, Japan Meteorological Agency (1961, p. 119).

BASE MAPS from Kokudo Chiriin (Geographical Survey Institute), Miyako and Tsugaruishi 1:25,000, 1996; and Rikuchi Sokuryōbu, Miyako 1:50,000, 1916.

A Minimum height inferred from loss of houses beside Miyako Bay



ASSUMPTIONS

Flow depth Tsunami crested 1 m deep where it destroyed houses.

Freeboard To avoid flooding during storm tides—and perhaps with the 1677 tsunami in recent memory (p. 51)—villagers sited their houses no less than 0.5 m above highest astronomical tide.

Tide zone The highest astronomical tide in 1700 was 0.7 m above mean sea level, by analogy with modern tides recorded in Kuwagasaki Harbor (footnote, p. 48).

Tide stage No correction attempted because “Nikki” gives dates of flooding but not its time.

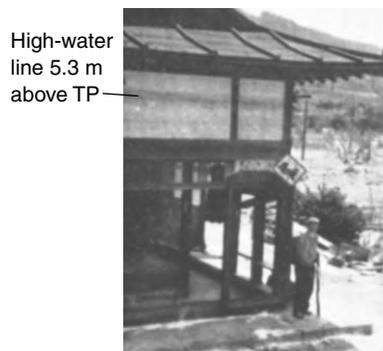
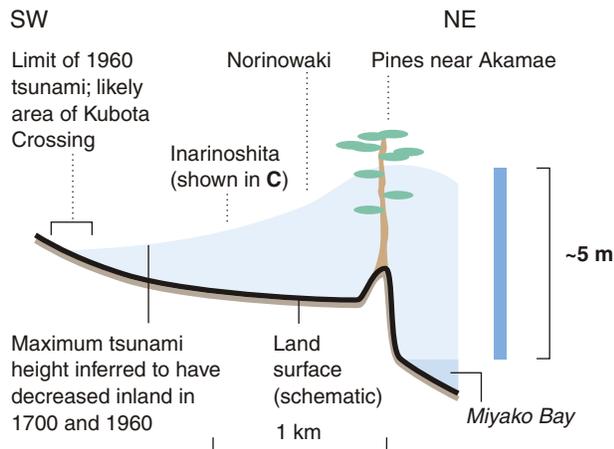


Photo from The Committee for Field Investigation of the 1960 Chilean Tsunami (1961, p. 7)



The 1960 Chile tsunami gutted this house in Akamae, 75 m inland from Miyako Bay. In 1999 a sign marked the 1960 high-water line.

B More realistic height inferred from inundation to Kubota Crossing



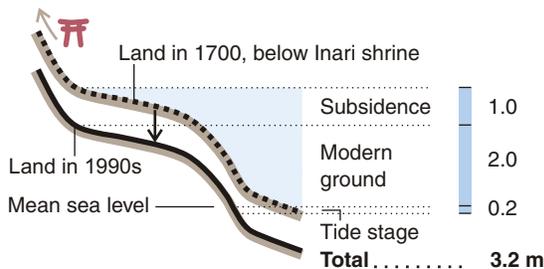
ASSUMPTIONS

Kubota Crossing Denotes a ferry where the area’s main Edo-period road intersected the Tsugaruishi River. Two such crossings appear on the picture map from 1739 (far left). The one nearer Miyako Bay coincides with the 1960 tsunami’s upriver limit, as judged from points shared with later maps (linked, facing page). “Kubota Hill” is the local name for high ground that overlooks this area, 2 km inland from the bay.

1960 analogy If the 1700 and 1960 tsunamis had similar inland limits, they probably reached similar heights at the south shore of Miyako Bay. On that shore the 1960 tsunami crested at 4.5–5.5 m.

Inland decline Both tsunamis probably decreased inland in maximum height. The 1960 maximum probably descended from 5.5 m at the bay to 3.5 m at Inarinoshita, where the water crested about 1.5 m deep on land 2 m above TP (likely site shown in photo below). Relative to TP, the 1960 maximum also descended landward at Ōtsuchi and Shinjō (p. 65, 89).

C Height inferred from inundation to Inarinoshita, adjusted for tectonic subsidence



ASSUMPTIONS

Modern ground Inarinoshita, now Inarigashita, refers to the area at right. (This area lies below, *shita*, a hill between Tsugaruishi and Norinowaki on which a shrine to Inari, a Shinto god, has stood since 1635 or earlier.) Flat ground in the photo is 2.0 m above TP.

Subsidence Relative to the sea, about 1 m since 1700 (see p. 65)

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



The 1700 tsunami probably flooded the site of the Tsugaruishi neighborhood now known as Inarigashita. Here, the 1960 tsunami flowed about 1.5 m deep and destroyed a house.

Height C from Tsuji and others (1998). Tsugaruishi fishermen went to “Inari Hill” in 1635 for divination of the year’s catch (Iwamoto, 1970, p. 21). Moriai Miya, interviewed in 1999 (p. 107), identified a 1960 high-water line near the site at right, for which a modern municipal map gives a height of 2 m TP.